Association science and business center, ''WORLD'', Kraljevo
Naučno poslovni centar, ''WORLD'', Kraljevo

Center for research, science, education and mediation "CINEP", Belgrade
Centar za istraživanje, nauku, edukaciju i posredovanje ''CINEP'', Beograd

Institute for plant protection and environment, Belgrade, Serbia
Institut za zaštitu bilja i životnu sredinu, Beograd, Srbija

11. JEEP INTERNATIONAL SCIENTIFIC AGRIBUSINESS CONFERENCE, MAK 2024 - KOPAONIK

"FOOD FOR THE FUTURE - VISION OF SERBIA, REGION AND SOUTHEAST EUROPE"

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA, MAK 2024 – KOPAONIK

"HRANA ZA BUDUĆNOST - VIZIJA SRBIJE, REGIONA I JUGOISTOČNE EVROPE"

PROCEEDINGS

Editor:

MA Milan Jovičić

Kopaonik, Serbia
02. - 04. February 2024.


WORLD
NAUČNO POSLOVNI CENTAR
SCIENTIFIC AND BUSINESS CENTER


ЦИНЕП
ЦЕНТАР ЗА ИСТРАЖИВАЊЕ, НАУКУ,
ЕДУКАЦИЈУ И ПОСРЕДОВАЊЕ


11.
МАК
2024


ИНСТИТУТ ЗА ЗАШТИТУ БИЉА И ЖИВОТИЊА СРБИЈЕ
• БЕОГРАД •


ПРИВРЕДНА
КОМОРА
СРБИЈЕ
1857

EDITION: EUROPEAN ROUTE
EDICIJA: EVROPSKI PUT

Publisher
Association science and business center, "WORLD", Kraljevo
Naučno poslovni centar, "WORLD", Kraljevo
Center for research, science, education and mediation "CINEP", Belgrade
Centar za istraživanje, nauku, edukaciju i posredovanje "CINEP", Beograd
Institute for plant protection and environment, Belgrade, Serbia
Institut za zaštitu bilja i životnu sredinu, Beograd, Srbija

In cooperation:
City of Kraljevo

For publisher
Prof. PhD Saša Stepanov
Dr Nenad Trkulja
B.Sc. Marija Jovičić,
Editor
MA Milan Jovičić, graduated manager

Issue editor
Prof. PhD Saša Stepanov

Technical editor
Dimitrije Milić

Circulation
50 exemplars

Printed by Kvark,
Kraljevo, 2024.

HONORARY COMMITTEE

Ph.D JELENA BEGOVIĆ, Minister of Science, Technological Development and Innovation, RS, **(Serbia)**,
JELENA TANASKOVIĆ, Minister of Agriculture, Forestry and Water Management, RS, **(Serbia)**,
SAVO MINIĆ, Minister of Agriculture, Forestry and Water Management in the Government of the Republic of Srpska, **(BiH)**,
Prof. Ph.D. ALEN SERANIĆ, Minister of Health and Social Protection of the Republic of Srpska Banja Luka, **(BiH)**,
Prof. PhD ILIJA DŽOMBIĆ, Director of PIM University, Banja Luka, **(BiH)**,
MARKO ČADEŽ, President of the Serbian Chamber of Commerce, Belgrade, **(Serbia)**,
BRANKO AZESKI, North Macedonia Chamber of Commerce, Skopje, **(North Macedonia)**,
Acad.Prof. Ph.D. DRAGAN DAMJANOVIĆ, Serbian Royal Academy of Scientists and Artists, Belgrade, **(Serbia)**,
Prof. Ph.D. BOŽIDAR MILOSEVIC, Dean of the Faculty of Agriculture in Leško, University of Priština with temporary headquarters in Kosovo Mitrovici, Kosovo and Metohija, **(Serbia)**,
NIKOLA LONČAR, President of the Tesla Science Foundation, NYC, **(USA)**,
Dr. PREDRAG TERZIĆ, Mayor of Kraljevo, Kraljevo, **(Serbia)**,
BOBAN ĐUROVIĆ, President of the Municipality of Vrnjačka Banja, Vrnjačka Banja, **(Serbia)**,
MAHMUD AL DAGISTANI, Cynological Association of the Republic of Serbia, Belgrade, **(Serbia)**,
Prof. Ph.D. VESNA MILIĆ, Dean of the Faculty of Agriculture in East Sarajevo, University of East Sarajevo, Republika Srpska, **(Bosnia and Herzegovina)**,
Prof. PhD GORDANA DIMITROVSKA, Dean, Faculty of Biotechnical Sciences, UKLO, Bitola, **(Northern Macedonia)**,
Prof. Ph.D. KAPLLAN SULAJ, Dean, Faculty of Biotechnology and Food, Agriculture University of Tirana, **(Albania)**,
Prof. PhD VJEKOSLAV TANASKOVIĆ, Dean, Faculty of Agricultural Sciences and Food, Skopje, **(Northern Macedonia)**,
Prof. Ph.D. MUZAFFER DENLİ, Dean, Dicle University Faculty of Agriculture, **(Turkey)**
Asst. Mr NEMANJA STEPANOV, Faculty of World Economy and International Affairs, Moscow, **(Russia)**,
RADO SAVIĆ, Mayor of Lopare Municipality, Republika Srpska, **(BiH)**,
MILAN DAMNJANOVIĆ, President of the Municipality of Bogatić, **(Serbia)**,
DIJANA KATICA, President of the Croatian Association for Tourism and Rural Development, Zagreb, **(Croatia)**,
SLOBODAN KRSTIĆ, e-Razvoj Association, Belgrade, **(Serbia)**.

ORGANIZING COMMITTEE

Mr. Nenad Nikolin, President, Belgrade, **(Serbia)**,
Marija Jovičić, Deputy President, Kraljevo, **(Serbia)**,
Acad. Prof. PhD Mirsad Nuković, member, Novi Pazar, **(Serbia)**,
PhD Milutin Matić, member, Kragujevac, **(Serbia)**,
PhD Stevan Petković, member, Banja Luka, Republika Srpska **(BiH)**,
PhD Jovan Marković, member, Podgorica, **(Montenegro)**,
PhD Adnan Tutić, member, Tutin, **(Serbia)**,
PhD Đorđe Čabilovski, member, Zrenjanin, **(Serbia)**,
Mr. Milorad Jeremić, member, Šabac, **(Serbia)**,
Mr. Zoran Šunjka, member, Belgrade, **(Serbia)**,
Mr. Žarko Nestorović, member, Kladovo, **(Serbia)**,
MSc Dragan Cvetković, member, Kumanovo **(North Macedonia)**,
B.Sc. Stojan Srbinoski, member, Skopje, **(North Macedonia)**,
Željko Sremčević, member, Prague, **(Czech Republic)**,
Zoran Jelenković, member, Raška, **(Serbia)**,
Jasmina Marić, member, Gornji Milanovac, **(Serbia)**,
Miša Ćirić, member, Belgrade, **(Serbia)**,
Ivan Trifunović, member, Vrnjačka Banja, **(Serbia)**,
Bojan Katanić, member, Kragujevac, **(Serbia)**,
Darko Masić, member, Bogatić, **(Serbia)**,
Radenko Cvetić, member, Raška, **(Serbia)**,
Zlatko Milenković, member, Brus, **(Serbia)**,
Svetlana Kovačević, member, Belgrade, **(Serbia)**.

SCIENTIFIC COMMITTEE

Prof. PhD Saša Stepanov, president of the scientific board, Center for research, science, education and mediation "CINEP", MEF, Faculty of Applied Management, Economics and Finance, Belgrade, **(Serbia)**,
Prof. PhD Todor Petković, secretary of the scientific board, Čačak Business School of Vocational Studies, Belgrade, **(Serbia)**,
Acad. Prof. PhD Mitar Lutovac, Balkan Science Center of the Russian Academy of Natural Sciences, Belgrade, **(Serbia)**,
Acad. Prof. PhD Rade Biočanin, Pan-European University "Apeiron", Banja Luka and International University Travnik, **(BiH)**,
Acad. Prof. PhD Dragutin Đukić, Faculty of Agriculture in Čačak, University of Kragujevac, **(Serbia)**,
Acad. Prof. PhD Radenko S. Krulj, Faculty of Philosophy, Kosovska Mitrovica, **(Serbia)**,
Prof. PhD Anka Vojvodić, High School of Health and Sanitary Vocational Studies "Visan", Belgrade, **(Serbia)**,
PhD Danica Mićanović, Scientific Advisor, Serbian Chamber of Commerce, Belgrade, **(Serbia)**,
PhD Danijela Šikuljak, scientific advisor, Institute for Plant Protection and Environment, Belgrade, **(Serbia)**,
PhD Nenad Trkulja, senior research associate, Institute for Plant Protection and Environment, Belgrade, **(Serbia)**,
PhD Snežana Janković, Scientific Advisor, Institute for the Application of Science in Agriculture, Belgrade, **(Serbia)**,
PhD Slađana Savić, research associate, Institute for Plant Protection and Environment, Belgrade, **(Serbia)**,
PhD Nenad Đurić, senior research associate, Institute of Vegetables Smederevska Palanka, **(Serbia)**,
PhD Veselinka Zečević, Scientific Advisor, Institute of Vegetables Smederevska Palanka, **(Serbia)**,
Prof. PhD Elena Joševska Milevska, Vice Dean, Faculty of Biotechnical Sciences, UKLO, Bitola, **(Northern Macedonia)**,
PhD Adisa Tufo, Faculty of Management and Business Economics Sarajevo, **(Bosnia and Herzegovina)**,
Prof. PhD Nikolay I. Bukhatoyarov, Rector, Voronezh State Agrarian University, Voronezh **(Russia)**,
Prof. PhD Zoran Jovović, Biotechnical Faculty, University of Montenegro, Podgorica, **(Montenegro)**,
Prof. PhD Vesna Milić, Faculty of Agriculture in East Sarajevo, University of East Sarajevo, Republika Srpska, **(Bosnia and Herzegovina)**,

Prof. PhD Siniša Berjan, Faculty of Agriculture, Department of Agricultural Economics and Rural Development, University of East Sarajevo, **(BiH)**,
Prof. PhD Tatjana Krajišnik, Faculty of Agriculture in East Sarajevo, University of East Sarajevo, Republika Srpska, **(Bosnia and Herzegovina)**,
Asst. Prof. PhD Igor Đurđić, Faculty of Agriculture in East Sarajevo, University of East Sarajevo, Republika Srpska, **(Bosnia and Herzegovina)**,
Prof. PhD Simin Hagh Nazari, Department of Food Science and Technology, Faculty of Agriculture, University of Zanjan, Zanjan, **(Iran)**,
Prof. PhD Reza Masoumi, Department of Animal Science, Faculty of Agriculture, University of Zanjan, Zanjan, **(Iran)**,
Prof. PhD Ali Soleimani, Department of Horticulture, Faculty of Agriculture, Zanjan University, Zanjan, **(Iran)**,
Ph.D. Milena Simić, Scientific Advisor, Maize Institute "Zemun Polje" Belgrade **(Serbia)**,
Prof. PhD Zoran Broćić, Faculty of Agriculture, Zemun, University of Belgrade, **(Serbia)**,
Prof. PhD Zoran Jovović, Biotechnical Faculty, University of Montenegro, Podgorica, **(Montenegro)**,
Prof. PhD Nese Uzen, Vice Dean Dicle University, Faculty of Agriculture Diyarbakir, **(Turkey)**,
Prof. PhD Gültekin Özdemir, Dicle University, Faculty of Agriculture Department of Horticulture, **(Turkey)**,
Prof. PhD Mehmet Yildirim, Dicle University, Faculty of Agriculture, Department of Field Crops, Diyarbakır **(Turkey)**,
Prof. PhD Muhittin Tutkun, Dicle University, Faculty of Agriculture, Department of Animal Science, Diyarbakır, **(Turkey)**,
Prof. PhD Džlijana Tomovska, Faculty of Biotechnical Sciences, UKLO, Bitola, **(Northern Macedonia)**,
Asst. PhD Blagojče Najdovski, Faculty of Biotechnical Sciences, UKLO, Bitola, **(Northern Macedonia)**,
Prof. PhD Ivana Janeska Stamenkovska, Faculty of Agricultural Sciences and Food, Department of Agricultural Policy, Skopje, **(North Macedonia)**,
Prof. PhD Marina Nacka, Faculty of Agricultural Sciences and Food, Skopje, **(North Macedonia)**,
Prof. PhD Dragi Dimitrievski, Faculty of Agricultural Sciences and Food, Skopje, **(Northern Macedonia)**,
Prof. PhD Riste Elenov, Faculty of Agricultural Sciences and Food, Institute of Agricultural Economics, Skopje, **(North Macedonia)**,
Prof. PhD Mladen Todorović, Senior Scientific Advisor at CIHEAM-Bari Institute, coordinator of the Climate Change Knowledge Unit. **(Italy)**,
Prof. PhD Kristina Vojvodić, College of Health sanitary school of vocational studies "Visan", Belgrade, **(Serbia)**,

Prof. PhD Sorin Mihai Cimpeanu, Universitatea de Științe Agronomice și Medicină Veterină din București, **(Romania)**,
Prof. assoc. PhD Artiona Laze, Department of Chemistry, Faculty of Biotechnology and Food, Agriculture University of Tirana, **(Albania)**,
Prof. assoc. PhD Erjon Mamoci, Faculty of Biotechnology and Food, Agriculture University of Tirana, **(Albania)**,
PhD. Merita Stafasani, Faculty of Biotechnology and Food, Agriculture University of Tirana, **(Albania)**,
Prof. Ph.D. **Mikica Drenovak**, Faculty of Economics in Kragujevac, **(Serbia)**,
PhD. Hamid El Bilali, CIHEAM – Mediterranean Agronomic Institute of Bari, **(Italy)**,
Asst. PhD Ljiljana Anđušić, Faculty of Agriculture in Leško, University of Pristina with temporary headquarters in Kosovska Mitrovica, Kosovo and Metohija, **(Serbia)**,
Asst. PhD Tatjana Ivanović, Faculty of Agriculture in Leško, University of Priština with temporary headquarters in Kosovska Mitrovica, Kosovo and Metohija, **(Serbia)**,
Prof. Ph.D Desimir Knežević, Faculty of Agriculture in Leško, University of Pristina with temporary headquarters in Kosovska Mitrovica, Kosovo and Metohija, **(Serbia)**,
Prof. PhD Ivana Penjišević, Faculty of Science, University of Pristina with temporary headquarters in Kosovska Mitrovica, Kosovo and Metohija, **(Serbia)**,
Prof. PhD Zoran Ilić, Faculty of Agriculture-Lešak, University of Pristina, with temporary headquarters in Kosovska Mitrovica, **(Serbia)**,
Prof. PhD Dragan Bataveljić, Faculty of Law, University of Kragujevac, **(Serbia)**,
Prof. PhD Jozef Peterka, Dean of the Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava (STU), Trnava, **(Slovakia)**,
Prof. PhD Marko Vojvodić, High School of Health and Sanitary Vocational Studies "Visan", Belgrade, **(Serbia)**,
Prof. PhD Sanja Radonjić, Biotechnical Faculty, University of Montenegro, Podgorica, **(Montenegro)**,
Prof. PhD Penka Moneva, Institute of animal science - Kostinbrod, **(Bulgaria)**,
Prof. PhD Lukrecija Đeri, Department of Geography, Tourism and Hotel Management, Faculty of Science, University of Novi Sad, **(Serbia)**,
Prof. PhD Monika Paula Marin, Faculty of Animal Productions Engineering and Management University of Agricultural Sciences and Veterinary Medicine of Bucharest, **(Romania)**,
Prof. PhD Francesco Tei, Director, Dipartimento di Scienze Agrarie, Alimentari e Ambientali Università degli Studi di Perugia **(Italy)**,
Prof. PhD Liubov Bovnegra, Head of Department information technology design in mechanical engineering, Odessa National Polytechnic University (ONPU), Odessa, **(Ukraine)**,
Prof. PhD Kosa Golić, "Union Nikola Tesla" University **(Serbia)**,
Prof. PhD Ružica Đervida, Independent University of Banja Luka, Republika Srpska, **(BiH)**,
Asst. PhD Gordana Petrović, Elementary School Radoje Domanović, Kragujevac, **(Serbia)**,

F O R E W O R D

Agricultural production is realized in the use of limited resources, land and water, which are not maximally used, in which there is a slowdown in the increase in productivity of agricultural edible plant species, a decrease in biodiversity, an increase in environmental pollution and the degradation of biological, chemical and physical properties of the soil. Natural resources, soil and water are exposed to the pressure of unreasonable depletion in agriculture, the application of inappropriate cultivation technology, enormous amounts of fertilizers, pesticides, climate change, intensive blocking of arable land with the formation of urban and industrial settlements, roads, wind farms, solar electric screens, which lead to insecurity production and food supply.

It is necessary to include the hitherto unused capacities of land and water and improve agricultural production based on ecological principles and increasing adaptability to changed climatic conditions with the introduction of new varieties and hybrids and new cultivation technologies. The state of the world's land and water resources for food and agriculture is an important subject for scientific consideration of the implications for agriculture and finding solutions for the transformation of the combined role of land and water in providing food, preserving the environment, improving energy efficiency as well as improving socioeconomic development, which is central topic in the program of the 11th International Scientific Agribusiness Conference " Food for the future - a vision of Serbia, the region and Southeast Europe".

Conference participants presented the latest knowledge, which is in the function of public policy to increase care for the future of natural resources, soil and water conservation, increase biodiversity, food security, improvement of nutrition and human health and development of compatible sources of clean energy, as well as ensuring fair trade. In addition, the Conference created an opportunity for the exchange of innovative research, methodologies and practices in various fields of agriculture, economy, education, for encouraging dialogue, interdisciplinary connection, and promotion of modern trends in education, marketing, excellence and innovation.

The results presented in the papers indicate the need and possibility of joint projects in the region, the Balkans, Europe and beyond in the field of socio-economic cultural and political life. How significant this is, it is not difficult to conclude based on the visible laws in the nature that surrounds us. The content of the papers and the results at this conference confirm the importance and potential of scientific, professional, cultural, economic and political cooperation in preserving the integrity, independent coexistence, respect and friendship of the Republic of Serbia in the European and world frameworks.

We express our heartfelt gratitude and respect to the meeting participants, board members, authors, reviewers, co-organizing institutions, sponsors and everyone who contributed to the realization of the Conference.

Kopaonik,
02-04. February 2024.

Editors

MSc Milan Jovičić

P R E D G O V O R

Poljoprivredna proizvodnja se ostvaruje u korišćenju ograničenih resursa, zemljišta i vode, koji nisu maksimalno iskorišćeni, u kojima se ispoljava usporavanje povećanja produktivnosti poljoprivrednih jestivih biljnih vrsta, smanjenje biodiverziteta, povećanja zagađenja životne sredine i degradacije bioloških, hemijskih i fizičkih osobina zemljišta. Prirodni resursi, zemljište i voda su izloženi pritisku nerazumnog iscrpljivanja u poljoprivredi, primenom neodgovarajuće tehnologije gajenja, enormne količine đubriva, pesticida, klimatskih promena, intenzivnog blokiranja obradivog zemljišta sa formiranjem urbanih i industrijskih naselja, saobraćajnica, vetroparkova, solarnih elekrana, što void u nesigurnost proizvodnje i snabdevanja hranom.

Neophodno je uključiti do sada neiskorišćene kapacitete zemljišta i vode i unaprediti polljoprivrednu proizvodnju na ekološkim principima i povećanju adaprivnosti na promenjene klimatske uslove sa uvođenjem novih sorti i hibrida i novih tehnologija gajenja. Stanje svetskih zemljišnih i vodnih resursa za hranu i poljoprivredu predstavljaju značajan predmet za naučno sagledavanje implikacije na poljoprivredu i iznalaženje rešenja za transformaciju kombinovane uloge zemljišta i vode u obezbeđenju hrane, očuvanju životne sredine, unapređenju energetske efikasnosti kao i unapređenju socioekonomskog razvoja, a što je centralna tema u programu 11. Međunarodne naučne agrobiznis konferencije "Hrana za budućnost - vizija Srbije, regiona i Jugoistočne Evrope".

Učesnici Konferencije su prezentovali najnovija znanja, koja su u funkciji javne politike za povećanje brige za budućnost prirodnih resursa, očuvanja zemljišta i vode, povećanja biodiverziteta, obezbeđenja hrane, unapređenja ishrane i zdravlja ljudi i razvoja kompatibilnih izvora čiste energije, kao i obezbeđenje fer tržišta. Pored toga na Konferenciji je stvorena mogućnost za razmenu inovativnih istraživanja, metodologija i praksi u različitim oblastima poljoprivrede, ekonomije, obrazovanja, za podsticanje dijaloga, interdisciplinarnog povezivanja, i promociju savremenih trendova u obrazovanja, marketingu, izvrsnosti i inovacija.

Predstavljeni rezultati u radovima, ukazuju na potrebu i mogućnost ostvarivanja zajedničkih projekata u regionu, Balkanu, Evropi i šire u oblasti socio-ekonomskog kulturnog i političkog života. Koliko je to značajno, nije teško zaključiti na osnovu vidljivih zakonitosti u prirodi koja nas okružuje. Sadržaj radova i rezultati na ovoj konferenciji potvrdjuju značaj i potencijal naučno-stručne, kulture, privredne i političke saradnje u očuvanju integriteta, nezavisne koegzistencije, uvažavanja i prijateljstva Republike Srbije u evropskim i svetskim okvirima.

Učesnicima skupa, članovima odbora, autorima radova, recenzentima, institucijama suorganizatorima, pokroviteljima i svima koji su doprineli realizaciji Konferencije izražavamo srdačnu zahvalnost i poštovanje.

Kopaonik,
02-04. February 2024.

Urednik
MSc Milan Jovičić

C O N T E N T S

INVITED SPEAKER

PLENARY PRESENTATION

SESSION A

CLIMATE CHANGE CHALLENGES IN IRRIGATION AND AGRICULTURE IN ARID AND SEMI ARID REGIONS

IZAZOVI KLIMATSKIH PROMENA U NAVODNJAVANJU I POLJOPRIVREDI U SUŠNIM I POLUSUŠNIM REGIONIMA

Nese Yaman, associate professor [1]
Isam M. Abdulhameed, full professor [2]

Abstract: *Climate change has made its effects are manifested in different ways all over the world after the Industrial Revolution. Climate change sometimes are manifested through heavy rains and storms, sometimes causes serious production losses through long-term droughts. Turkey is a country close to Europe, the Mediterranean, and the Middle East, due to its location and large surface area. Both Turkiye and Iraq are suffering from climate change effects.. Drought events, which have increased in frequency, especially in recent years, negatively affect agricultural production. The increasing frequency of drought events constitutes a risk factor not only for Türkiye but also for most countries that have a semi–arid climate in the south of Türkiye. Different seasons and climates can be experienced at the same time in Türkiye. However, when examined across the country, a semi-arid climate prevails in most parts of the country. Especially in the summer months, increasing temperatures, decreasing or absent precipitation, low relative humidity, and strong wind speed increase plant water consumption. For this reason, in most semi-arid regions of Türkiye, crop production cannot be carried out without irrigation during the summer months. For this purpose, the government has made significant irrigation investments, especially in semi-arid regions. For example, the Turkish Ministry of Agriculture and Forestry has been offering 50% grant support to pressurized irrigation systems that use water efficiently since 2007. Despite this, water resources are often insufficient or limited. In this study, the level of impact of climate change in recent years in semi-arid regions, especially in Turkey, and adaptation strategies against climate change are discussed.*

Key words*: Climate change, semi-arid region, agriculture, irrigation, production*

Apstrakt: *Klimatske promene su učinile da se njeni efekti ispoljavaju na različite načine širom sveta nakon industrijske revolucije. Klimatske promene se ponekad ispoljavaju kroz jake kiše i oluje, ponekad izazivaju ozbiljne gubitke u proizvodnji usled dugotrajnih suša. Turska je zemlja koja blizu Evrope, Mediterana i Bliskog istoka, prema svom položaju i velikoj površini. I Turska i Irak stradaju od posledica klimatskih promena.Turska je jedna od zemalja koja je bila i biće najviše pogođena klimatskim promenama. Sušne pojave, koje su sve učestalije, posebno poslednjih godina, negativno utiču na poljoprivrednu proizvodnju. Sve veća učestalost suša predstavlja faktor rizika ne samo za Tursku, već i za većinu zemalja koje imaju polusušnu klimu na jugu Turske. U Turskoj se mogu istovremeno iskusiti različita godišnja doba i klime. Međutim, izuččavanje klime širom zemlje pokazuje da u većem delu zemlje vlada polusušna klima. Naročito u letnjim mesecima, povećanje temperature, smanjenje ili izostanak padavina, niska relativna vlažnost i jaka brzina vetra povećavaju potrošnju vode u biljkama. Iz tog razloga, u većini polusušnih regiona Turske, proizvodnja useva se ne može obavljati bez navodnjavanja tokom letnjih meseci. U tu svrhu, vlada je napravila značajna ulaganja u navodnjavanje, posebno u polusušnim regionima. Na primer, tursko Ministarstvo poljoprivrede i šumarstva nudi 50% bespovratne podrške sistemima za navodnjavanje pod pritiskom koji efikasno koriste vodu od 2007. Uprkos tome, vodni resursi su često nedovoljni*

[1] Dicle University, Faculty of Agriculture, Dept. of Farm Structures and Irrigation, Diyarbakır, Türkiye, e-mail: nuzen@dicle.edu.tr
[2] Upper Euphrates Basin Developing Centre, University of Anbar, Iraq, e-mail: isambayati@uoanbar.edu.iq

ili ograničeni. U ovoj studiji se razmatra nivo uticaja klimatskih promena poslednjih godina na polusušne regione, posebno u Turskoj, i strategije prilagođavanja na klimatske promene.

Ključne reči: *klimatske promene, polusušni region, poljoprivreda, navodnjavanje, proizvodnja*

1. INTRODUCTION

Due to the intensive use of fossil fuels, energy production, agriculture, and other activities that are not carried out according to sustainability principles, greenhouse gases in the atmosphere have reached a dangerous level for the future of humanity. It is now a known fact that this increase in greenhouse gases directly affects the temperature.

Climate change is an important global problem in terms of its effects and consequences that are becoming more frequently observed today. Natural disasters such as floods, fires, and droughts that have occurred on a global scale in recent years threaten the entire ecosystem and human life. Increases in the frequency, impact, and duration of these disasters are observed. Climate change is no longer an environmental problem, but rather a problem of ensuring the sustainability of human life. It is now inevitable to take the necessary precautions against climate change to ensure the living standards of future generations.

Climate model simulations for the 21st century are consistent in projecting precipitation increases in high latitudes (very likely) and parts of the tropics, and decreases in some sub-tropical and lower mid-latitude regions [1,2]

Combating climate change, which requires a multidimensional and systematic structural transformation, is not an issue that can be reduced only to the ecological-environmental dimension. Essentially, it is a struggle that aims to transition to a low-carbon economy and requires economic, political, and strategic restructuring of countries.

In this context, the global fight against climate change officially started on 21 March 1994 with the United Nations Framework Convention on Climate Change (UNFCCC). In the 6th Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC), which is the scientific body of this agreement, published on August 9, 2021, it was stated that the world's average temperature has increased by 1.1^0C since the Industrial Revolution [3] and the last 10 years have been the hottest period of all time.

It is predicted that drought will be felt in large areas and the number of extremely hot days will increase in Turkiye, Iraq and neighbor countries, which is located in the Mediterranean Basin, one of the regions expected to be most affected by climate change in the world. Therefore, this problem needs to be addressed seriously at the national level.

As it is known, extreme temperature increases in the atmosphere cause global warming. Global warming is caused by the greenhouse effect caused by greenhouse gases released into the atmosphere as a result of some wrong practices. Energy consumption in the world is by far the largest source of human-caused greenhouse gas emissions and is responsible for 73% of greenhouse gas emissions worldwide. Other major areas that produce emissions outside the energy sector are agricultural activities (12%), forestry activities such as land use, land use change, and deforestation (6.5%), chemicals, cement, and different industrial processes (5.6%), and wastes including landfills and wastewater (3.2%) [4]

The agricultural sector is one of the sectors most affected by and causing climate change in terms of product productivity, product patterns, decreasing water resources, increasing temperature, and food security. For this reason, today, new agricultural approaches are used in the agricultural sector to ensure adaptation to changing climate conditions and to reduce carbon emissions caused by agricultural activities.

The climate in Türkiye varies by region. While the northern regions receive a lot of rainfall, the Central Anatolia and Southeastern Anatolia regions are two regions where drought limits agricultural production. For this reason, crop production cannot be done without irrigation in the summer months.

This study focuses on climate change in Türkiye from past to present, changes in agricultural production, and drought adaptation strategies. But in Iraq, the temperatures have risen clearly at the last four decades, accompanied by a decrease in rainfall rates. It was observed that the rain isoline moved about 100 km towards the north. [5].

2. CLIMATE CHANGE AND AGRICULTURE

In general, soil, water, sunlight, and temperature are needed for the growth of all agricultural products. Climate is a dynamic component that affects all of the components listed. For this reason, the risk it creates for the agricultural sector is very high due to the unknowns it involves. Climate is one of the factors that directly affects agricultural production.

The effects and consequences of climate change noticeably affect our lives. This situation; We encounter issues such as epidemics, drought, erosion, desertification, displacement of climate zones, as the shifting of the rain isoline causing deformation in the land use/land cover of the region. increase in severe weather events, rise in sea level, damage to wildlife species as a result of disruption of natural balance, and deterioration of human health.
Agriculture is an important sector that affects and is affected by climate change. How agricultural production systems will respond to changing climatic conditions is one of the issues that should be revealed first. New agricultural practices and new agricultural technologies should be developed for the changing climate. On the other hand, developing agricultural practices that reduce greenhouse gas emissions is a serious mitigation item in the fight against climate change.

The combined effects of changes in temperature, precipitation, and atmospheric CO_2 concentration affect crop yield, and this effect varies by region. A decrease in crop yield and an increased risk for livestock is predicted in most of the Mediterranean Basin [6]. Climate projections show that much of Europe will experience higher levels of warming than the global average.
The 13th of the United Nations (UN) Sustainable Development Goals is climate action to prevent the negative effects of climate change on agricultural production and to adapt agricultural production to climate change. With this action, strengthening the resilience and adaptation capacity against climate-related hazards and natural disasters in all countries, integrating measures related to climate change into national policies, strategies, and plans, providing education, awareness raising, and training on climate change mitigation, adaptation to climate change, impact reduction and early warning. The development of human and institutional capacity has been determined as the main objective [7].

In the agricultural sector, these targets are; Ending hunger, ensuring food security and promoting sustainable agriculture, resilience of plant patterns and adaptation of production systems to climate risks and natural disasters, an adaptation of agricultural systems to climate change, ensuring sustainable food production systems, increasing production and protecting ecosystems are highlighted as actions is coming out.

3. EFFECTS ON THE FOOD INDUSTRY

The agriculture and food sector, which is among the strategic sectors of the 21st century, is in danger of being inadequate to feed the world population, which is estimated to reach 10 billion in 2050. Research indicates that to feed the world population in 2050, agricultural and food production must be at least 50% more than today's level. IPCC's Assessment Reports predict that, due to the

impact of climate change, water scarcity, and drought will increase in the world, agricultural productivity will decrease, and food prices may increase by up to 85% worldwide [8]. It is known that some agricultural areas have become arid due to the change in the precipitation regime, the ripening times of agricultural products have changed, some agricultural areas have become unusable by being flooded or become saline due to the rise of seawater and productivity has decreased. Rising temperatures will also increase bacterial production in foods. In summary, climate change also threatens food security.

In line with all these explanations, it is stated by different authorities that the cultivation area and production pattern will change due to the effect of climate change, there will be a decrease in productivity and the amount of production will decrease, and there will be a decrease of approximately 25% in agricultural productivity in the next 30 years.

These reality forces researchers and farmers to improve the agriculture systems and irrigation methods and may contribute to migration from the villages to the cities, causing various social and economic problems.

4. EFFECTS OF CLIMATE CHANGE ON TURKIYE

Türkiye is located in the western part of the sub-tropical continents and in a climate zone called the Mediterranean climate. There are many sub-climatic types in Türkiye, which is surrounded by seas on three sides and has an average altitude of approximately 1,132 m. This diversity in climate types is related to the fact that Türkiye is located in a transition zone that is affected by various pressure systems and weather types originating from the polar and tropical (equatorial) zones throughout the year. This includes the complexity of topographic features and their variability over short distances, etc. Physical-geographical features can also be added.

As with past climate changes, there may be regional and time differences. For example, while there will be an increase in the severity and frequency of meteorological disasters such as hurricanes, heavy rains, and related floods in some parts of the world in the future, long-term and severe droughts and associated widespread desertification events may be more effective in some regions.

It is predicted that Türkiye may be affected by the negative aspects of global warming, especially the weakening of water resources, forest fires, drought and desertification, and related ecological disruptions. It is shown among the risk group countries in terms of the potential effects of global warming in international publications and IPCC reports [9].

Climate change affects water resources most negatively. It has been proven in all scientific reports that the most important impact of climate change will be on the water cycle. Research shows that more than 3 billion people will experience water scarcity by 2025 [10]. Türkiye economic irrigable land availability is 8.5 million hectares and the amount of land opened for irrigation (2020) is 6.7 million hectares [11]. The water resources of Türkiye, which is experiencing water stress, are 98 Billion m^3 of surface water, and 14 Billion m^3 of groundwater, and the total usable (net) amount of water is determined as 112 billion m^3. The amount of usable water per person is 1,347 m^3/year. This situation shows us that Türkiye is not a water-rich country and is even under water stress. In areas opened to irrigation throughout the country, the irrigation rate is 65% and the irrigation efficiency is 45%. Because of the projects developed by public institutions and organizations responsible for the development of water resources in Türkiye, as of the end of 2000, water consumption for various purposes has reached 39.3 billion m^3, 6.0 billion m^3 of which comes from groundwater and 33.3 billion m^3 from surface water. 29.3 billion m^3 (75%) of this water is for irrigation; 5.8 billion m^3 (15%) is used to meet drinking water needs and 4.2 billion m^3 (10%) is used to meet industrial water needs. Specifically, the sectoral distribution of groundwater is 2.1 billion m^3 in irrigation; 1.9 billion m^3 is used for drinking, and 2.0 billion m^3 is used for industry [11].

Another problem caused by climate change is drought. in Mediterranean countries, including Türkiye, with the negative effects of climate change being felt, the concepts of drought and humanitarian interventions due to natural events are frequently encountered. Because of drought, plant water needs cannot be met, and there is a decrease in product yield and quality along with an increase in weeds and pests. To combat drought nationwide, short-, medium-, and long-term measures are taken, and action plans are put in place to reduce the effects of drought on a sustainable basis. Spring recharge of many groundwater reservoirs (aquifers) in the world because of climate, shifts towards winter. Summer feeding is extremely reduced. Climate change has an impact on both the quantity and quality of groundwater resources. The indirect effects of climate change on the quantity of groundwater arise from changes in groundwater withdrawal and use initiated by the climate. Decreasing trends in groundwater levels (especially in the Central Anatolia region in Türkiye) are closely related to increasing drought trends. Climate change and variability can significantly alter the recharge rates of large aquifer systems and thus the sustainable groundwater supply in the region may change at a high rate. For shallow aquifers, air temperature has a greater impact on groundwater levels than precipitation. Increasing the level of public awareness, involving all stakeholders in the process, planning sustainable agricultural water use, taking necessary precautions in periods when drought is not experienced, and effective combat in times of crisis are managed within the scope of the "Agricultural Drought Combat Strategy Action Plan" of Agriculture and Forestry Ministry.

Erosion is the rapid removal of soil, especially fertile topsoil, by natural processes such as water and wind, as well as human activity. Temperature increases and soil cultivation increases the rate of soil degradation. In this case, the danger of erosion increases and soil fertility decreases. According to research, Türkiye's soil fertility has decreased by 23% in the last 10 years [4].

As soil fertility decreases, the organic structure in the soil weakens and therefore there is a decrease in plant nutrients. The decrease in nutrients is tried to be compensated by using more chemical fertilizers, which causes nitrate pollution and the release of N_2O emissions, a greenhouse gas, into the atmosphere.

Increasing climate change also causes changes in natural vegetation. It is considered that this situation may cause the expansion of steppe areas and the decrease of pasture areas in Türkiye.
With climate change, temperature increases or changes in precipitation regimes may create suitable environments for plant diseases and pests. Product quantity and quality decrease due to this sudden disease and pest infestation.

One of the important consequences of climate change is the negative effects it has on water resources and the water cycle. The negative effects of climate change on water resources can be listed as follows.
• Changes in the water cycle (increased atmospheric water vapor, change in precipitation regime, extreme consequences such as drought and floods, large-scale melting of polar and mountain glaciers, changes in soil moisture),
• High air temperatures affect water quantity and quality,
• High sea level causes salinization of estuarine and coastal groundwater, thus reducing the access of people and ecosystems to fresh water in coastal areas.

With climate change, changes are observed in the intensity and distribution of precipitation. Precipitation that should fall within a few months falls within a few hours, causing serious damage. While a significant decrease is expected in precipitation in the Western and Southern regions, where the Mediterranean climate prevails, precipitation is expected to increase in the Black Sea Region, where a moderate mid-latitude climate prevails. Due to increasing temperature and decreasing precipitation, an increase in the severity, frequency, and duration of drought events is expected. Water resources are becoming one of the highest priority issues regarding climate change in many

regions. Efforts should be made to balance water supply and demand, taking into account the effects of future climate change.

Water management requires being responsible for the regulation, control, allocation, and distribution of existing water resources and efficient use of stream-based uses such as irrigation and energy cooling, taking into account the effects of future climate change. It is recommended that not only the control of floods but also their predictions should be made based on climate change principles.

On these issues, local governments and all units of government, as well as the private sector and stakeholders, need to continue to deal with water management by regularly incorporating the effects of climate change. In this regard, when it comes to water management, one should not expect a magic wand to overcome problems by producing solutions only through scientific methods, because water use also includes social, economic, and cultural aspects. Engineering structures such as dams, levees, and drainage channels need to be sized and managed to adapt to climate change.

However, based on the research conducted, it has been concluded that this is not the case and that the behavior of different geographical regions of Türkiye against climate change should be revealed through a national climate change study and future predictions should be made accordingly.

Mass tree drying and pest epidemics, etc., have increased in Türkiye's forests in recent years. Strong findings have been found that the main causes of disasters are drought, air pollution, and acid rain [12] Between 1993 and 1994 alone, approximately 2 million m^3 of trees were destroyed due to insect destruction. In addition, visible tree drying, although not massive, is observed in the Aegean and Mediterranean regions due to the drier-than-normal conditions that have been effective in the Mediterranean Basin since the 1970s. In addition, the weakening of trees reduces the resistance of forests to the effects of storms, snow, avalanches, and similar meteorological disasters. As a result, the amount of fallen and broken trees increases. This makes the forest vulnerable to other pests. These negative effects negatively affect the biodiversity, gene stores, and carbon retention capacities of Türkiye’s forests. The effects of climate change on Türkiye’s forests also need to be examined in detail.

5. NEW POLICIES PRODUCED FOR CLIMATE CHANGE IN TURKIYE AND IRAQ

Türkiye has recently been creating its policies within the framework of sustainable development principles in almost every field of combating climate change. It is progressing towards developing its legal, institutional, and economic system in the context of the new climate economy. In the international arena, joint efforts against climate change attract attention.

While climate change has the potential to affect natural ecosystems, especially water and carbon cycles and the food chain, the agricultural sector is also considered the most vulnerable sector to climate change. In other words, climate change is a global crisis that can easily affect agricultural production. But this crisis also depends on how countries respond to climate variability.

Observed climate change affects food security with increasing temperatures, changing precipitation patterns, and the increased frequency of some extreme weather events. Studies distinguishing climate change from other factors affecting crop yields have shown that in many regions at higher latitudes, the yields of some crops (corn, wheat, and sugar beet) have been positively affected in recent years, while in many lower latitude regions, the yields of some crops (corn and wheat) have been negatively affected by the observed climate changes.

It is predicted that there will be decreases in yield and product suitability under higher temperatures, especially in tropical and semi-tropical regions. Heat stress reduces fruit sets and accelerates the development of annual vegetables, causing yield losses, deterioration of product quality, and increased food loss and waste. Longer growing seasons allow for greater plantings and can contribute to greater annual yields. However, some fruits and vegetables need a chilling period to produce a viable crop, and warmer winters may pose a risk at this point [13].

For Türkiye, which is an agricultural paradise under current conditions, ecosystem-oriented production should be continued by increasing the awareness of all stakeholders by international conventions and agreements on adaptation and mitigation to climate change, keeping the agricultural sector strong as a result of constantly changing climate conditions and protecting it from the negative effects of climate change.

The negative effects of climate change on the agricultural sector are evaluated by both the Türkiye Agriculture and Forestry Ministry and research institutions; While determining the next short and medium-term agricultural policies for Türkiye, policies are developed by considering a 2-3°C temperature increase and the effects of this increase on the climate as an assumption scenario.

Both Turkey and Iraq have large amount of moderate saline water that can be used to irrigate salt-tolerant plants. In Turkey for example, the Menderes river downstream is affected by the salinity of adjacent sea, its water used to irrigate cotton in Soce city. In Iraq, Main Outfall Drain (MOD) collecting the agricultural drainage water of the large fields in Iraq, its water used to irrigate the palm orchards [14].

6. MITIGATION AND ADAPTATION IN THE AGRICULTURAL SECTOR

In the process of combating climate change, practices are handled under two main headings: mitigation and adaptation, and are considered as two inseparable parts for result-oriented studies against climate change. Mitigation, which means mitigating the negative consequences of climate change, is used in the same sense as reducing greenhouse gas emissions.

A range of integrated farming systems are proposed to evaluate the synergies between mitigation and adaptation and provide a low-carbon and climate-resilient path to sustainable food security and ecosystem health. Integration here refers to the use of practices that enhance the mitigation, resilience, and sustainability functions of an agricultural ecosystem. These systems follow holistic approach methods to obtain biophysical, socio-cultural, and economic benefits from land management systems. These integrated systems include nature-based solutions such as agro ecology, climate-friendly smart agriculture, ecosystem-based agriculture, and protective agriculture.

Addressing the effects of climate change by reducing greenhouse gas emissions is possible by protecting and improving the current conditions of forests, wetlands, marine, and coastal ecosystems, meadows, agricultural areas, and peatlands, each of which can capture and store carbon.

The main objectives of all these systems are increasing the soil organic amount, effective use of water, land use planning, and practices aimed at increasing biodiversity. Below are some of the common practices in Türkiye.
Rain Harvest: Rain harvesting is the whole of the methods developed to collect and use the water that flows to the surface through rainfall for irrigation. Rain harvesting; In addition to the aims of feeding groundwater, increasing agricultural production and productivity restricted due to lack of water, it provides ecological and recreational benefits with side applications such as improving the soil, increasing the ground cover and organic content in the soil, producing fish and suitable plants

in ponds, and creating habitats for water birds. Many small dams was constructed to harvest rainwater in the large valleys in western desert of Iraq like Horan valley [5].

Economical Water Use: Droughts that have occurred in recent years have caused crop losses in various parts of the country and increased the need for irrigation. Pressurized irrigation methods should be used to meet the increasing water needs with limited water resources.

Reduced Tillage: Tillage is considered the oldest soil management system. In today's world, agricultural techniques such as no-till farming or reduced tillage;
• Prevent erosion,
• To maintain moisture content in the soil,
• It is preferred for reasons such as increasing the organic matter content of the soil.
Studies conducted in recent years reveal that reduced tillage or no-tillage agricultural practices are among the effective measures to reduce the amount of CO_2 in the atmosphere.

Direct Sowing Method: The direct sowing method is a method that allows planting in one go without the need to cultivate the soil before planting, and planting is carried out with special drills on the stubble-covered area of the previous crop.
Benefits of direct sowing;
• Increasing water retention in the soil,
• Preventing erosion,
• Improving the structure of the soil and carbon sequestration,
• Reducing fuel consumption significantly.

Green Belt and Wind Curtain: Live plants are used in wind curtains to prevent soil loss through wind erosion. Wind curtains protect agricultural products, animals, wildlife, and people from the effects of wind. Trees, shrubs, or herbaceous plants can be used to make windbreaks. These plants are planted singly or in parallel rows, perpendicular to the prevailing wind direction. Some Researchers have recommend the possibility of planting a Green Belt around the MOD stream in Iraq, its length is 526 Km and the average Green Belt Width is about 9.4 Km. This Belt will be improving environmental conditions and reducing the dust storms harmful to plants and ecosystem [14]

Fertilization: The main thing in fertilization is to provide the missing nutrients in the soil in a way that will bring productivity and quality to the optimum point. Fertilizing in the appropriate amount, at the appropriate time, and in the appropriate manner contributes to the reduction of N_2O emissions by ensuring that plant nutrients reach the plants. Effective fertilization methods include using slow-emission fertilizers or nitrification inhibitors, applying nitrogen during the period when the loss will be minimal, and fertilizing in a way that the roots of the crops can reach better. Using animal fertilizer instead of chemical fertilizer, no-till cultivation method practices, and using plant residues to increase the amount of organic matter are important measures in terms of adaptation and reduction.

Combating Agricultural Drought: The "Agricultural Drought Combat Strategy Action Plan", which was created to minimize the effects of drought by taking the necessary measures in periods when drought is not experienced and by applying an effective combat program in crisis periods, is implemented by our Ministry. In combating drought, it is important to plan sustainable agricultural water use, increase public awareness, and include all stakeholders in the process. In this context; Phenological observation results of cereals, meteorological data, and occupancy rates in Türkiye's dams are monitored and evaluated as a whole throughout the country and the necessary measures are delivered to our farmers.

Land Consolidation: Combining small and shapeless agricultural lands into neat and optimal parcels provides significant benefits in agricultural production. Since small parcels will be brought together through consolidation, the distance between the operation center and the parcels decreases and accordingly, emission reduction and fuel savings are achieved in in-field transportation. In addition, as the number of parcels decreases, their shapes improve and their sizes increase, productivity increases and losses in agricultural inputs such as seeds, fertilizers, and pesticides decrease. Reducing these losses means reducing the emissions generated during the production of each agricultural input.

Organic Farming: The most important feature of organic agriculture is that it tends to reintroduce the nutrients and organic carbon necessary for the soil into the soil. Therefore, practices include direct recovery of animal manure to prevent erosion of fertile topsoil, effective composting techniques for crop residues, and mixing crop waste with green manure. Improving soil structure with these methods helps reduce greenhouse gas emissions. Within the framework of harmonization with the European Union, the "Organic Agriculture Law No. 5262" was enacted in 2004 [15]

Agricultural Insurance: Reducing the fragility of the sector by ensuring agricultural activities against natural disasters and ensuring that farmers stay in the sector by ensuring their income balance is one of the important measures in adaptation to climate change. In 2020; With district-based drought yield insurance, wheat, barley, rye, oats, triticale, chickpeas, red lentils, and green lentils grown in dry agricultural areas and the certified seeds of these products (other than full packages) will be protected against drought, frost, hot wind, heat wave, extreme weather conditions. Covering productivity decreases due to humidity and excessive precipitation risks by the Agricultural Insurance Pool is one of the important practices within the scope of adaptation to climate change.

Bioenergy Resources: Bioenergy produces electricity, provides direct heat, and is used as fuel in the transportation sector; It is a type of renewable energy produced from solid biomass, biogas, or liquid biofuels, and its source is forestry, agriculture, organic waste, and residues. Energy crops such as corn, sugar cane, or sugar beet, wood, wood residues, animal and agricultural wastes, urban solid wastes, and organic elements in other waste piles are called biomass. Biomass is used directly to produce electricity and heat or indirectly to produce fuels in liquid, solid, or gaseous form. Bioenergy obtained from agriculture and forestry activities is used to combat climate change and ensure energy supply security. Biomass, biogas, and biofuels can be stored.

Carbon Farming and Agroforestry: Agro-ecological farming, food forestry, cultivation without tillage, the use of vegetated crops and perennials, improving crop rotation cycles, and the use of permanent agricultural design techniques contribute significantly to increasing the amount of carbon stored by the soil and reducing climate change. Farmers can be given incentives to adopt farming techniques that increase carbon storage and reduce greenhouse gas emissions.

Changing Irrigation Methods and Network Structures: The decrease in water potential that may occur because of climate change and the increase in water demand due to population growth necessitate the effective use of water resources. The use of approximately 75% of usable water resources in the agricultural sector in Turkey, Iraq and neighboring countries requires primarily water savings, especially in agricultural irrigation applications. Recently, studies have been carried out to popularize drip irrigation systems in agriculture for the effective use of water resources [16]. Irrigation methods applied in Turkey are 67% surface irrigation and 33% pressure irrigation [17]. If sprinkler and drip irrigation methods are used instead of classical irrigation methods, the efficiency can increase from 60% to 80% and 90% respectively. This means a water saving of 20% to 30% [18].

New technique in drip irrigation named the sub-surface nanotechnology trickle irrigation will be used in Turkey and Iraq to minimize the evaporation losses according to increasing temperature due to climate change effects [19].

Irrigation systems in Turkey are generally designed as open systems. Accordingly, surface irrigation methods are used in most of the irrigation areas. This design style and irrigation methods used increase water losses, especially evaporation, and endanger the environmental sustainability of agricultural areas. Therefore, the dissemination of irrigation technologies that will increase the efficiency of water use is the most important requirement for Turkey. With the efficient use of water in agriculture, evaporation also decreases significantly. In addition, the effective use of water resources and the negative effects that climate change has created or may have in the agricultural sector can be reduced to a certain extent [20].

Use of marginal water resources in agricultural irrigation: In many countries around the world, wastewater is used for agricultural irrigation purposes, whether treated, untreated, partially treated or diluted. For example, more than 85% of treated wastewater in Israel, approximately 71% in Spain [21] and 65% in the State of California in the United States [22] are reused for agricultural irrigation purposes. On the other hand, due to the scarcity of available clean water resources and the high cost of collecting and purifying wastewater, in underdeveloped and developing countries, wastewater can be used for agricultural irrigation purposes without any purification or by diluting it with a clean water source such as rainwater. In the city of Diyarbakır in Turkey, the yield of cotton plants irrigated with domestic wastewater was found to be 45.9% higher than the yield of plants applied with commercial fertilizer and irrigated with fresh water [23]. For this reason, purified wastewater with high nutritional value should be used for products that are not directly used in human nutrition. Thus, less fertilizer and fresh water will be used for adaptation to climate change. Wastewater and greywater for Ramadi city in Iraq can be expands the irrigated area at Ramadi project by 26% of planted area [24].

Understanding The Relationship between Water Resources and Food Security: It is possible to summarize food safety with four basic factors. These are stated below;

- Food accessibility
- Food use
- Food sufficiency
- Stability in the food

Food security can be expressed as the ability of societies to produce enough food to feed themselves, the economic level to access the food produced, having a sustainable food system, healthy storage methods, the quality of the food accessed, its nutritional value and hygiene conditions [25]. Food accessibility, sufficiency, and stability are under threat due to the changes that may occur because of climate change, especially with the contribution of the increasing population because of the inability to meet irrigation needs due to increasing temperatures and decreasing rainfall. According to studies, there are serious temperature increases observed especially in the inner regions of Turkey until 2100. Accordingly, it is predicted that winter precipitation is observed more as rain instead of snow, the snow cover melts much faster and mixes with surface waters, and the intensity and frequency of precipitation throughout the year will change and shift [26]. The melting of snow masses, as precipitation falls mostly in the form of rain, has the potential to cause serious problems in domestic and irrigation water in regions that meet their urban and agricultural water needs from snowmelt at high altitudes throughout the year. This change in the hydrological cycle may cause serious changes in the quality and quantity of water resources and may affect many climate-dependent sectors, especially food production, where water is of vital importance.

In addition, effects such as the increase in summer temperatures, decrease in winter precipitation (especially in the western provinces), loss of surface water, increase in droughts, soil degradation,

coastal erosion, floods, and floods resulting from climate change in Turkey directly affect the existence of water resources [27].

7. CONCLUSION

Climate change is an anthropogenic event that occurs due to the increasing population and the increasing needs of the population. Most countries feel climate change with climate parameters deviating from normal. However, increasing consumption habits also increase the continuity of production and therefore the amount of emissions. Solutions to climate change should start with regulating individual consumption habits. However, increasing social communication with global economies and industrialization is gradually increasing consumption habits. Decreasing rainfall amounts and increasing temperatures are the most felt aspects of climate change. About 70% of water is used for agricultural irrigation both in the world and in Türkiye. In Iraq, this ratio increased to 80% or more. Therefore, saving water in agricultural irrigation is a solution that will relieve other sectors. The use of modern water-saving irrigation technologies in agricultural irrigation will allow saving between 30-60% of water. In addition, the use of marginal water resources for irrigation will ensure the preservation of clean water resources in quantity and quality. For this, decision-making mechanisms at the government level must make decisions in this direction and take encouraging approaches to farmers. Rainwater harvesting must be expanded and used locally in houses and government building. The fight against climate change should start individually and be taken seriously regionally and nationally. There are many agreements between countries to reduce emission sources, and in this context, each country must fulfill its responsibilities.

Water scarcity is accompanied by many environmental impacts such as the dust storms. The decrease in rainfall casing migration from villages which contribute to various social and economic problems.

REFERENCES

[1] Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., (2008). Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

[2] Al-Salihi, Zainab A., Ammar H. Kamel , Isam M. Abdulhameed, (2022). Effects of the Climate Change on the Tigris River Basin in Iraq, International Journal of Design & Nature and Ecodynamics 17(4), pp. 585-593. https://doi.org/10.18280/ijdne.170413.

[3] IPCC, (2023). Climate Change Widespread, Rapid, and Intensifying – IPCC https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/ (access date: 28.12.2023)

[4] Anonymous, (2021). Climate Change and Agriculture Assessment Report, Türkiye Ministry of Agriculture and Forestry General Directorate of Agricultural Reform. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.tarimorman.gov.tr/TRGM/Belgeler/IKLIM%20DEGISIKLIGI%20VE%20TARIM%20DEGERLENDIRME%20RAPORU.pdf (Access date: 02.01.2024)

[5] Abdulhameed, I.M., Alhadeethi, I, Kh., Ahmed A. Jabir, Fayyadh, A.S. Mohammed A.S., Kamel, A.H., Mutar, H.A., Abdul Ghani, E.T., Al-Esawi Jabbar Sh.E. Almafrichi K.Y., Ibrahem M.K., Ahmed, M.A., Hamad, R.M., Hamed, W.H., Khlil, W.H. and Naif R.I. (2022). Guideline of Iraqi Valleys Development (1- Wadi Horan). Upper Euphrates Basin Developing Cennter-University of Anbar-Iraq. Book 2022, 146p.

[6] EEA Report, (2019). Climate Change Adaptation in the Agriculture Sector in Europe. ISSN 1977-8449, https://www.eea.europa.eu/publications/cc-adaptation-agriculture (Access date: 29.12.2023)

[7] Anonymous, (2023). The Sustainable Development Goals in Türkiye / Climate Action. https://turkiye.un.org/en/sdgs/13 (access date: 25.12.2023)

[8] FAO, (2018). The Future of Food and Agriculture: Alternative Pathways to 2050. Food and Agriculture Organization of the United Nations, Rome, Italy, 228 pp.
[9] IPCC, (2007). Climate Change. Impacts, Adaptation and Vulnerability.
[10] UNICEF, 2023. Water Scarcity. https://www.unicef.org/wash/water-scarcity#:~:text=Four%20billion%20people%20%E2%80%94%20almost%20two,by%20as%20early%20as%202025. (Access date: 20.12.2023)
[11] DSI, (2020). State Hydraulic Works, Annual Report 2020, pp.33. Ankara
[12] Hekimoğlu, B., Altındeğer, M., (2008). Global Warming and Climate Change. Samsun Governorship Provincial Directorate of Agriculture. Farmer Training and Extension Branch Directorate. pp.67
[13] IPCC, (2019). Special Report: Special Report On Climate Change and Land. Food Security. pp. 439.
[14] Abdulhameed, I.M., Sonay S.OK. , Hala N. Malloki, Muhittin O. Akca , Bilge Omar, Gokhan Cayci, 2022, Bio-Saline Agriculture Modeling, Using Saline Water for Irrigation Purposes, International Journal of Design & Nature and Ecodynamics 17(6), pp. 951-956. https://doi.org/10.18280/ijdne.170617.
[15] UNDP, (2018). Seventh National Communication of Turkey, under the United Nations Framework Convention on Climate Change Republic of Turkey Ministry of Environment and Urbanization. pp. 81. chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://unfccc.int/sites/default/files/resource/496715_Turkey-NC7-1-7th%20National%20Communication%20of%20Turkey.pdf (access date: 20.12.2023)
[16] Çakmak, B., Gökalp, Z. (2011). Climate Change and Effective Water Use, Journal of Agricultural Sciences. 4 (1), pp.87-95, pp.93 *(in Turkish)*
[17] Senyigit, U. (2023). Agricultural Irrigation. *(Lecture notes, in Turkish)*. Antalya Provincial Directorate of Agriculture and Forestry. pp.16.
[18] Çakmak, B., Yıldırım, M., Aküzüm, T. (2008). Agricultural Irrigation Management in Turkey, Problems and Solutions. 2nd Water Policies Congress, pp.215-224. *(in Turkish)*
[19] Al-Issawi, H.H.E., Al-Abaied, A.A., Abdulhameed, I.M. (2021). Evaluation of mobile trickle irrigation and sub-surface nanotechnology trickle irrigation by irrigating bean (cv. Veto) 5ISCESD 2021 IOP Conf. Series: Earth and Environmental Science 779 (2021) 012016 IOP Publishing doi:10.1088/1755-1315/779/1/012016
[20] Korukcu, A., Yazgan, S., Büyükcangaz, H. (2007). Efficient Use of Water in Agriculture: an Overview of Turkey (in Turkish). I. Turkey climate change congress-TIKDEK 2007, pp. 11-13 ITU, Istanbul.
[21] Reznik, A., Feinerman, E., Finkelshtain, I., Fisher, F., Huber-Lee, A., Joyce, B., and Kan, I. (2017). Economic implications of agricultural reuse of treated wastewater in Israel: A state wide long-term perspective. Ecological Economics135, pp. 222–233. https://doi.org/10.1016/j.ecolecon.2017.01.013
[22] Kalavrouziotis, I.K., Arambatzis, C., Kalfountzos, D., Varnavas, S.P. (2011). Wastewater Reuse Planning in Agriculture: The Case of Aitoloakarnania, Western Greece". Water, 3(4), pp. 988-1004.
[23] Üzen, N., Çetin, Ö., Ünlü, M., (2016). Effects of Domestic Wastewater Treated by Anaerobic Stabilization on Soil Pollution, Plant Nutrition, and Cotton Crop Yield, Environmental Monitoring and Assessment, 188, pp.1-11.
[24] Abdulhameed I.M., S.O. Sulaiman, and Najm Ab.A. (2021). Reuse Wastewater By Using Water Evaluation And Planning (WEAP) (Ramadi City–Case Study), 5ISCESD 2021 IOP Conf. Series: Earth and Environmental Science 779, 012104 IOP Publishing, doi:10.1088/1755-1315/779/1/012104.
[25] FAO, (2008). The State of Food Insecurity in the World 2008, High food prices and food security – threats and opportunities. Italy

[26] Büken, M.E., & Güner, E.D. (2017). Modeling of Seasonal Climate Change Projections for Nevsehir Province. 2nd International Conference on Civil and Environmental Engineering (8-10 May 2017), Nevşehir.
[27] UNDP, (2012). Project Team, Ministry of Environment and Urbanization, General Directorate of Environmental Management, Climate Change Department, Policy and Strategy Development Branch.

LIMITATION AND POTENTIAL OF WHEAT GROWING FOR FOOD SECURITY

OGRANIČENJE I POTENCIJAL GAJENJA PŠENICE ZA OBEZBEDJENJE HRANE

Ariona Laze, associate professor [1]
Desimir Knežević, full professor[2]
Danica Mićanović, scientific advisor [3]
Tatjana Ivanović, docent[4]
Mirjana Menkovska, full professor [5]
Simin Hagh Nazari, assistant professor [6]
Mirela Matković Stojšin, associate research [7]
Veselinka Zečević, full professor [8]

Abstract: *Wheat is the staple plant species for production food and end food products for nutrition of majority world populations. The constraints of natural resources and an increase of human population, require increasing arable land for plant cultivation and improving crop yield for security of food. Existing limitations present a challenge to breeders to use classical and new biotechnological methods to create new varieties with higher yield, better quality and greater resistance to stress conditions. In addition, during cultivation, it is necessary to apply adequate crop nutrition and protection of crops from diseases and pests with mineral fertilizers in order to increase crop resistance and reduce the negative impact of stress factors, thus increasing yields*.

Key words: *wheat, breeding, biotechnology, environment, adaptation*

Apstrakt: *Pšenica je osnovna biljna vrsta za proizvodnju hrane i krajnjih prehrambenih proizvoda za ishranu većine svetske populacije. Ograničenja prirodnih resursa i povećanje ljudske populacije, zahtevaju povećanje*

[1] Department of Chemistry, Faculty of Biotechnology and Food, Agriculture University of Tirana, Koder – Kames, 1001, Tirana, Albania, e-mail: alaze@ubt.edu.al
[2] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kopaonička bb, 38219 Lešak, Kosovo and Metohia, Serbia, e-mail: deskoa@ptt.rs
[3] Serbian Chamber of Commerce and Industry, Resavska15, Belgrade, Serbia, e-mail: danica.micanovic@pks.rs
[4] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kopaonička bb, 38219 Lešak, Kosovo and Metohia, Serbia, e-mail: tatjana.ivanovic@pr.ac.rs
[5] University Ss.Ciril and Methodius in Skopje, Institute of Animal Science and Fishery, 1000 Skopje, N. Macedonia, e-mail: menkovska06@yahoo.com
[6] Department of Food Science and Technology, Faculty of Agriculture, University of Zanjan, Zanjan, Iran, P.O.Box 45195-313, Iran, e-mail: haghnazari.simin@znu.ac.ir
[7] Tamiš Research and Development Institute, Novoseljanski put 33, 26000, Pančevo, Serbia, e-mail: mirelam89@gmail.com
[8] Institute for Vegetable Crops, Smederevska Palanka33, 71 Karadordeva St., 11420 Smederevska Palanka, Serbia, e-mail: vzecevic@institut-palanka.rs

obradivog zemljišta za uzgoj biljaka i poboljšanje prinosa i kvaliteta za sigurnost hrane. Postojeća ograničenja predstavljaju izazov oplemenjivačima za korišćenje klasičnih i novih biotehnoloških metoda za stvaranje novih sorti sa većim prinosom, boljim kvalitetom i većom otpornosti na uslove stresa. Osim toga, u toku gajenja, neophodno je primeniti adekvatnu ishranu useva i zaštitu useva od bolesti i štetočina mineralnim djubrivima u cilju povećanja otpornosti useva i smanjenje negativnog uticaja faktora stresa, a na taj način i povećanje prinosa.

Ključne reči: *pšenica, oplemenjivanje, biotehnologija, životna sredina, adaptacija*

1. INTRODUCTION

Natural resources are exposed to the influence of dynamic phenomena on the earth, planet (lithosphere, hydrosphere, and atmosphere), the cosmos, as well as the influence of human activities. Some of the phenomena, the work of volcanoes, wind, earthquakes, hurricanes, glaciers, heat waves as well climate changes are natural sources of pollution as a result of fires, floods, erosion and degradation of soil and living communities (biocenosis) [1]. In addition, man, with his historical socioeconomic development, and especially today, has a significant impact on the impoverishment and degradation of the environment. Through this activities (industrialization, urbanization, militarization), man contributes to the increase in environmental pollution (air, water, soil), desertification, reduction of arable land and sources of drinking water, reduction of biodiversity [2]. Together, natural dynamic processes and occurrences and anthropogenic activities and changes disrupt the established balance in the biosphere, which hinders the production of the necessary amount of food, healthy food, water and air, as well as living space.

The food security was serious task for governments of all world state, scientist, farmers in the past when it took 102 years (1825-1927) to increase the population from one billion to two billion people. Food safety is especially important these days when the number of the world's population is increasing faster, which is confirmed by the fact that the increase in the number of inhabitants in the world from 7 to 8 billion was registered in a period of 12 years (2010-2022).

The increasing demand for food and energy presents serious growing global concern, in conditions when over a billion people are malnourished and when five million children under the age of five die of hunger every year [3, 4].

In today's conditions of reduction of usable land and water, the biggest challenge is how to provide these resources in a sustainable way, which is acceptable and useful for agriculture? Biotechnological methods of genome transformation and genetic engineering at the molecular level are used in plant breeding. An efficient methods is markers-assisted selection in creation of genotypes with the desired combination of genes [5, 6]. In growing plants, it is necessary to apply new technologies of nutrition, care and protection that are more effective in order to select plants more resilient to environmental stress factors which cause yield losses [7].

In agricultural production of edible cultivated plants, as well as wheat, characterized low yield until the mid-1960s, what is linked with developing new plant architecture in wheat breeding. Genotypes with a smaller height of stem were resistant to lodging and could be grown under conditions of intensive nutrition and the application of a larger amount of fertilizer. Also, the industrial production of agricultural machinery enabled the introduction of mechanization for more efficient application of fertilizers, pesticides, soil cultivation, as well as for mechanical sowing and harvesting of crops [8].

In permanent work plant breeders make arrangement of genes which contribute benefit for expression of better resistance to disease, drought tolerance, efficiency of nutrient absorption and increased yield and quality. The combination of favorable genes is the base for improving wheat

production in different environment as well as in the future in climate change growing conditions [9].

2. AGRICULTURAL RESOURCES

2.1. DEPLETION OF LAND AND WATER

Due to industrialization, urbanization, illegal land use, and over-exploitation of cultivated land [10–12], the cultivated land is gradually decreasing all over the world [13]. The industrialize in world countries influenced on intensive migration of rural population to industrial centers and the development of numerous urban places. In industrialize country, the agricultural land used more and more for construction of factory, roads, highways and residential building etc. The left farming land is fragmented and reduced agricultural area for profitable yield production. The labors in industrial sectors lived in the cities and far away from farms. Farmers leave their plots mostly employed in industrial sector led to a decrease in grain production, which led to higher demand and increased prices, as well as dependence on the import of wheat seeds from other countries.

Increased incomes, especially in recent years, have contributed to a change in consumer demand for food, which significantly influences farmers to focus on new production and grow new valuable crops to meet consumer needs [14, 15].

Based on the current way of land use, it is estimated that by 20230, about 3.7% of farmland in the world will disappear, and this will be especially pronounced in developing countries. Cultivated land decreases and food crises continue to spread in many region of the world and global food insecurity will increase, considering that in the recent 50 years global food demand increased twofold [16], and demand for cultivated land increased. Also, the increasing in the production of plant species for other purposes, such as for animal feed, biofuels and other industrial products [17], contributes to the reduction of the production of crops for human consumption, whose share is about 62% in the total plant production, as and reducing the amount of food for people.

For the successful production of vegetable crops, soil moisture is needed, which is provided by water deposits from the atmosphere and by irrigation from surface water. The amount and distribution of rainfall are not synchronized with the critical stages of development of plant species, which are important for achieving yields. This is the reason for using surface water for irrigation. Irrigation is conducted for approximately 24% of croplands and have share for 34% of agricultural production. Without irrigation the global production of cereals would be decreased up to 20%, which require more land for production the same amount of food [18]. Thus, 70% of fresh water in the world is used for irrigation. In areas with arid conditions, the lack of water for irrigation affects yield reduction, so in the dry conditions of China, an 8% reduction in wheat production was found. The lack of water significantly threatens the production of other essential crops that are irrigated (rice), which represent the basic food for a large population of the world's population [19, 20].

The water scarcity occurs as physical lack of water where natural water resources are over-exploited, and economic water scarcity where there is insufficient investment in and maintenance of water distribution systems and infrastructures [21]. Both types of water shortage are uncertain in climate change condition but they are influence to change and adapt agricultural land use for crop production. Except that water scarcity affects the migration of people from rural to urban places within country as well as migration to foreign country. People’s abandonment of property and land, which creates additional problems in providing food, housing, as well as inclusion in any type of business and work in other countries. Often at the home leave women and children and many of the

difficulties associated with water scarcity tend to disproportionately burden women [22]. It's evident that water scarcity links rural and urban ecologies of vulnerability.

3. ABIOTIC AND BIOTIC STRESSES

Wheat is produced globally than any other crop because wheat is source of proteins and other nutrients for more than 70% of world population. This is a reason that wheat is a plant species that is grown in areas of different geographical latitudes and at different altitudes, on soils of different types and fertility, and in conditions of different temperature variations as well as illumination (day length). In these areas, is grown wheat that are adapted to different growing conditions and are exposed to specific areal abiotic and biotic stress factors.

Wheat crops are exposed to numerous environmental stress conditions (abiotic and biotic). The extremely high temperatures cause loss of wheat yield and other plant species [23]. In recent three decade average temperature has increased in average about 0.7 °C and due to extreme temperature with lethal consequence for several thousand people and high damages of crops [24]. If this trend were to continue, by the end of the 21st century, there could be an increase in the average temperature on Earth in the range of 1.4 °C to 5.8 °C, and there would be a greater increase in the temperature of land and sea [25]. In agricultural production drought and water deficit affect yield loss in wheat, as well in other crops. The yield loss is the highest when drought stresses occur at the phase of heading, pollination [26, 27]. Drought is a quite often natural hazard in Serbia and dry years were particularly frequent in the last two decades of the 20th century and beginning of 21 century [28, 29]. Drought is caused by climate variability, which cannot prevent, but its negative effect can mitigate through determination and monitoring of various parameters as the amount of available water, crop condition, the degree of degradation of land, the requirements for introduction of irrigation. Also, water shortage with drought cause significant damages in numerous continents including Europe [30]. To increase yield in abiotic stress conditions such as drought and salinity, it is necessary select the best genotype grown in optimal condition and adjust scientific farming measures in cultivation under stress conditions [31].

The effect of global warming on wheat yields is of prime concern worldwide. The extreme heat waves have negative influence to yield in wheat, so that is an increase of 1 ℃ of seasonal temperatures determines a decrease in yield depressed 3 to 4%, [32] and similar effect is in soybean (3.1%) and maize (7.4%) [33].

The increase of atmospheric CO_2 has contrast effects on crops, so that may increase in plant photosynthesis and growth an in contrary may negatively affects the nutritional quality of crops as well as their health status (example: increase in barley yellow dwarf virus infections in wheat under elevated CO2 levels) [34-35]. However, Intensive agriculture, during long-term period, may reduce the carbon content in the soil, which level is possible reverse by dynamic process in in interaction of plant roots, rhizosphere and soil [36].

Water deficit is a limiting factor of plant growth and development in each phase flowering, pollination, and grain-filling, and in the end limiting factor for yield of crops worldwide [37]. In case of abundant rainfall may have a positive effect on the formation of yields and quality. However, abundant rainfall may have a negative effect on plants in different stages of development (pollination, flowering, harvest) due to higher relative humidity, which represents favorable conditions for the development and attack of pathogens, emergence diseases and damage due to reduced pollination, intensive respiration and reduced yields [38, 39].

The pests and diseases cause serious yield losses in average between 10-30% per year, depends of type of pests and diseases and plant crops and their interaction with environmental conditions. The yield losses related to each alone pest have share in average of 14–25% of the total global

agricultural production [40, 41]. Insect such, aphids, stem borers (*Sesamia inferens*), Hessian flies (*Mayetiola destructor*), wheat midges (*Sitodiplosis mosellana*), and cereal leaf beetle (*Oulema melanopus* L.), are the serious harmful insects on cereals, which not only cause direct damage but also transmit virus diseasess [42-46]. In study [47] was established that the bird cherry-oat aphid (*Rhopalosiphum padi*) causes more damage to wheat than the green bug aphid (*Schizaphis graminum*) during the seedling stage, but at the flowering stage greenbug aphid causes more damage than bird cherry-oat aphid. The protection from insect pests in wheat production is essential by application insecticides and can be profitable up to 10% of cereal crops. Considering the harmful impact of insecticides on human health and the environment, other pest control methods are being developed, such as biological control agents, cultural practices, and the use of resistant crop varieties [48].

The losses of yield due to pests was established every year in average 26% of soybeans, 28% of wheat, 31% of maize, 37% of rice, and 40% of potatoes [49] while in tomatoes, and sunflowers, was in the range of 15–30%. Also, yield losses caused in average by pathogens (16%), animal pests (18%), and weeds (34%) [50].

Crop diseases cause significant food and economic losses which vary depend of seasons and geographical location. The risk of spreading crop infection of 80 pathogens to higher latitudes in the future and harming crop production in the catches of climate change is predicted [51]. Diseases cause great damage in wheat production, and the reasons are in reduced genetic variability, i.e. increased uniformity, which resulted from the use in breeding of a small number of varieties with high trait value, as well as the development of new pathogen strains in changing climate conditions [52]. The diseases such as leaf and stripe rust, *Fusarium head blight*, *Septoria leaf blotch*, spot blotch, tan spot and powdery mildew cause the significant economic losses [53]. In a study of wheat production was estimated that one of next disease: leaf, stripe and stem rust, *Septoria tritici blotch* and *Fusarium head blight*, caused annual losses more than 62 million tons, what is high economic losses [54].

The system of growing plant species in monoculture created favorable conditions for the development and harmful effects of phytopathogens (fungi, bacteria, viruses, nematodes). The system of growing plant species in monoculture created favorable conditions for the development and harmful effects of phytopathogens (fungi, bacteria, viruses, nematodes) which could be prevented by applying the crop rotation system, as well as the combined sowing system, which would increase the barrier to the spread of diseases [55].

4. BREEDING AND LIMITATION

Genetic uniformity as well as reduced genetic diversity is a limiting factor for successful breeding and creation of varieties with greater adaptive capacity, as well as higher yield and better quality. On the contrary, the great genetic variability of the genotype has an important role in mitigating the impact of the limiting values of climatic factors and adaptations to climate change, which contributes to the provision of food and the quality of life of people.

The strategy of developing adaptations directed to create genotypes, which are resistant to climate changes, which achieve high yields in conditions of high humidity and extreme temperatures [56]. The creation of genotypes resistant to drought and heat makes it possible to maintain productivity and reduce the risk of climate change in agricultural production [57, 58].

Plant breeding solves problems in agriculture related to climate change. Varieties are created that are resistant to the effects of climate change, varieties that are more economical (less investment/higher yield), which affects the reduction of greenhouse gas emissions from agriculture. The genetic diversity of plants plays an important role in the maintenance of the species, which is

the source of genes for various mechanisms of adaptation to biotic and abiotic stress factors and new combinations of genes that increase the resistance of the genotype to changes in the ecosystem [59].

To create varieties resistant to climate change, the breeding is necessary conduct on the based on genetic variability. The sources of favorable genes for greater adaptability to climate change condition are in wild relatives, local populations, old varieties of mutant lines [60]. Wild germplasms, which contain resistance genes, were introduced in cultivated crops [61]. Effective genetic improvement of yield varieties in breeding can be achieved using genetic variability, modern biotechnological methods, molecular markers, gene transfer and manipulation [62, 9].

Molecular breeding, gene mapping, insertion and deletion of gene sequences in the genome of a plant species is the basis for creating genotypes resistant to abiotic and biotic stress factors [63, 64]. Genotypes created by breeding are characterized by a combination of genetic traits, which contribute to adaptation to climate changes (temperature, precipitation, wind) that vary in seasons and regions [23, 65], and affect yield and quality variation [66-69].

Genome sequencing is a significant advance in the identification of genes and determination of genetic control of traits that can be used in breeding and more efficient cultivar creation level. This method made it possible to study molecular markers such simple sequence repeats (SSRs) single nucleotide polymorphisms (SNP), and copy number variations (CNV) identification of genetic variations such as insertions and deletions (INSDEL) translocations and inversions at the whole-genome level [70].

Genome sequencing enables further study of gene functions and structures [71]. Comparative analysis of genomes contributes to the identification of changes that have been conserved during evolution roles [72]. The possibility of predicting gene function and gene manipulation, i.e. insertion or deletion of genes in the process of creating varieties is a contribution to increasing the yield and quality of the plant species and thereby increasing food production and quality of nutrition [73]. The identification of the function of genes that control key stages of development has a significant contribution in the creation of species tolerant to different biotic and abiotic conditions [74]. Molecular breeding, using molecular markers, contributes to progress in the selection of varieties with improved traits of interest using appropriate molecular markers [69].

5. CONCLUSION

Existing land and water resources are limited and decreasing due to degradation under the influence of natural disasters, intensive construction of urban and industrial and transport facilities on fertile land, as well as due to farmers' improper processing and use in agricultural production. This situation makes it difficult to produce wheat and other edible agricultural crops to ensure a sufficient amount of food. In addition, the limiting factors for wheat production are abiotic stress factors (all temperatures, low rainfall, soil salinity, UV radiation, elevated CO_2) and biotic stress factors, diseases and pests (insects, fungi, bacteria, viruses), which cause a decrease in yield every year on average of 10-30% and in many cases the damage can be up to 100%. Also, in the future, the main task must be combining integrated disease and pest management, increase adaptability to change (warmer) climates and abiotic stresses, and sparing use of water and other resources. To reduce yield losses of wheat and other crops, it is necessary to monitor changes over a longer period of time, and invest in innovative research, which would be economically justified.

It is difficult to find a solution that would be generally applicable, efficient and economically profitable due to the different bio-economic values of yield loss, which vary in seasons and regions. The need to produce more food is imposed by the continuous increase in the population on world, which is a challenge and a task for statesmen, scientists and producers to find solutions for more

efficient production and increase of wheat yields and to ensure sufficient food for the human population. Abiotic and biotic stress factors in some regions act long-term and in others short-term, which is necessary to know in order to develop a strategy for creating adaptive wheat genotypes to stress factors.

For successful cultivation in climatic change condition, is necessary in breeding program create genotypes with advanced yield, quality and resistance to biotic and abiotic stress factors. In climate change condition each genotypes change behavior and affecting ecosystem changes. For these reasons, is necessary collect and conduct characterization of germplasm for choice parents for crossing and creation cultivars resilient to climate change. The very important is develop proper integrated management, such as models to predict the risk infection index, mechanisms of seed manipulations, genetics and breeding for resistance, and biological control are also considered.

Molecular breeding, using molecular markers, contributes to progress in the selection of varieties with improved traits of interest using appropriate molecular markers. Genomics-assisted breeding is very efficient method in creation new varieties with improved yield and quality as well increased resistance to biotic stresses. Molecular breeding overcome insufficiency of traditional plant breeding on the base of pedigree related to narrow the genetic diversity through the selection of more related individuals. By using modern biotechnological methods breeders can create wheat varieties with improved adaptability, that are resistant to pests and can reduce the impact of pests on wheat yields. These technologies will become increasingly important for ensuring global food security.

5. ACKNOWLEDGMENT

This work was supported by the Project TR 31092, and program 451-03-68/22-14/200189 Ministry of Education and Science of the Republic of Serbia.

6. REFERENCES

[1] López, R. E., Thomas, V., Troncoso, P. (2015). Climate Change and Natural Disasters. Echon.Uchile.cl/Publicaciones., Santjago, pp.1-45.
[2] Satterthwaite, D., McGranahan, G., Tacoli, C. (2010): Urbanization and its implications for food and farming. Philosophical transactions of the royal society B: biological sciences, 365, 2809-2820.
[3] Razzaq, A., Kaur, P., Akhter, N., Wani, S.H. Saleem, F. (2021). Next-generation breeding strategies for climate-ready crops. Front. Plant Sci., 12:620420
[4] Schulman, A.H. (2012). Genomics Tools for Accelerating Plant Breeding. Maataloustieteen Päivät 2012, 10.-11.1. 2012 Viikki, Helsinki: esitelmät, posterit/Toim. Nina Schulman ja Heini Kauppinen.
[5] Chawla, H. S. (2000). Introduction to Plant Biotechnology. Science Publishers Inc. Enfield, NH, USA.
[6] Reed, B.M., Sarasan, V., Kane, M., Bunn, E., Pence, V.C. (2011). Biodiversity conservation and conservation biotechnology tools. In Vitro Cellular and Developmental Biology - Plant, 47, pp. 1–4.
[7] Khera, P., Pandey, M.K., Varshney, R.K., 2013. Pest and diseases: old and new threats – modern breeding tools to tailor new crop cultivars. Secheresse, 24, pp. 261–273.
[8] Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B.L., Lassaletta, L., de Vries, W., Vermeulen, S.J., Herrero, M., Carlson, K.M., et al. (2018). Options for keeping the food system within environmental limits. Nature, 562, pp. 519–525.

[9] Knežević, D. Laze, A., Paunović, A., Djurović, V., Đukić, N., Valjarević, D., Kondić, D., Mićanović, D., Živić, J., Zečević, V. (2020). Approaches in cereal breeding. Acta Agriculturae Serbica, 25 (50) pp. 179-186.
[10] Abass, K., Adanu, S.K., Agyemang, S. (2018). Peri-urbanization and loss of arable land in Kumasi Metropolis in three decades: Evidence from remote sensing image analysis. Land Use Policy, 72, pp. 470–479.
[11] Gorgan, M., Hartvigsen, M. (2022). Development of agricultural land markets in countries in Eastern Europe and Central Asia. Land Use Policy, 120, pp.106257
[12] Berihun, M.L., Tsunekawa, A., Haregeweyn, N., Meshesha, D.T., Adgo, E., Tsubo, M., Masunaga, T., Fenta, A.A., Sultan, D., Yibeltal, M. (2019). Exploring land use/land cover changes, drivers and their implications in contrasting agro-ecological environments of Ethiopia. Land Use Policy, 87, pp. 104052
[13] Pribadi, D.O., Pauleit, S. (2015). The dynamics of peri-urban agriculture during rapid urbanization of Jabodetabek Metropolitan Area. Land Use Policy, 48, pp. 13–24
[14] Tscharntke, T., Clough, Y., Wanger, T.C., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J., Whitbread, A. (2012). Global food security, biodiversity conservation and the future of agricultural intensification. Biological Conservation 151(1),pp. 53–59.
[15] Bu, T., Tang, D., Liu, Y., Chen, D. (2021). Trends in dietary patterns and diet-related behaviors in China. Am. J. Health Behav., 45, pp. 371–383.
[16] Bodirsky, B.L., Rolinski, S., Biewald, A., Weindl, I., Popp, A., Lotze-Campen, H. (2015). Global food demand scenarios for the 21st century. PLoS ONE, 10, e0139201
[17] Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, M.D., O'Connell, C., Ray, D.K., West, P.C., Balzer, C., Bennett, E.M., Carpenter, S.R., Hill, J., Monfreda, C., Polasky, S., Rockström, J., n Sheehan, J., Siebert, S., Tilman, D., Zaks, D.P.M. (2011). Solutions for a cultivated planet. Nature, 478, pp. 337–342.
[18] Siebert, S. & Döll, P. (2010). Quantifying blue and green virtual water contents in global crop production as well as potential production losses without irrigation. J. Hydrol. 384, pp. 198–217.
[19] Wheeler, T., Von Braun, J. (2013). Climate change impacts on global food security. Science, 341, pp. 508-513.
[20] Brown, L.R., 2009. Could food shortages bring down civilization? Scientific American 300, pp. 50–57.
[21] IPCC. (2021). Sixth Assessment Report: Regional Fact Sheet – Africa 17
[22] Lama, P., Hamza, M., Wester, M. (2021). Gendered dimensions of migration in relation to climate change, Climate and Development, 13 (4), pp. 326-336.
[23] Djukić,, N., Knežević, D., Pantelić, D., Živančev, D., Torbica, A., Marković, S. (2019). Expression of protein synthesis elongation factors in winter wheat and oat in response to heat stress. Journal of Plant Physiology, 240, 2019, 153015.
[24] Fischer, G., Tubiello, F.N., van Velthuizen, H., Wiberg, D. (2007). Climate change impacts on irrigation water requirements: effects of mitigation, 1990–2080. Technological Forecasting and Social Change. 74, pp. 1083–1107.
[25] Tester, M., Langridge, P. (2010). Breeding technologies to increase crop production in a changing world. Science 327, pp. 818–822.
[26] Memon, S., Shar, P.A., Memon, S., Memon, S., Shar, A.,H., Shar, A.G. (2014). Water Stress tolerance in relation to yield and its contributing traits in wheat (*Triticum aestivum* L.). International Journal of Inovative Science, Enginering & Technology, 1(10), pp. 681-703
[27] Tiwari, R., Sheoran, S., Rane, J. (2015). Wheat improvement for drought and heat tolerance. In: Shukla, R.S., Mishra, P.C., Chatrath, R., Gupta, R.K., Tomar, S.S., Sharma, I. (Eds.), Recent Trends on Production Strategies of Wheat in India. Directorate of Wheat Research, Karnal, Haryana, India, pp. 39–58.

[28] Dodig, D., Zoric, M., Knezevic, D., King, S.R., Surlan-Momirovic, G. (2008). Genotype x environment interaction for wheat yield in different drought stress conditions and agronomic traits suitable for selection. Australian Journal of Agricultural Research, 59, pp. 536-545.
[29] Gocić, M., Trajković, S. (2013). Analysis of precipitation and droguht data in Serbia over the period 1980- 2010. Journal of Hydrology 494, pp. 32-42.
[30] Jovanović, M., Pavić, D., Mesaroš, M., Stankov, U., Pantelić, M., Armenski, T., Dolinaj, D., Popov, S., Ćosić, Đ., Popović, Lj., Frank, A., Crnojević, V. (2013). Water shortage and drought monitoring in Bačka region (Vojvodina, North Serbia) – setting-up measurement stations network. Geographica Pannonica • Volume 17(4), pp. 114-124.
[31] Matković Stojšin, M., Petrović, S., Banjac, B., Zečević, V., Roljević Nikolić, S., Majstorović, H., Đordević, R., Knežević, D. (2022). Assessment of Genotype Stress Tolerance as an Effective Way to Sustain Wheat Production under Salinity Stress Conditions. Sustainability 2022, 14, 6973.
[32] Ottman, M., Kimball, B.A., White, J., Wall, G.W. (2012). Wheat growth response to increased temperature from varied planting dates and supplemental infrared heating. Agron. J., 104 (1), pp. 7-16.
[33] Zhao, C., Liu, B., Piao, S., Wang, X., Lobell, D.B., Huang, Y., Huang, M., Yao, Y., Bassu, S., Ciais, P., et al. (2017). Temperature increase reduces global yields of major crops in four independent estimates. Proc. Natl. Acad. Sci. USA, 114, 9326–9331.
[34] Irigoyen, J.J., Goicoechea, N., Antolín, M.C., Pascual, I., Sánchez-Díaz, M., Aguirreolea, J., Morales, F. (2014). Growth, photosynthetic acclimation and yield quality in legumes under climate change simulations: An updated survey. Plant Sci., 226,pp. 22–29.
[35] Trębicki, P., Nancarrow, N., Cole, E., Bosque-Pérez, N.A., Constable, F.E., Freeman, A.J., Rodoni, B., Yen, A.L., Luck, J.E., Fitzgerald, G.J. (2015). Virus disease in wheat predicted to increase with a changing climate. Glob. Change Biol., 21, pp. 3511–3519
[36] Cusack, D.F., Chadwick, O.A., Ladefoged, T., and Vitousek, P.M. (2013). Long-Term Effectsof Agriculture on Soil Carbon Pools and Carbon Chemistry Along a Hawaiian Environmental Gradient.Biogeochemistry, 112(1-3), pp. 229-243.
[37] Rivero, R.M., Kojima, M., Gepstein, A., Sakakibara, H., Mittler, R., Gepstein, S., Blumwald, E. (2007). Delayed leaf senescence induces extreme drought tolerance in a flowering plant. Proc. Natl. Acad. Sci. USA 104, 19631–19636.
[38] Rosenzweig, C., Iglesias, A., Yang, X., Epstein, P.R., Chivian, E. (2001).Climate change and extreme weather events; implications for food production, plant diseases, and pests. Glob. Change Hum. Health, 2, 90–104
[39] Torbica, A., Živančev, D., Mastilović, J., Knežević, D., Bodroža-Solarov, M. (2011). Impact of changes in climate conditions on the technological quality of wheat. Proceedings of 46th & 6th International Symposium on Agriculture, February 14-18, 2011, Opatija, Croatia pp. 617-621
[40] DeVilliers, S.M., Hoisington, D.A., 2011. The trends and future of biotechnology crops for insect pest control. African Journal of Biotechnology 10, pp. 4677–4681.
[41] Farook, U. B., Khan, Z. H., Ahad, I., Maqbool, S., Yaqoob, M., Rafieq, I., ... & Sultan, N. (2019). A review on insect pest complex of wheat (*Triticum aestivum* L.). J Entomol Zool Stud, 7(1), pp. 1292-1298.
[42] Ullah, F., Gul, H., Said, F., Ali, A., Tariq, K., Zaman, M., & Song, D. (2020). 4. Population dynamics of wheat aphids Rhopalosiphum padi (Linnaeus) and Sitobion avenae (Fabricius) at District Mardan, Khyber Pakhtunkhwa Pakistan. Pure and Applied Biology (PAB), 9(1), pp. 27-35.
[43] Beant, S. (2012). Incidence of the pink noctuid stem borer, Sesamia inferens (Walker), on wheat under two tillage conditions and three sowing dates in north-western plains of India. Journal of Entomology, 9(6), pp. 368-374.

[44] Tooker, J. F., & De Moraes, C. M. (2011). Feeding by Hessian fly (Mayetiola destructor [Say]) larvae on wheat increases levels of fatty acids and indole-3-acetic acid but not hormones involved in plant-defense signaling. Journal of Plant Growth Regulation, 30, pp.158-165.
[45] Olfert, O., Elliott, R. H., & Hartley, S. (2009). Non-native insects in agriculture: strategies to manage the economic and environmental impact of wheat midge, Sitodiplosis mosellana, in Saskatchewan. Ecological Impacts of NonNative Invertebrates and Fungi on Terrestrial Ecosystems, pp. 127-133
[46] Császár, O., Tóth, F., & Lajos, K. (2021). Estimation of the expected maximal defoliation and yield loss caused by cereal leaf beetle (Oulema melanopus L.) larvae in winter wheat (Triticum aestivum L.). Crop Protection, 145, 105644
[47] Wang, K., Zhang, M., Huang, Y., Yang, Z., Su, S., & Chen, M. (2018). Characterisation of imidacloprid resistance in the bird cherry-oat aphid, Rhopalosiphum padi, a serious pest on wheat crops. Pest management science, 74(6), pp. 1457-1465
[48] Xie, H., Shi, J., Shi, F., Xu, H., He, K., & Wang, Z. (2020). Aphid fecundity and defenses in wheat exposed to a combination of heat and drought stress. Journal of Experimental Botany, 71(9), pp. 2713-2722.
[49] Oerke, E.C. (2006). Crop losses to pests. Journal of Agricultural Science 144, pp. 31–43
[50] Dhaliwal, G.S., Jindal, V., Dhawan, A.K. (2010). Insect pest problems and crop losses: changing trends. Indian Journal of Ecology 37 (1), pp.1–7
[51] Chaloner, T. M., Gurr, S. J., Bebber, D. P. (2021). Plant pathogen infection risk tracks global crop yields under climate change. *Nat. Climate Change* 11 (8), pp. 710–715.
[52] Figueroa M., Hammond-Kosack K. E., Solomon P. S. (2018). A review of wheat diseases - a field perspective. Mol. Plant Pathol. 19 (6), pp. 1523–1536.
[53] Savary S., Willocquet L., Pethybridge S. J., Esker P., Mc Roberts N., Nelson A. (2019). The global burden of pathogens and pests on major food crops. Nat. Ecol. Evol. 3, pp. 430–439
[54] Chai, Y., Senay, S., Horvath, D., Pardey, P. (2022). Multi-peril pathogen risks to global wheat production:A probabilistic loss and investment assessment. Front. Plant. Sci., 33 doi.org/10.3389/fpls.2022.1034600
[55] Jevtić, R., Župunski, V., Grčak, M., Živančev, D., Knežević, D. (2023): Cereal–Pea Intercropping Reveals Variability in the Relationships among Yield, Quality Parameters, and Obligate Pathogens Infection in Wheat, Rye, Oat, and Triticale, in a Temperate Environment. Plants 2023, 12, 2067. https://doi.org/10.3390/ plants12112067
[56] Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., Sen, P.T., Sessa, R., Shula, R., Tibu, A., Torquebiau, E.F. (2014). Climate-smart agriculture for food security. Nature Climate Change, 4(12), pp. 1068–1072
[57] Matković Stojšin, M., Zečević, V., Urošević, D., Božović, D., Bačić, J., Bratković, K., Knežević, D. (2023). Stress resistance indicators as the tool for selecting drought tolerant wheat genotypes. Book of proceedings of the XIV International Scientific Agriculture Symposium "Agrosym 2023", Jahorina, October 05-08, 2023, pp. 318-323.
[58] Zečević, V., Stojšin, V., Knežević, D., Matković Stojšin, M., Savić, S., Urošević, D., Mićanović, D. (2023). Response of different wheat genotypes to drought in semi-arid climate conditions. Book of proceedings of the XIV International Scientific Agriculture Symposium "Agrosym 2023", Jahorina, October 05-08, 2023, pp. 359-364.
[59] Bernhard, G.H., Neale, R.E., Barnes, P.W., Neale, P.J., Zepp, R.G., Wilson, S. R., Andrady, A.L., Bais, A.F., McKenzie, R.L., Aucamp, P.J., Young, P.J., Liley, J.B., Lucas, R.M., Yazar, S., Rhodes, L.E., Byrne, S.N., Hollestein, L.M., Olsen, C.M., Young, A.R., Robson, T.M., Bornman, J.F., Jansen, M.A.K., Robinson, S.A., Ballaré, C.L., Williamson, C.E., Rose, K.C., Banaszak, A.T., Häder, D.-P., Hylander, S., Wängberg, S.-Å., Austin, A.T., Hou, W.-C., Paul, N.D., Madronich, S.,

Sulzberger, B., Solomon, K.R., Li, H., Schikowski, T., Longstreth, J., Pandey, K.K., Heikkilä, A.M. Whit, C. C. (2020). Environmental effects of stratospheric ozone depletion, UV radiation and interactions with climate change. Photochem. Photobiol. Sci., 19, pp. 542-584.

[60] Knežević, D., Zečević, V., Mićanović, D., Roljević Nikolić, S., Branković, G., Paunović, A., Brzaković, T., Matković Stojšin, M., Radosavac, A. (2021): Plant breeding and adaptation to climate change. National scientific-profesional meeting with international participation "Biotehnology and modern approach in cultivation and breeding of plant" December, 15, 2021. year, Smederevska Palanka Serbia, Proceeding, pp..17-29

[61] Khush, G.S. (2001). Green revolution: the way forward. Nature Reviews Genetics 2, pp. 815–822.

[62] Tilman, D., Clark, M. (2014). Global diets link environmental sustainability and human health. Nature, 515, pp. 518-522.

[63] Grassini, P., Eskridge, K.M., Cassman, K.G. (2013). Distinguishing between yield advances and yield plateaus in historical crop production trends. Nat Commun, 4, 2918.

[64] Ray, D.K., Mueller, N.D., West, P.C., Foley, J.A. (2013). Yield trends are insufficient to double global crop production by 2050. PloS one 8: e66428

[65] Matkovic Stojsin, M., Petrovic, S.,, Sucur Elez, J., Malencic, Dj., Zecevic, V., Banjac, B., Knezevic, D. (2022). Effect of Salinity Stress on Antioxidant Activity and Grain Yield of Different Wheat Genotypes. Turkish J. Field Crops, 27(1), pp. 33-40.

[66] Knezevic, D., Djukic, N., Paunovic, A., Madic, M. (2008). Variability of harvest index and yield components in wheat (*Triticum aestivum* L.). Cereal Res. Commun., 36, pp.1151-1154.

[67] Đukić, N., Knežević, D., Zečević, V. (2008). Genetic determination of technological quality in *Triicum durum*. Periodicum Biologorum, 110(3). Pp.285-289.

[68] Zečević, V., Bošković, J., Knežević, D., Mićanović, D., Milenković, S. (2013). Influence of cultivar and growing season on quality properties of winter wheat (*Triticum aestivum* L.). African Journal of Agricultural Research, 8(21), pp. 2545-2550

[69] Menkovska, M., Levkov, V., Damjanovski, D., Gjorgovska, N., Knežević, D., Nikolova, N., Andreevska, D. (2017). Content of TDF, SDF and IDF in Cereals Grown by Organic and Conventional Farming – a Short Report. Polish Journal Food Nutritional Science, 67(3), pp.241–244.

[70] Gupta, P.K., Varshney, R.K. (2013). Cereal Genomics II. Springer

[71] Mochida, K., Shinozaki, K. (2013). Unlocking Triticeae genomics to sustainably feed the future. Plant & Cell Physiology 54 (12), 1931–1950.

[72] Friedman, R.C., Burge, C.B. (2014). MicroRNA target finding by comparative genomics. Methods in Molecular Biology (Clifton, NJ) 1097, pp. 457–476.

[73] Khush, G.S. (2005). What it will take to feed 5.0 billion rice consumers in 2030. Plant Molecular Biology 59 (1), pp. 1–6.

[74] Kim, D.W., Agrawal, G.K., Rakwal, R., Ahmed, S., Rohila, J.S. (2014). Genomic methods for improving abiotic stress tolerance in crops. In: Plant Biotechnology. Springer, pp. 35–42.

MANAGEMENT OF USING SALINE WATER IN IRRIGATION

UPRAVLJANJE KORIŠĆENJEM SLANE VODE U NAVODNJAVANJU

Isam M. Abdulhameed,[1]
Neşe Yaman,[2]

Abstract: *In the last five decades, water resources have been decreasing in quantity and very defective in quality. The drainage water and poor-quality ground water are available in considerable quantities, so saline water has been widely used for irrigation purposes in many countries around the world.*
This paper aims to study the effect of rainfall and leaching requirements on crop yield. The computer program has been constructed to estimate the relative yield of four strategic crops, wheat, barley, maize, and cotton. Saline water from two wells has been used, its salinity was 5.43 ds/m and 8.39 ds/m.
A combination of three leaching requirements and four effective rainfall ratios has been recommended, and an important relation has been proposed and discussed, a leaner relation between effective rainfall and crop yield, and a non-leaner relation between leaching requirement and the yield for all crops.

Key words: *leaching requirements, effective rainfall, saline irrigation water*

Apstrakt: *U poslednjih pet decenija, vodni resursi su u kvantitetu i veoma lošem kvalitetu. Drenažne i podzemne vode lošeg kvaliteta dostupne su u znatnim količinama, tako da se slana voda naširoko koristi za navodnjavanje u mnogim zemljama širom sveta.*
Ovaj rad ima za cilj proučavanje uticaja padavina i potreba za ispiranjem na prinos useva. Kompjuterski program je konstruisan da proceni relativni prinos četiri strateška useva, pšenice, ječma, kukuruza i pamuka. Korišćena je slana voda iz dva bunara, njen salinitet je bio 5,43 ds/m i 8,39 ds/m.
Preporučena je kombinacija tri zahteva za ispiranje i četiri efektivna odnosa padavina, a predložena je i diskutovana važna relacija, slabiji odnos između efektivne količine padavina i prinosa useva, i odnos između potrebe za ispiranjem i prinosa za sve useve

Ključne reči: *zahtevi za ispiranjem, efektivne padavine, slana voda za navodnjavanje*

[1] Upper Euphrates Basin Developing Centre, University of Anbar, Iraq,
e-mail: isambayati@uoanbar.edu.iq
[2] Dicle University, Faculty of Agriculture, Dept. of Farm Structures and Irrigation, Diyarbakır, Türkiye, e-mail: nuzen@dicle.edu.tr

THE RIGHT TO FOOD AS AN INTANGIBLE RIGHT ESTABLISHED IN THE UNITED NATIONS INTERNATIONAL HUMAN RIGHTS – LACKING CLARITY

PRAVO NA HRANU KAO NEMATERIJALNO PRAVO UTVRĐENO U MEĐUNARODNIM LJUDSKIM PRAVIMA UJEDINJENIH NACIJA – BEZ JASNOSTI

Darinka Tomić, PhD[1]

Abstract: *The United Nations established the right to food as a human right, though only as a part of the broader right to an adequate standard of living. The later International Covenant introduced the right to adequate food and the right to be free from hunger. Other terms like food sovereignty, security and safety have also been introduced in various international human rights documents, adding diffusion rather than clarity to the meaning of the right to food. This researcher argues that lack of clarity in the definition of the right to food causes disbalance with other rights, especially in international trade, where the development of new technologies in food production has become increasingly commercialized.*

Key words: *Right to food, Universal Declaration of Human Rights (UDHR), International Covenant on Social Economic and Cultural Rights (ICESCR), International human rights, Food and Agriculture Organization (FAO)*

Apstrakt: *Ujedinjene nacije su uspostavile pravo na hranu kao ljudsko pravo, ali samo kao deo šireg prava na adekvatan životni standard. Kasniji Međunarodni pakt uveo je pravo na adekvatnu hranu i pravo na slobodu od gladi. Drugi termini kao što su suverenitet hrane, sigurnost i bezbednost takođe su uvedeni u različite međunarodne dokumente o ljudskim pravima, dodajući difuziju, a ne jasnoću značenju prava na hranu. Ovaj istraživač tvrdi da nedostatak jasnoće u definiciji prava na hranu izaziva disbalans sa drugim pravima, posebno u međunarodnoj trgovini, gde se razvoj novih tehnologija u proizvodnji hrane sve više komercijalizuje.*

Ključne reči: *Pravo na hranu, Univerzalna deklaracija o ljudskim pravima (UDHR), Međunarodni pakt o socijalnim ekonomskim i kulturnim pravima (ICESCR), Međunarodna organizacija za ljudska prava, hranu i poljoprivredu (FAO)*

1. INTRODUCTION

Food is a tangible good that was traded long before national boundaries were established and tariffs in trade were introduced. In this case, food does not require a definition. However, the "right to food" is a distinctive new concept introduced in the post-WWII international human rights law arena. This development created a distinction between food and the right to food: food (a tangible good) represents a commodity in various trade agreements, while the right to food, being introduced as a human right, is an intangible entity that cannot be traded. Therefore, the right to food requires definition.

[1] Professor at Seneca Polytechnic, School of Legal, Public and Office Administration, Toronto, Canada, e-mail: dtomic@uwo.ca

It is common knowledge that an unambiguous definition is a precursor for recognizing, respecting, and protecting any right at law. Helen Xanthaki said:

> First, without clarity, precision and consistency the law lacks predictability. Second, democratic governments seeking to induce transformation require that the law is understood and followed by common people. Third, democracy requires clarity and precision: the rule of law requires that officers of the law understand and apply the law. Fourth, there are high costs to inaccessible law related to enforcement, application and interpretation of texts whose meaning is under doubt [1].

In scholarly literature, authors [2], [3] agree that the right to food (like other rights, for example, the right to intellectual property (IP)) received its first normative recognition in the 1948 *Universal Declaration of Human Rights* (UDHR) [4].
Scholars also agree that the position of the right to food was further enhanced in the 1966 *International Covenant on Economic Social and Cultural Rights* (ICESCR) [5][1] and in UN documents succeeding the ICESCR [6],[7].

However, these developments brought little clarity to the meaning of the right to food. The right to food was not articulated explicitly in a separate provision in the UDHR, and the meaning of the right to food became more diffuse when the ICESCR was drafted [8] – the trend that continued in subsequent UN documents.

This research established the hypothesis that the right to food lacks clarity in international human rights instruments. Applying a doctrinal approach, it begins by identifying whether the right to food existed in any significant source documents that may have influenced the creation of the UDHR. Then, it traces the drafting history of the right to food from the first draft created by Canadian law professor John P. Humphrey [9][2] to the final adopted version of the UDHR. It describes the right to food in post-UDHR documents: in the ICESCR, the UN General Comment 12 [10] reports of the Special Rapporteur on the Right to Food [11], the UN General Assembly *Resolution* 2009 on the right to food [12], and the UN Human Rights Council Resolution 2015 on the right to food [13]. By applying a doctrinal approach throughout, this research also explores the right to food as it has been further developed by the UN special agencies, the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). In proving the validity of the established hypothesis that there is no clarity in the meaning of the right to food in international human rights law, this research concludes that the emergence of expressions associated with the right food, such as food sovereignty, security, and food safety coined by various non-governmental agencies, only contributed to further diffusion of the right to food.

2. THE DEFINITION OF THE RIGHT TO FOOD PRIOR TO ITS ADOPTION IN THE UNIVERSAL DECLARATION OF HUMAN RIGHTS

The UDHR was adopted less than two years after the UN Commission on Human Rights first met on 27 January 1947, with "a clear mandate to draft the International Bill of Rights" [9, p. 17]. Canadian law professor John P. Humphrey crafted the first complete draft of the *Declaration* [14]. The Humphrey's and all subsequent drafts were put forward for discussion, with the opportunity given to all UN member states and experts to suggest changes and propose new provisions. This latter was a novel practice by the UN. Not only did official government representatives of UN member states have their say in drafting the Declaration, but the invited experts from all parts of the

[2] The ICESCR was created by the Office of the High Commissioner for Human Rights (OHCHR), with the Human Rights Council - responsible for implementing the Covenant. It has more binding power than the UDHR.
[3] Coming from the creator of the UDHR's first draft, this is probably the most authentic source depicting the circumstances surrounding the development of the UDHR.

globe also contributed their views. Elected as representatives of their own governments, the 'nuclear' Commission on Human Rights "had recommended that the members of the definitive commission should also be individuals elected to act in their personal capacity" [9, p. 17]. The experts certainly contributed to shaping the Declaration's specific provisions.[4]

Humphrey's first draft was edited by French law professor René Cassin [15], the UN representative for France. René Cassin[5] either copied or rewrote the articles from Humphrey's "draft outline" document. Cassin removed several provisions from Humphrey's draft, including Article 42 on the right to food. Article 42 said: "Everyone has the right to good food and housing and to live in surroundings that are pleasant and healthy" [16, art. 42]. Cassin replaced the right to food reference with several provisions indicating a right to "a decent standard of living" [17, art. 37], or a right to "betterment of housing conditions and nutrition" [17, art. 39].

Cassin's draft was put up for discussion, line by line, with the opportunity given to all UN member states and all invited consultants, non-governmental organizations, and individual citizens to suggest changes and new provisions [18].[6] Several hundred meetings at various levels ensued before the final version of the Declaration was presented at the Third Session of the UN General Assembly in Paris. Johannes Morsink, in his book, said, "The seventh drafting stage was the debate in the Plenary Session of the Third General Assembly, which led to the adoption of the Declaration that same day, on December 10, 1948. This was the fourth time the rest of the UN membership could amend what the eighteen-member Commission had done. Both the General Assembly and the Third Committee met in Paris that year" [18, p. 11]. The UDHR was adopted on 10 December 1948. Two years later, recognizing the historical significance of that event, the UN General Assembly declared the 10th of December to be International Human Rights Day.[7]

In 1946, before the Human Rights Commission began crafting the UDHR, many documents were made available to the Commission and used as preliminary source instruments. Three of those source documents are particularly interesting when researching the origin of the right to food. First, a document was created for the UN's inaugural San Francisco Conference in 1945, the *Draft Declaration of the International Rights and Duties of Man and Accompanying Report*, prepared by the Inter-American Council of Jurists of the Organization of American States and submitted by the delegation from Chile [19]. This document does not refer to the right to food but does refer to the right to an "adequate standard of living," much like Cassin's later reference to "a decent standard of living" [17, art. 37].

The second source document is the Cuban original *Draft Declaration on Human Rights* [20]. The Cuban Delegation put forward a draft "Declaration of Human Rights," which was prepared as a proposal for the agenda of the UN General Assembly session. As this proposal was rejected at the

[4] Canadian John P. Humphrey, McGill Law professor, wrote about his time in the UN. His book is a personal view of his 20 years in the UN Human Rights Division, including his experience in creating the first draft and his views on the emergence of the UDHR. Although he purposely omitted references, the initial chapters of Humphrey's book are valuable testimony to the process and the people who contributed to the shaping of the UDHR as we know it.

[5] René Cassin received a Nobel Peace Prize in 1968 for his contribution to developing human rights and building peace through international human rights law. Cassin unjustly never acknowledged the role John P. Humphrey played in creating the UDHR. This naming of Cassin – for the editing of Humphrey's draft – was the last time individual names were associated with the drafts of the Declaration.

[6] Johannes Morsink said: "The opinions of groups that did not have consultative status were forwarded to the Commission by the Secretariat in forms of précis ... All indications are that most of this more or less informal, non-governmental input was appreciated and often used" [18, p. 9] (reference omitted).

[7] At the 5th session of the UN General Assembly, during its 317th plenary meeting, held on 4 December 1950, the Resolution adopted on reports of the Third Committee declared the 10th of December the Human Rights Day, GA Res 423(V) (1950).

Assembly level, the Cuban Delegation submitted the Draft to the Economic and Social Council for use as a "working document." This document referred to "the right to adequate food" [20, art. 11]. The third source document submitted by the UN delegation from Panama was the American Law Institute's "Statement of Essential Human Rights" [21]. This document also referred to "the right to adequate food and housing" [21, art. 14]. Although Humphrey knew about all three source documents, he wrote that he drew inspiration for his first draft of the UDHR from the document submitted by the delegation from Panama [9, pp. 31-32][8] and thus included reference to "the right to good food and housing" [16, art. 42].

3. THE FIRST UN HUMAN RIGHTS COMMISSION DRAFT: ARTICLE 42

An explicit right to food provision was short-lived. As mentioned above, Humphrey introduced it as Article 42 in his first draft of the UDHR, where it read as follows: "Everyone has **the right to good food** and housing and to live in surroundings that are pleasant and healthy" [16, art. 42]. Humphrey's Article 42 text was not completely original. As Johannes Morsink wrote, "Regarding the right to food and housing Humphrey had before him a clear statement drafted by the American Law Institute[9] and submitted by the delegation of Panama" [18, p. 193]. Humphrey also had an earlier original Cuban proposal in which the right to food was explicitly declared. At this point, the right to food was new to human rights, whereas the right to housing (also included in Article 42) had already been in several constitutions, predominantly constitutions of countries with socialist traditions [18, p. 193]. Morsink noted, "But the right to food was a novel addition" [18, p. 193].

As quoted above, Humphrey's version was "the right to good food," whereas the earlier proposal of the Panamanian delegation, discussed above, from which he drew inspiration, used the form "the right to adequate food." The UDHR simply referred to "food." The Panamanian concept reappears in the expression "including adequate food" in the *International Covenant on Economic, Social and Cultural Rights* [5, art 11(1)] twenty years later.

While some basic rights - the right to clothing, housing and medical care, health, and social security - appeared in all of the UDHR drafts, the right to food was excluded from the Cassin's draft and then from the Human Rights Commission Draft. This could be partially due to pressure imposed on

[8] Humphrey said: "I was no Thomas Jefferson and, although a lawyer, I had had practically no experience drafting documents. But since the Secretariat had collected a score of drafts, I had some models on which to work. One of them had been prepared by Gustavo Gutierrez and had probably inspired the draft declaration of the international duties and rights of the individual which Cuba had sponsored at the San Francisco Conference. […]. Still others came from the American Law Institute, the American Association for the United Nations, the American Jewish Congress, the World Government Association, the *Institut de droit international* and the editors of *Free World*. The American Bar Association had sent an enumeration of subjects. […]. The documentation which the Secretariat brought together *ex post facto* in support of my draft included texts extracted from the constitutions of many countries. But I did not have this before me when I prepared my draft. The best of the texts from which I worked was the one prepared by the American Law Institute, and I borrowed freely from it. This was the text that had been unsuccessfully sponsored by Panama at the San Francisco Conference and later in the General Assembly. It had been drafted in the United States during the war by a distinguished group representing many cultures, one of whom was Alfredo Alfaro, the Panamanian foreign minister" [9, pp. 31-32].

[9] The American Law Institute (ALI) created the Statement of Essential Human Rights in 1944. The Statement was never adopted by the ALI, although it was soon published. However, one of the ALI members, Ricardo J. Alfaro, the president of Panama, also the government representative of his country to the UN, submitted the integral text of the Statement to the Economic and Social Council of the UN in April 1946. The Statement became the proposal of the Panama delegation to the UN General Assembly, held in October 1946, with the intention to be adopted as an integral part of the UN Charter. The General Assembly was not ready to vote in its favour. However, the text of the Statement became the significant resource which John P. Humphrey used in creating the first draft of the UDHR.

the Drafting Committee to make the Declaration a succinct document. For example, Morsink said that

> [b]ecause the Third Session of the Commission was very eager to keep things short and to the point, it decided to merge the article on health care rights which we have been discussing (the Second Session's Article 33) with another even longer article (then 34) on the rights to social security and the protection of motherhood and children [18, pp. 195-196].

It could also be that food, being an essential necessity for life, was not considered at 'threat' such that it would require the protection of law. Implementing the right to food was not seen as a direct responsibility of the state or the government, as explained in the comment added to Article 14 of the Panama delegation proposal [21, p.12]. An explanation that "[w]hat is "adequate food and housing" must be determined at any given time in the light of developing knowledge and or the material and technical resources within a country" [21, p.12] is also found in the same comment to Article 14.

The intervention of the Chinese delegation [18, p. 197] 'saved' the right to food (and clothing) and placed it back in the Geneva Draft of 1947. At that time, the right to food was included in all formal and less formal drafts and kept its presence all the way to the final version of the *Universal Declaration of Human Rights*, in which it appears as follows:

Article 25(1)

> Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family**, including food**, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control [4, art. 25(1)].

However, it must be noted that, at the end of the drafting stage, the right to food was not declared a right in itself. Rather, it was embedded into "a standard of living": the concept of the right to adequate food, at that moment, remained merely a submission made by the Panamanian delegation as described above.

Several cross-connected Articles appear in the UDHR. For example, Article 3 declares the right to life in the broadest sense, while Article 25 proclaims specific attributes about an individual's life in society. In his book, Morsink describes this type of cross-connection as follows:

> The drafters augmented the presumably minimal protection of the right to life in Article 3 with the **positive rights** to food, clothing, housing, and medical care in Article 25. The same point must be made about the social security benefits listed in Article 25. These were seen as **real rights**, which means that if – for reasons beyond one's control – one becomes unemployed, sick, or widowed, or bereft of old age benefits, then it is incumbent upon the state to see to it that the substance of these things is provided [18, p. 237].

Morsink summarizes that the drafters of the UDHR added to the protection of the right to life (UDHR, art. 3) "positive" rights to food, clothing, housing and medical care (UDHR, art. 25). He also points out that the "right to necessary social services" is viewed by others as a "real" right. Morsink also quotes Henry Shue,[10] a philosopher skeptical about the division of positive and negative rights, who speaks about rights to food, housing, clothing or medical attention as "basic rights" [18, p. 192].

[10] British philosopher Henry Shue, best known for his book *Rights of Duties* (first published in 1980, 2nd ed. in 1996), is skeptical about the division into "positive" and "negative" rights because he believes that positive rights do not exclude characteristics of negative rights.

4. THE RIGHT TO FOOD POST UNIVERSAL DECLARATION OF HUMAN RIGHTS

From its inception, the UDHR was recognized worldwide and respected as a highly authoritative document, although – as a simple declaration - it was considered non-binding. As Laurence Helfer and Graeme Austin observe, "[t]he Universal Declaration is not a treaty" [6, p. 8]. Helfer and Austin also indicate that the UDHR "was adopted by the United Nations General Assembly in the form of a resolution that has no force of law, and the Assembly did not intend to create binding legal obligations. Contrary to popular myth, it was not signed, nor is it an instrument intended to be signed" [6, p. 8].

Those are the facts. However, a historical look at various stages in the process of drafting the UDHR serves as a reminder that the initial task assigned to the Drafting Committee was to write an International Bill of Rights to be included in the UN *Charter* [18, p. 2]. In his memoirs, John P. Humphrey said, "[t]he general consensus after much discussion was that the bill would be a declaration to be adopted by resolution of the General Assembly. Only at the second session was it decided that it would have three parts: a declaration, a convention and measures of implementation" [9, p. 26] - and only the Declaration in fact occurred in 1948.

The UDHR consists of a preamble and thirty articles. These were not categorized. However, from an early drafting stage, it was obvious that there were two major, distinct categories of human rights: civil and political rights on the one hand and economic, social and cultural rights on the other.

With the adoption of the UDHR in 1948, the task of the UN Commission on Human Rights was not completed. The Commission continued working on two "legally binding covenants on civil and political rights, and economic, social and cultural rights, flanking the UDHR" [22]. However, paradoxically, the work on a binding treaty took much longer than the work on the UDHR itself. With the emergence of two main political blocks after WWII and growing differences in states' economic development, disagreements developed on expressing the UDHR's standards in a binding international instrument [23].

While the right to food may be connected to the right to life as implied in civil and political rights, there is still no mention of the right to food in the *International Covenant on Civil and Political Rights* (ICCPR) [24]. The silence of the ICCPR on the right to food likely related to the fact that the right was only one attribute of "a standard of living adequate for the health and well-being of himself and his family," and thus directly associated with health. It, therefore, reappeared in the ICESCR rather than in the ICCPR.

This first binding document to proclaim the right to food (although still not as a provision in itself) was the ICESCR. Today, it remains the only treaty that specifically identifies protection of the right to food for an individual.

The ICESCR modified the UDHR's wording of several human rights, including the right to food. The right to food in the ICESCR appears as follows:

Article 11

> 1. The States Parties to the present Covenant recognize **the right of everyone to an adequate standard of living** for himself and his family, **including adequate food**, clothing and housing, and to the continuous improvement of living conditions. The States Parties will take appropriate steps to ensure the realization of this right, recognizing to this effect the essential importance of international cooperation based on free consent 1 [5, art. 11(1)].

> 2. The States Parties to the present Covenant, recognizing the **fundamental right of everyone to be free from hunger**, shall take, individually and through international co-operation, the measures, including specific programmes, which are needed [5, art. 11(2)].

In the ICESCR, while the right to food remained under "an adequate standard of living … including adequate food, clothing and housing," [5, art. 11(1)], it was expanded and contained a different focus. Article 11(1) expanded the role of states in the realization of the right to food by shifting the focus to the "essential importance of international co-operation based on free consent," thus signaling a new direction for the right to food in international human rights law. It emphasizes (i) the role of an individual in implementing the right and (ii) the participation of States Parties in exercising the right to food by recommending international cooperation. Article 11(2) represented a significant shift by, first, referring to the right "to be free from hunger," and second, the right to be free from hunger was declared a "fundamental right.". The right to be free from hunger differs from the right to food, although both rights stemmed, as discussed earlier, from the right to life.[11] To illustrate this point, the following table places the expressions of the right to food in UDHR and ICESCR next to each other.

Table 1. The expressions of the right to food in UDHR and ICESCR

UDHR	**ICESCR**
Art 25(1) …[**R]ight** to **a standard of living adequate** for the health and well-being of himself and of his family, **including:**	Art 11(1)…[T]he **right of everyone to an adequate standard of living** for himself and his family, **including**:
-Food	**-Adequate food**
-Clothing	-Clothing
-Housing	-Housing
-Medical care	-Continuous improvement of living conditions
-Necessary social services	
-Right to security in the event of unemployment sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control	
	Art 11(2) …[T]he **fundamental right** of everyone **to be free from hunger** shall take, individually and through international co-operation, the measures, including specific programmes, which are needed.

The new provision - the right to be free from hunger - is the first explicitly declared fundamental treaty right associated with the right to food in international human rights law. This right is a mandatory obligation for States Parties as they "shall take, individually and through international co-operation, the measures" for its implementation.

Article 11(2) has two additional sub-articles in which the measures that must be taken to fulfill the mandatory obligation of being free from hunger are explained. The first, Article 11(2)(a), talks about food production and the reforming of agrarian systems. It states:

[11] The example of an individual receiving nutrients through an intravenous (IV) drip satisfies the right to be free from hunger. It is not the exercise of the right to food, though.

> To improve methods of production, conservation and distribution of food by making full use of technical and scientific knowledge, by disseminating knowledge of the principles of nutrition and by developing or reforming agrarian systems in such a way as **to achieve the most efficient development and utilization of natural resources**; [5, art. 11(2)a].

Article 11(2)(a) draws attention to the importance of disseminating knowledge of nutrition principles and the importance of developing or reforming agrarian systems – both based on the technical and scientific achievements that can enhance the production, conservation and distribution of food. Article 11(2)(b) refers to possible obstacles imposed by trade in the process of equitable food distribution. It states:

> Considering the problems of both food-importing and food-exporting countries, to ensure an equitable distribution of world food supplies in relation to need [5, art. 11(2)b].

In summary, the ICESCR made two advances for the right to food. It extended the concept of the "right to food" to the "right to adequate food" (Article 11(1)), and it proclaimed the right to be "free from hunger" (Article 11(2)) as a fundamental right. In scholarly literature, those are described as "two norms" or "two components" of the right to food as enshrined in international human rights law [2, p. 32], [8, p. 11].

Though the ICESCR is the first international treaty in which the right to food is recognized as the right to **adequate food**, that phrase was not new. It appeared in two preliminary UDHR documents submitted by delegations of Cuba and Panama. In the Cuban Draft Declaration, the relevant article stated, "Every human being shall have the following rights:.. 11. The Right to adequate food" [20, art. 11]. The Panamanian Submission stated: "Everyone has the right to **adequate food** and housing" [21, art. 14].

The treaty body of the ICESCR, the Committee on Economic, Social and Cultural Rights, subsequently explained the right to adequate food in the 1999 General Comment 12. It states that "[t]he human right to adequate food is of crucial importance for the enjoyment of all rights" [10, par. 1]. Further, it points out that, during the 1996 World Food Summit member states requested "a better definition of the rights relating to food in article 11 of the [ICESCR] Covenant" [10, par. 1]. The 1999 General Comment, therefore, began by defining the scope of the right:

> The right to **adequate food** is realized when every man, woman and child, alone or in community with others, have physical and economic access at all times to **adequate food** or means for its procurement [10, par. 6].

It then identified three types of state obligations supporting the right to food: the obligation to respect, the obligation to protect and the obligation to fulfill [10, par. 15]. While the obligation to respect and the obligation to protect were unambiguous, the third obligation to fulfill was subject to further clarification:

> The obligation to ***fulfil* (facilitate)** means the State must proactively engage in activities intended to strengthen people's access to and utilization of resources and means to ensure their livelihood, including food security. Finally, whenever an individual or group is unable, for reasons beyond their control, to enjoy the right to adequate food by the means at their disposal, States have the obligation to ***fulfil* (provide)** that right directly [10, par. 15].

This extended explanation of the third obligation has definitional elements significant for this discussion. It speaks of access to and utilization of resources. It also speaks of access to and utilization of the means to ensure people's livelihood, including food security. The advanced definition related component is that the right to food means states must provide adequate food directly when individuals have no access or means to ensure their food security.

In 2000, the UN Commission on Human Rights (replaced by the Human Rights Council in 2006)[12] appointed a Special Rapporteur on the Right to Food with the mandate:

> -to collect and analyze information on all aspects of the realization of the right to food,
> -to cooperate with governments, NGOs, and international organizations on the promotion and effective implementation of the right to food, and to make appropriate recommendations on the realization thereof, and
> -to identify emerging issues related to the right to food worldwide [25].

Jean Ziegler from Switzerland was the first Special Rapporteur on the Right to Food.[13] He served in this role from 2000-2008. Olivier De Schutter from Belgium served as Special Rapporteur on the Right to Food from 2008-2014.[14] Hilal Elver, from Turkey, was appointed a Special Rapporteur on the Right to Food in June 2014 and held this position until 2020.[15] Michael Fakhri, a University of Oregon School of Law professor, assumed this function in May 2020.[16]

Within two months of his appointment, the first Special Rapporteur (Ziegler) defined the right to food based on the explanation in General Comment 12. Inspired by this General Comment, the Special Rapporteur provided a definition:

> **The right to food is** the right to have regular, permanent and free access, either directly or by means of financial purchases, to quantitatively and qualitatively **adequate and sufficient food** corresponding to the cultural traditions of the people to which the consumer belongs, and which ensures a physical and mental, individual and collective, fulfilling and dignified life free of fear [26].

As can be seen from the foregoing discussion, the above quote from Ziegler's Report provided the first definition of the right to food in the UN arena.

---

[12] Since 1980, the UN Human Rights Council, formerly the UN Commission on Human Rights, has established several working groups and appointed expert individuals, assigning them various thematic mandates to report on the status of human rights. Among them, the right to food has benefitted. Those human rights protection mechanisms are known under the common title "Special Procedures." Details of the role and activities of Special Procedures of the Human Rights Council. [Online]. Available: www.ohchr.org/EN/HRBodies/SP/Pages/Welcomepage.aspx

[13] Jean Ziegler, a sociology professor from Switzerland, author, and the UN advisor, was the first appointed Special Rapporteur on the Right to Food, although his appointment received serious criticism. See, for example, postings on the UN Watch website. [Online]. Available: http://www.unwatch.org/swiss-nominate-rapists-apologist-un-human-rights-expert/ containing several appeals and requests for removal of Jean Ziegler from the UN appointments predominantly because of his tight connections with Libya's dictator Muammar El Gaddafi, and for putting his personal career preferences above the UN appointment. His University colleagues also criticized Jean Ziegler. See, for example, E.S. et al., "Switzerland: The University of Geneva: A Controversy about M. Jean Ziegler," *Minerva*, vol.14, no. 4, pp. 530-569, Winter 1976-77. [Online]. Available: https://www.jstor.org/stable/i40085788. Jean Ziegler's mandate spanned from 2000 to 2008. In his report submitted to the UN Economic and Social Council – Commission on Human Rights on January 10, 2002, Ziegler supported the Norwegian concept of the right to food as a public good. This concept may be observed as a special definition of the right to food.

[14] Olivier De Schutter, a legal scholar from Belgium, served as Special Rapporteur on the Right to Food from 2008-2014. The details about his mandate. [Online]. Available: www.srfood.org/

[15] Hilal Elver, a research professor from Turkey, was appointed Special Rapporteur on the Right to Food as of June 2014. Some controversies surrounded her appointment. See, for example, the UN Watch. [Online]. Available: U.S. blasts UN appointment of Richard Falk's wife Hilal Elver, citing 'biased and inflammatory' statements - UN Watch
The details about Hilal Elver's mandate. [Online]. Available: www.ohchr.org/EN/Issues/Food/Pages/HilalElver.aspx

[16] Michael Fakhri, a professor at the University of Oregon School of Law, was appointed Special Rapporteur on the right to food in May 2020. [Online]. Available: https://www.ohchr.org/en/special-procedures/sr-food/mr-michael-fakhri

The second Special Rapporteur (De Schutter) focused on food security and the legal policy framework.[17] He did not advance his own definition of the right to food or discuss the question of definition. However, his final report submitted to the UN's General Assembly at the end of his mandate in 2014 evinced a different approach to the right to food than that pursued by the first Special Rapporteur Ziegler.

In his final report, De Schutter said that "[a]ctions should be launched at three levels to democratize food security policies, thus weakening existing lock-ins and allowing these policies to shape the new model [called] for" [27]. De Schutter referred to the rebuilding of local food systems that should be supported on local, national and international levels, emphasizing that **the right to food** is central to the success of these efforts [27, p. 16].

During the mandate of the second Special Rapporteur on the Right to Food, Olivier De Schutter, the UN General Assembly adopted the first UN General Assembly Resolution on the Right to Food [12]. The Resolution was certainly a significant addition to UN human rights mechanisms established to protect the right to food, although, as mentioned earlier, UN General Assembly resolutions are non-binding. The Resolution reaffirms "the right of everyone to have access to safe, sufficient and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger" [12, par. 2]. This text in the Resolution, which aligns with Article 11 of the ICESCR, may be observed as a valuable addition to the content of the definition of the right to food with a focus on the right of everyone to have access to safe, sufficient and nutritious food. In a certain way, it blends the definition provided by the Special Rapporteur on the Right to Food with the text of the UDHR and ICESCR.

With respect to the definition of the right to food, both De Schutter and his successor Hilal Elver, in reports, accepted Ziegler's definition of the right to food quoted above. Elver, the third Special Rapporteur on the Right to Food, in her address to the Human Rights Council in Geneva in 2015, said that "the right to food is enshrined in international human rights law with States obliged to ensure its progressive realization, through the development of supportive domestic and national legislation" [28]. She reminds her readers that the Optional Protocol to the ICESCR [29] reaffirms the right to food.

The 2015 Human Rights Council resolution on the Right to Food [13], though similar in concept to the definition of the right to food defined by the Special Rapporteur on the Right to Food, adds new elements such as "preserving access to food for future generations" [13, p. 2]. In addition, it "[r]ecognizes the importance of smallholders and subsistence farmers in developing countries, including women and local indigenous communities, in ensuring food security, reducing poverty and preserving ecosystems, and the need to assist their development" [13, art. 8]. It also "[r]eaffirms the need to ensure that programmes delivering safe, sufficient, nutritious and culturally accepted food are inclusive and accessible to persons with disabilities" [13, art. 10]. It also "[c]alls for the early conclusion to and a successful, development-oriented outcome of the Doha Round of trade negotiations of the World Trade Organization as a contribution to creating international conditions permitting the full realization of the right to food" [13, art. 29].

Special Rapporteur Michael Fakhri, who replaced Hilal Elver, reaffirmed all previous UN definitions of the right to food. However, in his report submitted to the General Assembly in 2023, he focused on the current situation in the world, which is characterized by violence. His report titled

[17] Olivier De Schutter's reports considered relevant to the topic of the right to adequate food include *Building Resilience: A Human Rights Framework for World Food and Nutrition Security*, 2008*; Seed Policies and the Right to Food: Enhancing Agrobiodiversity, Encouraging Innovation*, 2009; *Annual Report to the Human Rights Council*, 2010. However, the final report marking the end of his mandate, *Report of the Special Rapporteur on the Right to Food*, 2014, summarizes De Schutter's approach to the transformative potential of the right to food.

"Conflict and the Right to Food" [30] reflects this. He said, "Violence in food systems has increased in recent years … affecting global food security" [30, par. 4]. He pointed to "how different forms of violence in food systems harm people and generate the conditions that lead to human rights violations" [30, par. 5].

5. UN SPECIALIZED AGENCIES AND THE RIGHT TO FOOD

The UN system includes several Specialized Agencies.[18] These are legally independent international organizations operating within their own regulations (i.e. many have their own constitutions) and financial resources. Their relationship with the UN has been established through negotiated agreements. Some of the agencies have a long history, as they were established long before the UN; others were created almost at the same time as the United Nations, and yet the United Nations itself created others to meet the UN's emerging needs.

The Food and Agriculture Organization (FAO) is a special UN agency engaged in food-related activities. Another UN special agency whose activities, to some extent, relate to the FAO is the World Health Organization (WHO). These two agencies are solely discussed in conjunction with the definition of the right to food. Recall that the right to food in the UDHR appears together with the right to health.

The FAO is a major UN agency established immediately following the establishment of the UN. The FAO's mandate is to look after the food-related issues around the globe. The FAO is directly concerned with "achieving food security," aiming "to make sure people have regular access to enough high-quality food." [19] On the other hand, the WHO is concerned about food safety, focusing on quality and nutritional values.[20]

The FAO was founded when 45 states gathered on 16 October 1945 in Quebec City to sign the Constitution establishing the Food and Agriculture Organization [31].

The FAO reiterates all definitions of the food rights specified in the UDHR, ICESCR, General Comment 12 of the Committee on Economic, Social and Cultural Rights, and the Special Rapporteur on the Right to Food [31].

The FAO also produced *Voluntary Guidelines to the Progressive Realization of the Right to Adequate Food in the Context of National Food Security*, which were adopted in 2004 [32]. The document is reaffirmed in the 2009 UN General Assembly resolution on the right to food [12] and referenced in the 2015 report of Special Rapporteur on the Right to Food, Hilal Elver [28, p. 3]. [21] Regarding the definition of the right to food, the *Voluntary Guidelines* repeated the provisions from the UDHR and the ICESCR and then continued to focus on the obligations of states towards the realization of the right to adequate food [32, pars. 11-19].

However, several years later, in addition to more detailed explanation about expectations from individuals as well as States with respect to the right to food, the FAO has also added a statement about what the right to food is not:

> The right to food is not a right to be fed, but primarily the right to feed oneself in dignity. Individuals are expected to meet their own needs, through their own efforts and using their

[18] For the position of Specialized Agencies in the UN system, see the Directory of United Nations System Organization. [Online]. Available: https://www.un.org/en/about-us/un-system

[19] About FAO. [Online]. Available: http://www.fao.org/about/en

[20] About WHO. [Online]. Available: http://www.who.int/about/en/

[21] Elver said: "Similarly the Right to Food Guidelines have been instrumental in promoting the importance of recognizing the right to food in national legal frameworks. States should refer to the Guidelines when developing constitutional principles and framework laws to ensure the progressive realisation of the right to food at the domestic level."

> own resources. To be able to do this, a person must live in conditions that allow him or her either to produce food or to buy it. To produce his or her own food, a person needs land, seeds, water and other resources, and to buy it, one needs money and access to the market. The right to food requires States to provide an enabling environment in which people can use their full potential to produce or procure adequate food for themselves and their families. However, when people are not able to feed themselves with their own means, for instance because of an armed conflict, natural disaster or because they are in detention, the State must provide food directly [33].

Although the statement aligned itself with the orthodox international human rights law provisions on food, it broadens the concept of the right to food, including the right to locally produced food. The FAO's definition of the right to food, however, includes the obligation of the State to its citizens. Nevertheless, while the FAO includes obligations on states, it also clarifies that, in the first instance, individuals are obligated to "meet their own needs, through their own efforts."

While the FAO agency was established at the same time as the UN in 1945, the WHO emerged later, in 1948, the same year the UDHR was adopted.[22] The WHO does not define the right to food, though its Constitution includes a commitment "to develop, establish and promote international standards with respect to food" [34]. In 1950, a joint FAO/WHO committee of nutrition experts noticed "that the conflicting nature of food regulations may be an obstacle to trade and may therefore affect the distribution of nutritionally valuable food" and suggested that FAO and WHO study these problems more closely.[23]

The FAO and WHO were united in their growing concern about food security and held their first conference together in Rome in 1963.[24] Ever since those two UN agencies have worked together and developed a collection of internationally recognized food standards (*Codex Alimentarius*). These standards are mentioned as a result of joint efforts of two UN special agencies working together, though the standards themselves do not directly contribute to a definition of the right to food. "When formulating national policies and plans with regard to food, Governments should take into account the need of all consumers for food security and should support and, as far as possible, adopt standards from the Codex Alimentarius or, in their absence, other generally accepted international food standards."[25]

Not directly a definitional aspect of the right to food, food sovereignty is yet another expression associated with the right to food discourse developed based on "food security." The term was coined at the World Food Summit in 1996 (in Rome, Italy, at the FAO Headquarters) by members of La Via Campesina movement[26] who believed that people who produce and distribute food should also control the policies and other instruments that are governing the food production and distribution, rather than control being held by large corporations and international trade monopolists.

---

[22] In Quebec City, on 16 October 1945 the FAO was established by the adoption of the Constitution. The Constitution of the World Health Organization came into force in 1948, although it had been signed by 61 countries on 22 July 1946, in Geneva.

[23] The first session of the Joint FAO/WHO Expert Committee on Nutrition (1950): Origins of the Codex Alimentarius. [Online]. Available: https://www.fao.org/3/y7867e/y7867e03.htm

[24] In May 1963, the Sixteenth World Health Assembly approved establishing the Joint FAO/WHO Food Standards Programme with the Codex Alimentarius Commission as its principal organ. The Commission held its first session in Rome in October 1963. Some 120 participants from 30 countries and 16 international organizations attended.

[25] The cited text comes from the *Codex Alimentarius: International Food Standards*. [Online]. Available: https://www.fao.org/fao-who-codexalimentarius/about-codex/en/

[26] About La Via Campensina. [Online]. Available: https://viacampesina.org/en/

An Intergovernmental panel project (2004-2007) sponsored, among others, by the UN, FAO, WHO, and World Bank developed the following definition of food sovereignty: "Food sovereignty is defined as the right of peoples and sovereign states to democratically determine their own agricultural and food policies" [35].

6. CONCLUSION

Since WWII, the right to food has not been clearly or consistently defined. Its first articulation in international human rights law came relatively late, in 1948, with the adoption of the UN UDHR. Although the right to food was a new introduction to the process of human rights codification, it did not secure the provision as a right in itself. Rather, in the final version of the UDHR (Article 25(1)), the right to food remained an included element in the concept of an "adequate standard of living." In the ICESCR, in addition to the right to adequate food, a new right - the right to be free from hunger – was introduced and qualified as a fundamental right. These new concepts of the right to food were supported by the two UN resolutions in 2009 and 2015, each taking a different functional approach. While the 2009 Resolution focuses on the role of the Special Rapporteur on the Right to Food, it made a textual connection to international trade by addressing TRIPS and WTO. On the other hand, the 2015 Resolution includes that aspect, but the focus of its recommendations was shifted to the work of various organizations, especially the UN's FAO as a leader in eradicating hunger.

The question that stems out of the research on the right to food chronicled in this paper is whether the ambiguous definition of the right to food or the lack of instruments for its implementation has contributed to the development of tension between international human rights law and other international legal concepts, particularly intellectual property and especially since IP joined the World Trade Organization in 1994, shifting its focus from international human rights (soft law) to private economy driven agreements.

In the turbulent times the world is facing today, the right to food once again has been caught in a conflicting situation. As the Special Rapporteur on the Right to Food said, violence in food systems harms people, causing the violation of human rights. As a fundamental human right, the right to food has yet to receive a much more prominent articulation.

Abbreviations:

ALI	American Law Institute
CESCR	Committee on Economic, Social and Cultural Rights
ECOSOC	Economic and Social Council
FAO	Food and Agriculture Organization
ICCPR	International Covenant on Civil and Political Rights
ICESCR	International Covenant on Economic, Social and Cultural Rights
IP	Intellectual Property
NGO	Non-Governmental Organization
OHCHR	Office of the High Commissioner for Human Rights
TRIPS	[Agreement on] Trade-Related Aspects of Intellectual Property Rights
UDHR	Universal Declaration of Human Rights
UN	United Nations
WHO	World Health Organization
WTO	World Trade Organization
WWII	World War II

Acknowledgement

This paper is based on the substantive research conducted by this author during her graduate studies in law. It stemmed from her master's in law thesis *The Right to Food and the Right to Intellectual Property in the United Nations (including International Human Rights) and International Trade: Finding the Definition* - defended at Western University, Faculty of Law, Canada, in 2017. Pursuing her doctoral studies in law, this author broadened her research on the right to food by incorporating reputation as expressed in the Canadian law of geographical indications - a section of her doctoral thesis, defended in 2022. As part of her postdoctoral research, this author explores the protection of the right to food in the context of developing new technologies in food production associated with outer space missions. The history of the right to food as an intangible right and how it has been established as a human right in the UN and international human rights law, chronicled in this paper, has never been published.

REFERENCES

[1] Xanthaki, H., (2016), "On transferability of legislative solutions: the functionality test," in *Drafting Legislation: A Modern Approach*, C. Stefanou and H. Xanthaki, Eds., Abingdon and New York, NY, USA: Routledge, ch. 1, p. 11,

[2] Alston, P., (1984), "International Law and the Human Right to Food," in *The Right to Food*, P. Alston and K. Tomasevski, Eds., Boston, MA, USA and Utrecht, Netherlands: Martinus Nijhoff Publishers and Stichting Studie- en Informatiecentrum Mensenrechten, p. 21.

[3] Tofan, C., Ed., (2013), *Human Rights and the Right to Food*, vol. 1, Hague, Netherlands: International Courts Association, 2013, p. xii.

[4] *Universal Declaration of Human Rights*, 10 December 1948. General Assembly Resolution 217 A (III) (entered into force 16. December 1949) [UDHR].

[5] *International Covenant on Economic, Social and Cultural Rights*, 16 December 1966, 993 UNTS 3 (entered into force 3 January 1976) [ICESCR].

[6] Helfer, L. R., Austin, G., (2011), "The human right to food, plant genetic resources, and intellectual property" in *Human Rights and Intellectual Property: Mapping the Global Interface*, Cambridge, UK: Cambridge Univ. Press, ch. 6, pp. 371-375.

[7] "The right to food stipulated as independent right" in B. Wernaart, *The Enforceability of the International Human Right to Adequate Food*, Wageningen, Netherlands: Wageningen Academic Publishing, 2013, p. 60.

[8] Golay, C., (2009), *The Right to Food and Access to Justice: Examples at the National, Regional and International Levels*, Rome, Italy: FAO, p. 11.

[9] Humphrey, J.P., (1984), *Human Rights and the United Nations: A Great Adventure*, New York, NY, USA: Transnational Publishers, 1984.

[10] Office of the High Commissioner for Human Rights, CESCR *General Comment* No. 12, *The Right to Adequate Food* (Art. 11) (12 May 1999), 20th Sess, E/C.12/1999/5. [General Comment 12].

[11] United Nations Human Rights Office of the High Commissioner, *Special Rapporteur on the Right to Food*. [Online]. Available: https://www.ohchr.org/en/special-procedures/sr-food

[12] *Resolution Adopted by the General Assembly on 18 December 2009*: 64/159. *The Right to Food*, A/RES/64/159, 10 March 2010 [General Assembly the Right to Food Resolution 2009].

[13] *Resolution Adopted by the Human Rights Council* (adopted on 26 March 2015): 28/10. *The Right to Food*, A/HRC/RES/28/10, 2 April 2015 [Human Rights Council the Right to Food Resolution 2015].

[14] The first draft of the Declaration written by John P. Humphrey comprised 48 articles under the title "Draft Outline of an International Bill of Human Rights (Prepared by the Division of Human Rights of the Secretariat)", UN Doc E/CN.4/AC.1/3/; published as Annex in the *U.N. Human Rights Yearbook for 1947*, pp. 484-487. It is also available (as Appendix 1) in M. A. Glendon, *A World Made New: Eleanor Roosevelt and the Universal Declaration of Human Rights*, New York, NY, USA: Random House, 2001, pp. 27-274 [Humphrey's Draft].

[15] Winter, J., Prost, A., (2013), *René Cassin and Human Rights: From the Great War to the Universal Declaration*, Cambridge, UK: Cambridge Univ. Press.
[16] Commission on Human Rights Drafting Committee, *Draft Outline of International Bill of Rights (prepared by the Division of Human Rights)*, UN ECOSOC E/CN.4/AC.1/3, 4 June 1947, art 42. [Humphrey's Draft].
[17] [René Cassin] Commission on Human Rights Report of the Drafting Committee on an international Bill of Human Rights Suggestions Submitted by the Representative of France for Articles of the International Declaration of Human Rights Annex D, UN ECOSOC E/CN.4/21, 1 July 1947, art 37 [Cassin's Draft].
[18] Morsink, J., (1999), *The Universal Declaration of Human Rights: Origins, Drafting and Intent*, Philadelphia, PA, USA: Univ. of Pennsylvania Press, 1999.
[19] Inter-American Juridical Committee, (1946), Draft Declaration of the International Rights and Duties of Man and Accompanying Report, 40:3 AJIL/Am J Intl L Supplement: Official Documents 93-116. [Chilean Submission].
[20] *The Cuban Delegation to the General Assembly of the United Nations Draft Declaration on Human Rights* (1946), London 12 February 1946, UN ECOSOC E/HR/1, 22 April 1946. [Cuban Draft].
[21] *Statement of Essential Human Rights Presented by the Delegation of Panama,* UN Economic and Social Council E/HR/3 (26 April 1946); UN General Assembly A/148 (24 October 1946) [Panamanian Submission].
[22] James, S., (2007) *Universal Human Rights: Origins and Development*, New York, NY, USA: LFB Scholarly Publishing LLC, p. 175.
[23] Henkin, L., et al, (2009), *Human Rights* (University Casework Series), 2nd ed, Foundation Press and Thomson Reuters, 2009, p. 219. "The adoption of a legally binding international agreement to protect economic, social and cultural rights did little to resolve competing conceptions of how to structure the relationship between state values and human values. Although the drafters intended the ICESCR to be acceptable to socialist states, developing nations, and industrialized "free-market" countries, the differences between the two Covenants have been often characterized as reflecting political and ideological divisions between these groups of countries."
[24] Wernaart, B., (2013), *The Enforceability of the Human Right to Adequate Food*, Wageningen, Netherlands: Wageningen Academic Publishing, p. 63 ("In some circumstances, the right to food may be considered to be a prerequisite to fulfil the right to life. Although the ICCPR is not too often viewed in the context of economic, social and cultural rights, Article 6 ICCPR implies, according to the Human Rights Committee, a duty for Member States to 'take all possible measures to reduce infant mortality and to increase life expectancy, especially in adopting measures to eliminate malnutrition and epidemics.' Furthermore, to withhold (access to) food with the purpose to destroy life is a clear violation of Article 11(c) of the convention on the Prevention and Punishment of the Crime of Genocide." [reference omitted]); *International Covenant on Civil and Political Rights,* 19 December 1966, 999 UNTS 171(entered into force 23 March 1976, accession by Canada 19 May 1976). Citation on the right to food being mentioned in context of right to life; and ICCPR citation.
[25] Special Rapporteur on the Right to Food, mandate and role described. [Online]. Available: www.ohchr.org/EN/Issues/Food/Pages/FoodIndex.aspx
[26] *The Right to Food. Report by the Special Rapporteur on the Right to Food, Mr. Jean Ziegler, submitted in accordance with Commission on Human Rights resolution 2000/10*. ESCCHR, 57th Sess., U.N. Doc. 2000/10. E/CN.4/2001/53 [emphasis added].
[27] *Report of the Special Rapporteur on the Right to Food, Olivier De Schutter: Final Report: The Transformative Potential of the Right to Food.* submitted to the Human Rights Council, A/HRC/25/57, 24 January 2014, p. 14.
[28] Elver, H., (2015), *Special Rapporteur on the Right to Food* [Report], Human Rights Council 28th Session, Geneva, Switzerland, 9 March 2015, p. 2.

[29] *Optional Protocol to the International Covenant on Economic, Social and Cultural Rights,* UN A/RES/63/117, 10 December 2008 (entered into force 5 May 2013). (Optional Protocol to the International Covenant on Economic, Social and Cultural Rights is an international treaty establishing complaint and inquiry mechanisms for the *International Covenant on Economic, Social and Cultural Rights*. It allows individuals to submit complaints once all domestic remedies have been exhausted).
[30] Fakhri, M., (2022), *Report of the Special Rapporteur on the right to food*, (A/HRC/52/40) [EN/AR/ZH/RU], 29 December 2022.
[31] *Basic Texts of the Food and Agriculture Organization of the United Nations,* vols. 1 and 2, Rome, Italy: FAO, 2015, p. 3. Constitution, art. 1. "The Organization shall collect, analyze, interpret and disseminate information relating to nutrition, food and agriculture".
[32] Food and Agriculture Organization [FAO], *Voluntary Guidelines to the Progressive Realization of the Right to Adequate Food in the Context of National Food Security*, Adopted by the 127th Session of the FAO Council, November 2004. In the Foreword of the document, it says that "[t]he Voluntary Guidelines represent a step forward integrating human rights into the work of agencies dealing with food and agriculture, such as FAO, as called by the United Nations Secretary-General within his UN reforms."
[33] Food and Agriculture Organization [FAO], (2010), "The Right to Adequate Food," *Fact Sheet*, no. 34, p. 3,
[34] Constitution of the World Health Organization, 1946, art. 2(u).
[35] McIntyre, B., (2009), International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD): Global Report, Washington, DC, USA: Island Press, p. 563.

APPLICATION OF BLOCKCHAIN TECHNOLOGY IN INCREASING THE FOOD SECURITY

PRIMJENA BLOCKCHAIN TEHNOLOGIJE U POVEĆANJU SIGURNOSTI OPSKRBE HRANOM

Vesna Gantner, full professor,[1]
Krešimir Kuterovac, mag.ing,[2]

Abstract: *In a world where the position and priorities of individuals in society are drastically changing, the current system of food supply and security will not endure. Therefore, it is time to take care of our future by ensuring the production of quality food. GoAgro represents a service that allows you to participate in food production projects through direct connection with producers. You can support production by financing their production. Your NFT GOAGRO for a particular selected project provides you with a safe financial return, and you can exchange it for products (food) produced in the project or you can trade with it on the GoAgro platform.*

Key words: *food production, food security, GoAgro, digitalization*

Apstrakt: *U svijetu u kojem se položaj i prioriteti pojedinaca u društvu drastično mijenjaju, sadašnji sustav opskrbe i sigurnosti hrane neće opstati. Stoga je vrijeme da se pobrinemo za našu budućnost osiguravajući proizvodnju kvalitetne hrane. Goagro predstavlja uslugu koja vam omogućuje sudjelovanje u projektima proizvodnje hrane kroz izravnu vezu s proizvođačima. Proizvodnju možete podržati financiranjem njihove proizvodnje. Vaš NFT GOAGRO za određeni odabrani projekt osigurava vam siguran financijski povrat, a možete ga zamijeniti za proizvode (hranu) proizvedene u projektu ili njime trgovati na Goagro platformi..*

Ključne reči: *proizvodnja hrane, prehrambena sigurnost, GoAgro, digitalizacija*

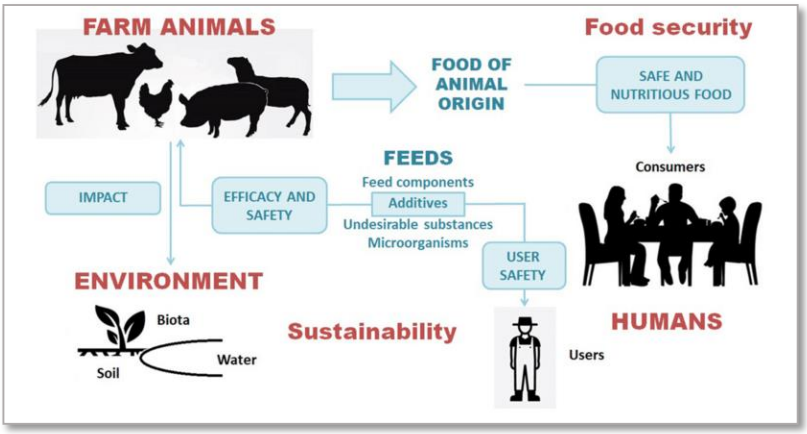
1. INTRODUCTION

Food security is a concept that is multifaceted and covers various aspects. It can be defined as a state in which all individuals have adequate physical and economic access to safe, nutritious, and sufficient food that meets their dietary requirements and preferences for a healthy and active life [1]. There are multiple dimensions to food security, such as the physical availability of food, which deals with the supply side of food security and is determined by food production levels, inventory levels, and net trade. Additionally, adequate food supply at the national or global level alone does not guarantee food security at the household level, as issues with insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets, and prices to achieve food security objectives. Utilization of food is another dimension of food security and refers to the way the body optimizes various nutrients in food. Good care and feeding practices, food preparation, diet diversity, and intra-household distribution of food contribute to sufficient energy and nutrient intake by individuals. Along with effective biological utilization of food consumed, this determines the

[1] Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences, Osijek, Croatia, e-mail: vgantner@fazos.hr
[2] Agroporc, Petrinja, 40250, Croatia, e-mail: kresimir.kuterovac@gmail.com

nutritional status of individuals. Lastly, the stability of the other three dimensions over time is essential, as even if an individual's food intake is sufficient today, they are still considered food insecure if they have inadequate access to food periodically, which could lead to a deterioration of their nutritional status. Food security status may be impacted by adverse weather conditions, political instability, or economic factors such as unemployment or rising food prices.

The global concern surrounding the future of food production is due to the challenges posed by climate change and the increasing population [2]. A few of the primary concerns are as follows: The demand for food is increasing as the global population is predicted to reach nearly 10 billion people by 2050 and 10.9 billion in 2100. This indicates that global food production will have to increase significantly. The way we produce and consume food today contributes to global warming and other environmental problems such as deforestation and soil erosion. Traditional agricultural methods release harmful amounts of carbon and nitrogen into the soil and atmosphere, causing environmental impact. Across all stages of the food chain, food wastage is common, with almost 13.8% of food lost in supply chains. When food is wasted, all the energy, land, and resources used to create it are also wasted. Food production is increasingly at risk from climate change, particularly from droughts, increasing frequency of storms, and other extreme weather events. There is also a nutritional concern as nearly 800 million people lack access to adequate food, and two billion people are affected by hidden hunger, lacking key micronutrients. Moreover, approximately two billion people are overweight and affected by chronic conditions.



Picture 1: Chain of food production [3].

In light of the crucial importance of maintaining a steady food supply, this paper aimed to highlight the innovative ways in which modern technologies can be utilized to bridge the gap between consumers and food producers, with the ultimate goal of ensuring the safety and sustainability of food production and supply. By exploring and showcasing various cutting-edge techniques and tools, this paper aims to demonstrate how technology can be leveraged to create a more transparent, secure, and efficient food system.

2. DIGITAL TECHNOLOGIES – BLOCK CHAIN

Blockchain technology is a kind of shared database that distinguishes itself from a standard database by how it stores data [4]. Instead of storing data in a traditional format, blockchains store it in blocks that are linked together through cryptography. The primary features of blockchain technology include a shared, unalterable ledger that simplifies the process of recording transactions and tracking assets in a business network. Whether an asset is tangible (such as a car, house, cash, or land) or

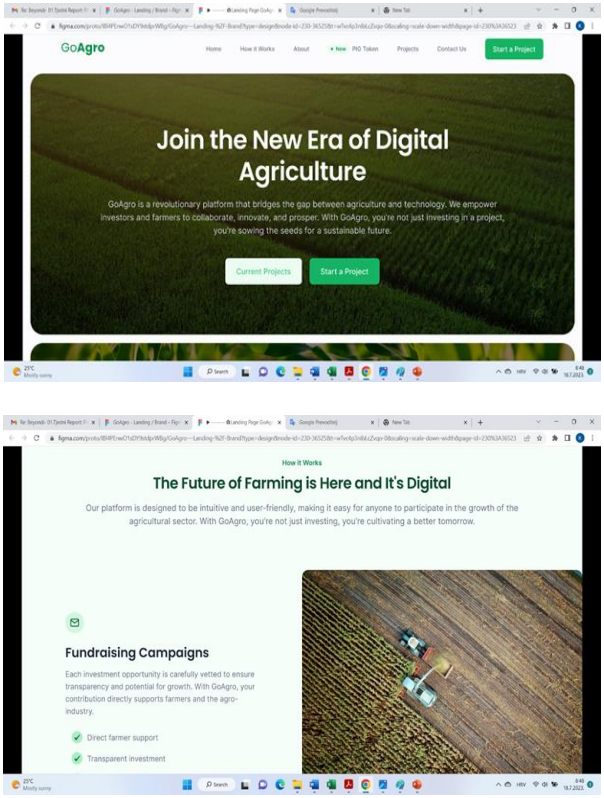
intangible (such as branding, copyrights, intellectual property, or patents), it can be tracked and traded on a blockchain network, reducing risk and cutting costs for everyone involved. The importance of blockchain technology lies in its ability to provide immediate, shared, and completely transparent information that can be accessed only by permissioned network members. A blockchain network can track orders, payments, accounts, production, and much more. The key elements of blockchain technology include distributed ledger technology, immutable records, and smart contracts. Distributed ledger technology ensures that every network participant has access to the distributed ledger and its immutable record of transactions. Immutable records mean that no participant can alter or tamper with a transaction once it has been recorded on the shared ledger. Smart contracts speed up transactions by storing a set of rules on the blockchain and executing them automatically. Blockchain technology works by recording each transaction as a "block" of data. These blocks form a chain of data as an asset moves from one place to another or ownership changes hands. The blocks confirm the exact time and sequence of transactions, and they link securely together to prevent any block from being altered or a block being inserted between two existing blocks. Blockchain technology has the potential to revolutionize many industries by providing a secure, decentralized method of recording and verifying transactions. Since the introduction of Bitcoin in 2009, blockchain uses have exploded via the creation of various cryptocurrencies, decentralized finance (DeFi) applications, non-fungible tokens (NFTs), and smart contracts. In essence, blockchain technology has the potential to revolutionize many industries by providing a secure, decentralized method of recording and verifying transactions.

3. GoAgro – DIGITAL PLATFORM

GoAgro – the digital platform is intended to finance various projects in agriculture in such a way that each project issues NFT Coins in a certain amount [5]. The funds collected through the sale of NFTs are intended for the financing of certain agricultural production with the ultimate goal of creating an agricultural product. The buyer of NFT realizes the benefits that are determined for each project by the contract between the buyer and the issuer of NFT. As a rule, each NFT represents the ownership of a digital form of an agricultural product, and at the time of purchase, the quantity of the product and the price are defined (principle of price determination). This digital form is converted by the issuer over a certain period into an actual semi-primary product using the funds collected from the sale of the NFT. The NFT buyer has the right after the agreed time to exchange his NFT for a real product or he can sell the NFT on the stock exchange through this platform.

The benefits that the customer realizes are the direct connection between the buyer and the producer without intermediaries, decentralized financing of production avoiding the existing systems of banks, and funds that take a large part of the profits of producers and buyers. The system is based on blockchain technology and is extremely secure and easy to use. The product behind buying NFTs is a real commodity that prevents losses in value due to inflation, and:

1. The customer ensures dedicated production and availability of food of a certain quality in the future period;
2. The yield that a digital product achieves during conversion into a real product is natural (kg of product per year) and is protected from inflation;
3. NFT can be easily traded through the platform or after the time of production you can sell it back to the issuer or you can exchange it with them for a real product.

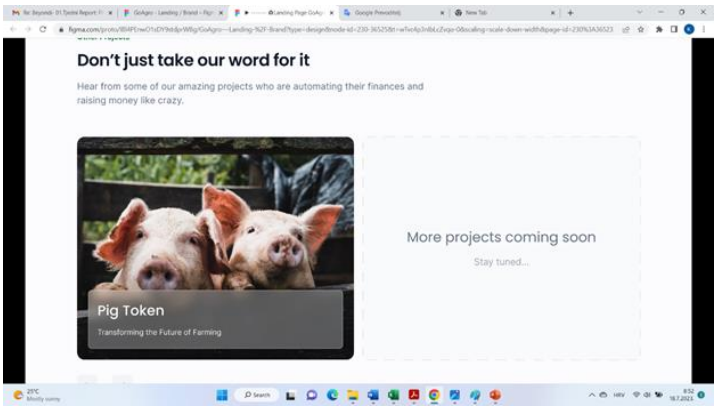


Picture 2: GoAgro platform [5].

The first project that will offer NFT sales on the GoAgro platform is the ***Agroporc doo PIG NFT project*** or the ***First Digital Pig Farming Project***. This is a unique project that fully follows modern EU policies, which say that our salvation lies in the digitalization of agriculture (and the economy). As far as we know, it is the first in the EU and the world.
Each ***NFT represents*** the right of ownership of one digital pig at the time of purchase, the digital pig weighs 100 kg (halves) which have an annual increase of 3% in kg [5]. The money used to buy the digital pig is invested in production. The costs of building and equipping farms, procurement of the basic herd, food and water costs, labor and energy costs and other production costs are financed.

Over the course of 2.5 years, the invested funds ensure the production of a real pig in the weight that was paid for plus growth.

- The initial price of each series of PIGNFT is determined according to the stock market price with a certain discount or special sale of a certain quantity.
- The customer can sell his tokens on the GoAgro platform (Marketplace) when the sold series of PIGNFT is related to the realization phase. The new NFT owner registers through the platform.
- After 2.5 years, the owner of the PIGNFT can sell it back to the issuer. The issuer undertakes to purchase the NFT in the initial weight plus an increase of 3% per year from the moment of sale until payment. The NFT price is determined according to the stock exchange price of the German VEZG stock exchange in the week of NFT sales for the E class half.



Picture 3: Pig NFT [5]

• After 2.5 years, the owner can at any time exchange his PIG NFT for a pig produced by the issuer. Pigs are produced according to the highest standards of quality and animal welfare. The owner of PIGNFT a collects half of the pigs at a pre-arranged place with the issuer of PIGNFT. The weight of the halves will approximately correspond to the weight of the purchased kg plus the increase. The final settlement between the owner of PIGNFT and the issuer will be made after delivery, and the owner will pay extra or the issuer will return the difference in half kg in Euros, according to the price determined for the sale of PIGNFT to the issuer.
• The publisher PIG NFT guarantees that it will take special care of pig production and that the pigs will be fed without GMO components, according to the antibiotic-free production principle. Farm welfare standards will be at the highest EU level. Farms do not produce waste and have a closed cycle of slurry processing and produce high-quality organic fertilizers for agricultural production. All farms are energy efficient and independent. By using the most modern systems for food preservation, fermentation and food preparation on the farm and a closed slurry processing system, the CO2 footprint has been reduced by 90% compared to standard production.
• The owner of PIGNFT through the platform will have the possibility of live video transmission from production farms. Regular periodic reports on the realization of production will be available on the platform and website of the issuer.

What does the ROI calculator say (Return on invested capital)?

• Today your digital pig (100 kg half) costs 250 EUR today and on the stock market During the first purchase, you will buy it for a 5% discount and you will pay 237.50 EUR (2.375 EUR/kg)
• Your pig grows 3% per year and will weigh 109.27 kg in 3 years.
• The largest EU association COPA COGECA [6] predicts a 50% increase in pig prices by 2025, which would amount to 3.75 Euros/kg for your pig
• Your pig is worth 410 Euros in 3 years
• Yield over three years is 410-237.5 = 172.5 Euros or 73%

4. FOOD PRODUCTION IN EUROPEAN UNION

Food production is a significant contributor to the global status of the European Union (EU). The following are some important facts about food production in the EU [6]: In 2022, the EU produced a total of 270.9 million tonnes of cereals, which was 26.7 million tonnes less than the previous year. The production of many crops, including grain maize (down 27.4%), sunflowers (down 10.1%), and olives for olive oil (down 38.1%), was negatively impacted by drought conditions in significant parts of the EU; Many crops, including cereals (+45.6%), sugar beet (+34.9%), potatoes (+30.5%), and oilseeds (+29.0%), experienced a surge in output prices in 2022; The agricultural policy of the EU covers several areas, including food quality, traceability, trade, and promotion of EU farm products; The EU supports its farmers both financially and to adopt sustainable and eco-friendly practices, while also investing in the development of rural areas; Finally, the agricultural and food-related sectors provide employment to more than 44 million people in the EU, including 20 million engaged within the agricultural sector itself.

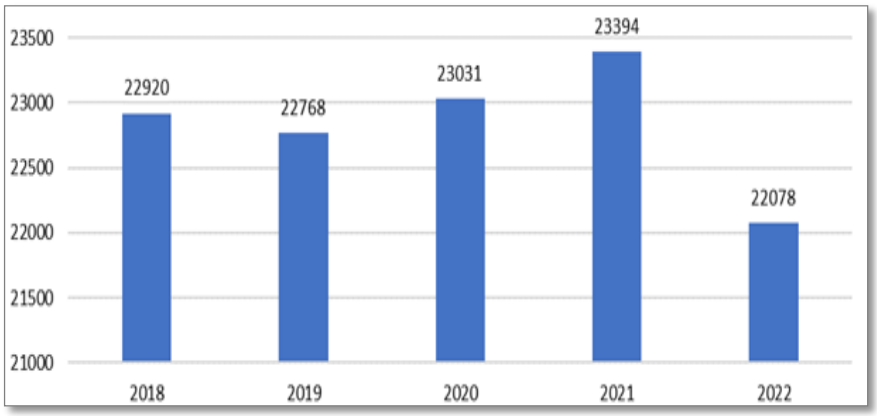
Animal production is also a crucial aspect of the EU's agricultural output [7]. The following are some essential facts about animal production in the EU: As of 2022, there were 134 million pigs, 75 million bovine animals, and 70 million sheep and goats in the EU; Pig meat production in the EU decreased by 1.3 million tonnes (-5.7%) from its peak of 23.4 million tonnes in 2021; Poultry meat production in the EU continued to decline (a further -1.5% to 13.0 million tonnes) from its 2020 high; In 2022, Spain had approximately one-quarter of the EU's pig (25.4%) and sheep (24.5%) populations, while Greece had a similar share of the EU's goat population (26.3%), and France had a somewhat smaller share (22.7%) of the bovine population; Lastly, several EU countries have specialized in livestock farming. For example, Ireland accounted for 8.8% of the EU's bovine animals in 2022 (slightly more than in Spain and Italy), while Denmark accounted for 8.6% of the EU's pig population (only slightly less than in France).

EU key data for pig farming

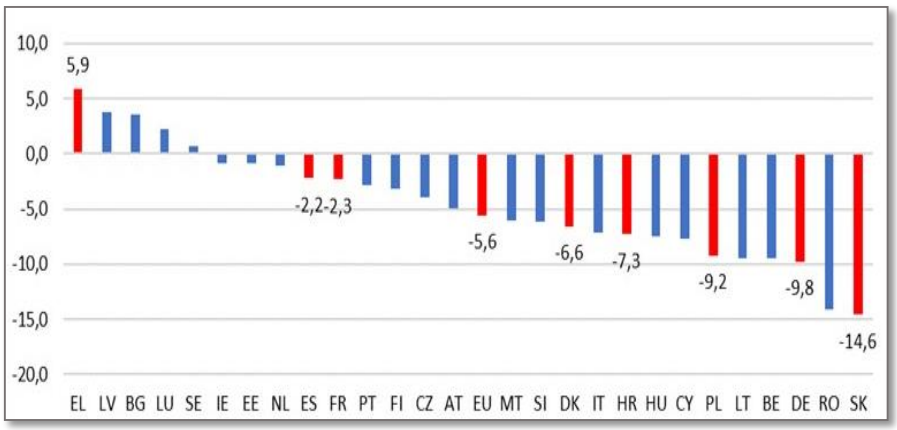
The EU is the world's second largest producer of pork and the largest exporter of meat and meat products. EU self-sufficiency in pork is 120%. The problems of EU production are contained in the following several points:
• post COVID impacts,
• war in Ukraine,
• the price of animal feed and energy,
• the spread of African swine fever in countries with significant pig production in addition
• environmental challenges of adapting production to the standards of the Nitrate Directive
• climate requirements for reducing GHG emissions
• socio-economic problems related to the aging of the population and the abandonment of production by small and medium-sized producers
• global non-competitiveness due to high EU standards in pig production (ecological, climatological and animal welfare)

The most important destinations for pork exports from the European Union are China, Japan, the Philippines and South Korea (62% of all quantities). In the year 2021, exports to China were reduced by 49%, and in 2022 by another 35%. During 2022, European pork production was 5.6%

lower. The largest producers recorded a decrease in production (Spain -2.2%, Germany -9.8%, Poland 9.2%, Denmark -6.6%) The marked increase in meat prices was caused by a decrease in production due to a decrease in the number of sows and gilts. Due to the problems with the political implications of the restructuring of the world, the availability of lucrative export markets for EU pork is decreasing, and with all the mentioned problems of EU production, the forecasts are a continuation of the trend of further reduction of production.



Picture 4: Production of pig in European Union [8].

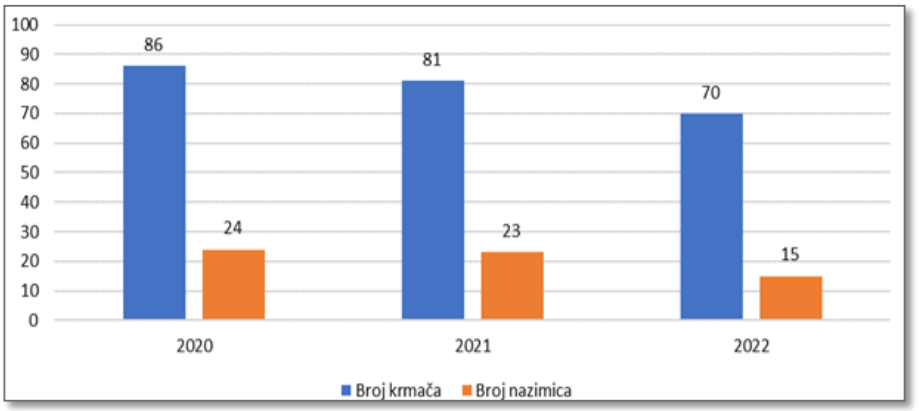


Picture 5: Production index for pig meat in 2022:2021 in European Union by states [8].

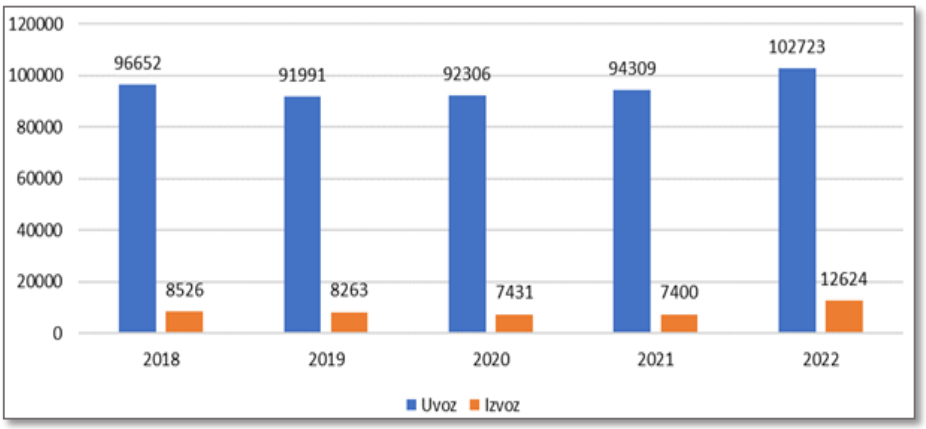
5. PIG BREEDING IN CROATIA

The pig production industry in Croatia has been experiencing a significant decline in recent years, with the number of sows decreasing rapidly. According to data published by DG AGRI [8], the number of sows for the year 2022 has decreased by 13.5% compared to the previous year, and the number of gilts has decreased by 34.7%. In 2021 alone, the number of sows decreased by 8%, and the number of gilts by 4.2%. This trend has been ongoing for the past five years, resulting in a loss of 35% of the number of sows and gilts in the Republic of Croatia. As a result of the shortage of piglets for fattening, Croatia has been importing them from the EU. In 2022, 410,000 piglets were imported for fattening, which is a 16.5% increase compared to the previous year. The value of these piglets was approximately 30,000,000 euros. Furthermore, during the year 2022, a total of 1,147,096 classified pig carcasses of all categories were recorded in the Republic of Croatia, which

is 5.5% less compared to the year 2021. Moreover, the total mass of carcasses on the slaughter line decreased by 7.3% in 2022 compared to the previous year. In 2022, the import of meat from the EU amounted to 102,258 tons, which is a 9% increase compared to 2021. The value of imported meat was approximately 250,000,000 Euros. This increase in imported meat can be attributed to the decline in the domestic pig production industry.



Picture 6: Number of gilts and sows in Croatia (in 000) [8].



Picture 7: Import and export of fresh pig meat in Croatia (in 000 kg) [9]

In the Republic of Croatia, pork meat is the most popular choice among citizens with an estimated consumption of 42 kg per year. Poultry meat comes in second with 19 kg and beef meat follows with around 10 kg. However, despite the high consumption of pork meat, self-sufficiency in pork production in the country is only 55% when including production for own needs. If we take into account production for the market, the slaughtering of approximately 81,000 t takes place in Croatia, out of which 20% is imported. Additionally, the country imports 102,000 t of meat, which means that self-sufficiency drops to 36%. This lack of self-sufficiency in food production is a major national security issue for Croatia, as it only produces around 55% of its needs. As Croatia continues to import more than half of its pig meat, it is expected that pork prices will increase and may become more difficult to find in the future, due to the negative trend in pig production across the EU. The current food supply and security system has become highly unstable, which has prompted the country to seek alternative and digital solutions to ensure the production of quality food in a revolutionary way. Through the GoAgro platform, citizens can directly participate in investment projects in food production by connecting directly with producers. This innovative

platform aims to address the existing food production issues by offering a transparent and secure way for producers and investors to collaborate and support each other.

6. CONCLUSION

Asset tokenization is an innovative concept that combines the traditional financial sector with advanced blockchain technology. This process enables the conversion of real assets into digital tokens on the blockchain chain and brings many advantages compared to traditional asset management methods, such as greater availability, simplified transfer, and easier asset management. In a broader context, we are not only talking about tokenizing the world but also using technology combined with artificial intelligence to fuel a new industrial revolution. The technology helps to solve the fundamental challenges of digitization - it prevents the copying of digital data, which enables the development of new digital processes and digital legal transactions in combination with a high level of legal security and efficiency. To preserve the databases, they are strictly protected from cyber and physical attacks because they are centralized. Blockchain technology, which is itself a database as a replacement for a traditional database, is a potential solution. By connecting this technology with agricultural production, we are solving two major problems in the food production sector. The first is a safe market for the producer and guaranteed availability of food of known quality for citizens, and the second is the financing of food production through a decentralized private monetary system. This approach greatly reduces the influence of classic monetary financing, which under the centralized policies of the owners often contradicts the goals of ensuring quality food available to citizens. Through these digital technologies, we connect consumers again and emotionally with food production because they become part of the food production chain, they become farmers who produce food for themselves and their families without having to do this work every day. Through a direct connection with the producer, he can influence the targeted quality of food for his needs.
GoAgro is a simple platform where production and consumer will meet directly without intermediaries and the secure technology of smart contracts ensures the connection of these two worlds. Mutual simple interaction will allow better understanding and fulfillment.

7. ACKNOWLEDGEMENTS

Research and dissemination were supported by the Fund for Bilateral Relations within the Financial Mechanism of the European Economic Area and Norwegian Financial Mechanism for the period 2014-2021 (Grant number: 04-UBS-U-0031/23-14).

REFERENCE

[1] WORLD BANK, WB, (2024), What is Food Security? https://www.worldbank.org/en/topic/agriculture/brief/food-security-update/what-is-food-security

[2] FAO, (2024), Global Perspectives Studies: Food and agriculture projections to 2050. https://www.fao.org/global-perspectives-studies/food-agriculture-projections-to-2050/en/

[3] Mantovani, A., Aquilina, G., Cubadda, F., Marcon, F., (2022), Risk-Benefit Assessment of Feed Additives in the One Health Perspective. Frontiers in Nutrition. 9. 10.3389/fnut.2022.843124.

[4] Hayes, A., (2023), Learn what these digital public ledgers are capable of: Blockchain Facts: What Is It, How It Works, and How It Can Be Used. https://www.investopedia.com/terms/b/blockchain.asp

[5] GoAgro, (2024), PIG NFT: Your Stake in Sustainable Swine Farming. https://goagro.eu/en/pig-nft

[6] COPA COGECA, (2024), Feeding Europe's future together. https://copa-cogeca.eu/

[7] EUROPEAN COMISSION, EU (2024), Agricultural production - crops - Statistics Explained. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_production_-_crops

[8] EUROPEAN COMISSION, EU (2024), Agricultural production - livestock and meat - Statistics Explained. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_production_-_livestock_and_meat

DZS, (2023), Publikacije. https://podaci.dzs.hr/hr/publikacije/

THE MODERN TRENDS FOR THE IMPROVEMENT OF SAFETY DAIRY PRODUCTION

SAVREMENI TRENDOVI ZA UNAPREĐENJE SIGURNOSTI PROIZVODNJE MLEKA

Aleksandra Ivetić, associate research [1]
Bojan Stojanović, full professor [2]
Milivoje Ćosić, associate professor [3]
Božidar Milošević, full professor[4]
Radmila Beskorovajni, associate research [5]
Marijana Maslovarić, associate research [6]
Nikola Popović, PhD student [7]
Ivana Grujičić, master student [8]

Abstract: *The paper gives an overview of modern safety diary production, from three aspects such as silage quality, aflatoxin feed contamination, and enteric methane emission. The improvement of dairy production is most efficiently achieved by implementing the latest technologies and innovative solutions in all production segments, but most of all in the field of feeding technology. Modern technologies of ensiling are key to improving safety nutrition and mitigation of enteric methane (ECH_4) emissions. These technologies enable farmers to better manage resources because, in addition to the above, there is a constant risk of contamination of aflatoxins in the food chain around the world, with a serious impact on human and animal health*

Key words*:* milk production, silage, enteric methane, ruminant nutrition, aflatoxin, health safety of milk and feed production

Apstrakt: *U radu je prikazan pregled savremene bezbedne proizvodnje mleka, sa tri aspekta kao što su kvalitet silaže, kontaminacija aflatoksinima i emisija enteričnog metana. Unapređenje proizvodnje mleka najefikasnije se postiže implementacijom najsavremenijih tehnologija i inovativnih rešenja u svim segmentima proizvodnje, ali pre svega u oblasti tehnologije ishrane.Savremene tehnologije siliranja su ključne za poboljšanje bezbednosti ishrane životinja i ublažavanje emisija enteričnog metana (ECH_4). Ove tehnologije omogućavaju poljoprivrednicima da bolje upravljaju resursima jer pored navedenog postoji stalna opasnost od kontaminacije aflatoksina u lancu ishrane širom sveta, sa ozbiljnim uticajem na zdravlje ljudi i životinja.*

Ključne reči: *proizvodnja mleka, silaža, enetični metan, ishrana preživara, aflatoksin, zdravstvena bezbednost proizvodnje mleka i hrane za životinje*

[1]The Institute for Science Application in Agriculture, Belgrade, e-mail: aivetic@ipn.bg.ac.rs
[2] University of Belgrade-Faculty of Agriculture, Serbia, arcturas@agrif.bg.ac.rs
[3] Bijeljina University – Faculty of Agriculture, BIH, micko.cosic@gmail.com
[4] University of Priština temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lešak, Kopaonička bb, 38219 Lešak, Kosovo and Metohia, Serbia, e-mail: bozidar.milosevic@pr.ac.rs
[5]The Institute for Science Application in Agriculture, Belgrade, rbeskorovajni@ipn.co.rs
[6] The Institute for Science Application in Agriculture, Belgrade, mmaslovaric@ipn.bg.ac.rs
[7]The Institute for Science Application in Agriculture, Belgrade, npopovic@ipn.co.rs
[8] University of Belgrade-Faculty of Agriculture, Serbia, grujicic43@gmil.com

1. INTRODUCTION

Ensiling is a microbial process used to preserve fresh feed in animal production as well as in biorefinery [1]. In those processes, lactic acid bacteria (LAB) play a key position in silage microorganisms and the effects of exogenous lactic acid bacteria on silage quality have been widely studied [2]. Additions of LAB inoculants are frequently used to speed up the process of ensiling, prevent the growth of harmful microorganisms, and improve the silage quality of different crops. Furthermore, LAB belongs to the microorganisms that have the GRAS (generally recognized as safe) status [3]. One of the most common silages in the world is made from corn. Com (*Zea mays L.*) silage is a major forage source for ruminants in climates where com is moderate to well adapted, consisting of the high energy, low-protein forage commonly used for growing and finishing beef cattle as supplemental energy for cow and calf production, for growing dairy heifers, and for lactating dairy cows, often in combination with a complementary high-protein forage such as alfalfa (*Medicago sativa L.*) [4].

But, most often corn is infected by mycotoxins on farms, frequently in the form of aflatoxins. Aflatoxins have a significant health, nutritional, and economic impact on the nutritional chain of humans and animals. All participants in the production and food chain such as farmers, grain producers, distributors, crop processors, farmers, and consumers have consequently losses [5]. Direct effects include increased veterinary care costs, reduced livestock production, and continued endangered food safety for humans and animal feed [6].

To minimize the aflatoxin contamination in crop plants, various physical, chemical, and biological methods, and various breeding and genetic engineering approaches as well, have been used to minimize the toxicity of aflatoxin and reduce its level below the recommended one. Several approaches have been manifested to reduce the aflatoxin contamination in crops which include various physical, chemical, and biological methods.

Mycotoxins are secondary products of mold metabolism, which are synthesized by a series of reactions catalyzed by enzymes from a large number of biochemically simple intermediate products of primary metabolism [7]. Mycotoxins are produced by toxic strains of fungi that are found in food for humans and animals [8]. Worldwide, the possibility for the contamination of the nutritional chain with mycotoxins is permanently present, with a serious impact on human and animal health. The presence of a persistent risk from mycotoxins and their undesirable presence in food and feed influenced many countries that have adopted a policy of rigorous controls. The global problems of mycotoxicosis are causing a health hazard, and the toxin-contaminated products losing economic value in the global food market. Therefore, mandatory for food industries to perform analysis on potentially contaminated commodities before the trade [9]. Aflatoxins are one of the most globally well-known and common food and feed contaminants. As a secondary product of mold metabolism, aflatoxins can contaminate a large number of different agricultural and food products, as well as feeds. It is estimated that about 25% of the world is contaminated with at least one mycotoxin. The entry of aflatoxins into the nutritional chain poses a global risk to the public health of humans and animals. Due to its carcinogenic effect, a major negative impact on the health of humans and animals, as well as the great impact on economic losses, aflatoxins pose it exceptional challenge for research around the world. Mycotoxins are considered one of the most important causes of nutritional stress [10]. The International Agency for Research on Cancer (IARC) included AFB1 in the first group by the end of the second millennium, while AFB2, AFG1, AFG2, and AFM1 were grouped in the same class in the 2002 year. There is a need for continuous monitoring of the appearance of aflatoxins in food, feeds, and AFM1 in milk, intending to protect consumers from risks associated with their proven toxicity and carcinogenic effects.

Air pollution depends on many natural and human factors, and the variation of pollutants and weather changes modify the concentration of pollutants in time and space [11]. To meet the

increasing demand for meat and milk, the livestock industry has to increase its production, and without improving its efficiency, raised livestock, especially ruminant animals, will worsen the environmental damage, mainly from ECH_4 emission [12]. Diary organizations worldwide announced greenhouse gas neutrality goals [13]. Mitigation of enteric methane emissions is necessary to achieve these goals. Many innovative solutions are being tested and considered. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization [14]. Addressing these challenges requires collaboration among many organizations and across different sectors, followed by cross-border and worldwide cooperation [14].

2. NEW TRENDS AND OPPORTUNITIES FOR ENSILING

The technology of silage preparation consists of several routine techniques but, each step brings with it several possible consequences for the quality of the obtained silage if it is not implemented correctly [15]. The main points of risk are the selection of the correct stage of maturity of the plant for ensiling, the rapid squeezing of air inside the plant mass in the silo, and the correct covering. Changes in the silo mass occur practically as soon as the mass of plants is transferred from the field to the prepared silo object. What will be the course and intensity of the change depend on several factors, but mostly on those that condition the successful development of lactic acid fermentation, such as moisture in the nutrient, anaerobic environment, carbohydrate content, and temperature. These factors enable the conditions in which the desired microorganisms will dominate during the fermentation of the plant mass and obtain quality silage with high nutritional value.

Choosing the right corn hybrid, and other plant cultivar has implications for silage's nutritional value and milk production. Optimization of harvest maturity, kernel processing, theoretical length of the cut, and cutting height improve or maintain the nutritive value and milk production of lactating dairy cows [16]. Authors point out that technological advancements have been developed and made available to dairy producers and corn growers desiring to enhance the fiber and starch digestibility of whole-plant corn silage. However, inconsistency in silage quality may be also due to the lack of information on gene expression and molecular mechanisms of the microbiota involved in silage production, and modern research is focused on the production of the developing nutrient-quality animal feeds with improved LAB inoculants [1]. Because the adaptability, establishment, and development of LAB in forages during ensiling are partially unknown, the additives with LAB inoculants do not always successfully regulate silage fermentation [17, 18]. One of the main reasons for not establishing sufficient domination of LAB inoculants is the influence of epiphytic microflora in the ensiling plants. Classical microbiological planting techniques defined the epiphytic microbial populations associated with fresh forage, the pivotal role of lactic acid-producing bacteria in the ensiling process, and the contribution of clostridia, bacilli, yeast, and molds to the spoilage of silage [19]. Authors emphasize that polymerase chain reaction-based techniques, including length heterogeneity PCR, terminal RFLP, denaturing gradient gel electrophoresis, and automated ribosomal intergenic spacer analysis were the first molecular methods used to study silage microbial communities. Also, advancements in whole comparative genomic, metagenomic, and metatranscriptomic sequencing have or are in the process of superseding these methods, enabling microbial communities during ensiling to be defined with a degree of detail that is impossible using classical microbiology [19].

To efficiently preserve the green mass of plants and reduce the loss of nutrients during the aerobic degradation of silage, biotech companies have produced microbial inoculants. The number of LAB colonies in such products is usually about $1x10^{11}$ cfu and only 10 g of such additives need to be added for ensiling 10 tons of green plant mass. According to [20], preservation depends on the ability of LAB to produce sufficient acids to stop the growth and other activities of undesirable microorganisms (MO) under anaerobic conditions, whereas the microbial composition of the inoculants is different. Inoculants can consist only of homofermentative or heterofermentative LAB,

or they can consist of a combination of both, with or without the addition of enzymes. The main differences among them are the production of lactic acid (LA) and acetic acid (AA), which greatly affect the fermentation process and aerobic stability of silage. Lactic acid rapidly lowers the pH of the ensiled mass, but unlike AA and propionic acid (PA), it has weak fungicidal properties [21]. *Lactobacillus buchneri* is the dominant species used in obligate heterofermentative LAB silage additives, and it slowly converts LA to AA and 1,2-propanediol during silo storage, improving aerobic stability, while having no effect on animal productivity [22].
Preserving forages as baled silage has increased in the last 2 decades, particularly for small and mid-sized dairy and beef producers. Coblentz and Akins [23] point out that additional wilting (45-50%DM), coupled with the long-stemmed nature of most baled silages, acts to restrict the rate and extent of fermentation for baled silages, thereby suggesting emphasis should be continued maintaining anaerobiosis through (1) applying PE-film wraps promptly; (2) using an appropriate number of PE-film layers (6 to 8); (3) selecting a storage site free of sharp objects or other debris; and (4) monitoring wrapped bales closely for evidence of puncture, particularly by birds or vermin.

Complete or total mixed rations (TMR) are produced by mixing forages, byproducts, concentrates, minerals, vitamins, and additives formulated for a specific concentration of nutrients into a single blend of feed. Animals consume the nutrients necessary to meet the requirements of maintenance and production, [24]. The interest in ensiling total mixed rations (TMR) for ruminants reemerged in the last decades because has: been a sustainable alternative to efficiently handle wet byproducts in ruminant diets, and has markedly higher aerobic stability than its respective fresh TMR, and increases ruminal protein degradability due to proteolysis during storage [25]. Appropriate silage particle size is important because long particles increase eating time [26] especially in silage which is the compulsory component of TMR. In that way at the farms, competitive feeding behavior is created, with limited time for DMI (dry matter intake) at the feed bunk. That limitation in the feeding behavior is often the negative response to poor silage fermentation. The compounds that are shown to have the greatest effect on feeding behavior are lactate, acetate, propionate, butyrate, ammonia-N, and amines in silage [27]. Also, poorly silage fermentation is connected with an exceeding 30% loss of DM (dry matter) [28].

Contamination with undesirable microbes and chemical agents is one of the major problems in silage production. The presence of yeasts and molds can negatively affect silage's nutritional value (NV) because they produce toxic compounds that are harmful to ruminants [29]. These microbes can proliferate massively once the silo is opened due to the presence of oxygen [30]. As a result, increasing yeast and mold populations decrease aerobic stability and reduce silage shelf life [31]. Mycotoxins are secondary fungal metabolites that have been detected in a variety of feed ingredients and can affect human and animal health, and animal productivity. Consuming the contaminated silage, ruminants are often exposed to mycotoxins, primarily such as aflatoxins, trichothecenes, ochratoxin A, fumonisins, zearalenone, and many others. Mycotoxins in silage can be minimized by preventing fungal growth before and after ensiling, with proper silage management to reduce mycotoxin contamination of feeds, and certain mold-inhibiting chemical additives or microbial inoculants can also reduce the contamination levels [32]. Apart from mycotoxins, microbial hazards include *Clostridium botulinum* (associated with cattle botulism), *Bacillus cereus*, *Listeria monocytogenes*, *Shiga toxin-producing Escherichia coli*, *Mycobacterium bovis*, and various mold species [33]. Nevertheless, LAB (*L. brevis* and *L. buchneri*) is capable of producing acetate, proteinaceous compounds, peptides, and hydrogen peroxide which exert antifungal activity [34]. The ability of LAB to release antifungal substances varies among strains [35]. The mixture of homo-and heterofermentative strains improves silage quality by increasing nutrient digestibility and reducing yeast contamination. The use of starter cultures of LAB strains characterized by the ability to lower the level of pathogenic microorganisms may be an optimal method of forage preservation concerning the most hazardous species, like *E. coli*, *Salmonella* spp., or *L. monocytogenes* [3]. In addition to biotic factors that can affect silage

quality, it is important to mention ambient temperature (due to the recent negative climate changes) is a factor that influences all stages of silage making from production in the field to utilization at the feed bunk [36].

Silage management practice should include aspects of workers' safety. Silage-related injury knows no age boundary as workers and bystanders of all ages have been killed in silage accidents [37]. The risk of an accident can be dramatically reduced by correctly sizing the bunker silos and drive-over piles [38], and every farm, feedlot, dairy, and silage contractor should have safety policies and procedures for their silage program, and they should schedule regular meetings with all their employees to discuss safety [37].

3. AFLATOXINS

Mycotoxins are secondary products of mold metabolism, which are synthesized by a series of reactions catalyzed by enzymes from a large number of biochemically simple intermediate products of primary metabolism [7]. Mycotoxins are produced by toxic strains of fungi that are found in food for humans and animals [8]. There is a constant threat of mycotoxin contamination all over the world in the nutritional chain, with a serious impact on human and animal health [39]. The presence of a persistent risk from mycotoxins and their undesirable presence in food and feed influenced many countries that have adopted a policy of rigorous controls. The global problems of mycotoxicosis are causing a health hazard, and the toxin-contaminated products losing economic value in the global food market. Therefore, mandatory for food industries to perform analysis on potentially contaminated commodities before the trade [9]. Various physical,
chemical, biological, and nano-particles based approaches are used for minimizing and management of aflatoxin in food crops. However, researchers are also progressing in the development of fungal-resistant varieties through breeding and genetic engineering approaches but their outcome is still a major concern. Hence a combined approach of using resistant varieties along with recommended pre- and post-harvest practices should be followed by farmers and food industries to minimize and degrade the aflatoxin content in food crops and their derived products. Mycotoxins are considered one of the most important causes of nutritional stress [10].

Molds that produce toxic metabolites - aflatoxins during growth are *Aspergillus flavus, Aspergillus parasiticus* [40], *Aspergillus nominius* [41], *A. minisclerotigenes, A. korhogoensis, A. aflatoxiformans, A. texensis, A. novoparasiticus* and *A. arachidicola* [42]. The four major aflatoxins AFB1, AFB2, AFG1, and AFG2 are commonly found in a wide range of food commodities, AFB1 and AFB.2 are produced by *A. flavus* while AFG1 and AFG2 are produced by *A. parasiticus* [43]. Authors reported that AFB1 constitutes the most harmful type of aflatoxins and is a potent hepato-carcinogenic, mutagenic, and teratogenic, and it suppresses the immune system. The synthesis of AFM1 occurs in the mammalian organism after the intake of contaminated feed with AFB1. Aflatoxins affect the quality of milk because cows metabolize AFB1 to form the monohydroxide derivative aflatoxin M1 (AFM1), which is secreted into cow's milk and is highly resistant to thermal treatments such as pasteurization and freezing [44]. AFM1 is stable in raw milk and prepared dairy products. They mostly undergo undamaged pasteurization processes, cheese production, yogurt, sour cream, and butter. During cheese processing, AFM1 with casein is linked to a specific complex that affects a higher concentration of this mycotoxin in cheese than in whey. However, contaminated whey with AFM1 is often used to feed young animals [45]. The presence of mycotoxins in cow's milk and dairy products is one of the most serious problems in producing a health-safe diet, as milk is a key source of nutrients for humans. The effect of aflatoxin on the organism of domestic animals depends on genetic, physiological, and external factors [14]. The biggest impact on cow's milk contamination is AFB1 with AFM1. Many authors report that the diet of cows with food containing AFB1, in milk toxin AFM-1 will appear in milk after 12-24 h, after consuming a contaminated diet, and will disappear from milk after 3-5 days [46]. Animal feed contaminated with aflatoxins can cause different acute and chronic diseases in animals: refusal of

food, weight loss, decrease in immunity, cancer, decreased reproductive capacity decreased production, and death. Secondary aflatoxicosis tends to introduce into the body a smaller amount of aflatoxin for a very long period, compared to those that lead to obvious signs of poisoning and a change in the immune system [14]. However, in this way, altered immune function makes the animal more susceptible to other infectious diseases. Aflatoxins suppress the immune system of humans and animals by acting on the cells responsible for boosting immunity [43]. Currently, consumers are continuously exposed to low doses of AFM1 [41].

Aflatoxin contamination in crops is a global threat that compromises the safety of food, and feed, and also influences the agricultural economy and crop-dependent small-scale industries [43]. Crops can be contaminated during the process of harvesting, storing, and transporting by the fungi which leads to the production of several mycotoxins. Mycotoxins are produced by certain fungi as secondary metabolites and aflatoxin is one of them. Crops can be contaminated during the process of harvesting, storing, and transporting by the fungi, and this leads to the production of several mycotoxins. Mycotoxins are produced by certain fungi as secondary metabolites and aflatoxin is one of them. Aflatoxin contamination in crops caused a serious threat to production, the food market, health, and economics.
Aflatoxins are synthesized by many fungi spp. including *Aspergillus*, *Penicillium*, *Fusarium*, and *Alternaria* but *Aspergillus flavus* and *Aspergillus parasiticus* are known to produce the most toxigenic strains of aflatoxins [43].

Aflatoxins have a significant health, nutritional, and economic impact on the nutritional chain of humans and animals. All participants in the production and food chain such as farmers, grain producers, distributors, crop processors, farmers, and consumers have consequently losses [5]. Direct effects include increased veterinary care costs, reduced livestock production, and continued endangered food safety for humans and animal feed [6]. To minimize the aflatoxin contamination in crop plants, various physical, chemical, and biological methods, and various breeding and genetic engineering approaches as well, has been used to minimize the toxicity of aflatoxin and reduce its level below the recommended one. Several approaches have been manifested to reduce the aflatoxin contamination in crops which include various physical, chemical, and biological methods.

3.1. LEGAL REGULATIONS

Both toxins, AFB1 and AFM1 are carcinogenic. However, AFM1 is the most toxic secondary metabolite secreted in milk and is classified as group 1 carcinogenic by the International Agency for Research on Cancer (IARC, 2002) [47]. As such, AFM1 poses a global health risk to food safety for humans and animals. Regulation (EC) No 1881/2006 sets a maximum limit of 0.05 μg/kg for AFM1 in raw milk, heat-treated milk, and milk for the production of milk-based products (European Commission, EC/1881/2006) [48]. The same limit was valid in Serbia from 2011 (Official Gazette of RS, 28/2011) [49] until the end of February 2013.

However, after the appearance of contamination of milk with AFM1 in Serbia at the end of February 2013, the Government of Serbia established a new maximum level of 0.25 μg/kg of milk. The permissible level of aflatoxin (AFM1) in milk in Serbia, is five times higher than in the European Union and may be reduced at the end of 2024, according to the Regulation amending the Regulation on maximum concentrations of certain contaminants in food (Official Gazette of the Republic of Serbia, No. 110/2023) [50]. The amendment of the Regulation on maximum concentrations of certain contaminants in foodstuffs (Official Gazette of the Republic of Serbia, No. 81/2019, 126/2020, 90/2021, 118/2021, 127/2022, 110/2023) [50]. provides for the lowering of the permitted levels of this substance from 1 December 2023, Table 1.

Table 1. Permitted levels of aflatoxin contamination in foodstuffs, Regulation on maximum concentrations of certain contaminants in foodstuffs (Official Gazette of the Republic of Serbia, No. 81/2019, 126/2020, 90/2021, 118/2021, 127/2022 and 110/2023*)

No	Food		Maximum permissible concentration (μg/kg)		
			B_1	Amount B_1, B_2, G_1 i G_2	M_1
2.1.13.	**Raw milk, thermally processed milk, and milk for the production of dairy products**	**Until 30 November 2023. *Extend to ▼ Until 30 November 2024.**	-	-	**0,25**
		As of December 1, 2023. *Extend to ▼ As of December 1, 2024.			**0,050**

Regulation on the quality of feed (Official Gazette of the Republic of Serbia, No. 4 /2010, 113 /2012, 27 /2014, 25 / 2015, 39 /2016, 54 /2017), [51]. more closely prescribes the conditions regarding the quality of feed. The limits of the levels of AFB1 in feedstuffs, complementary and complete mixtures for animals, are prescribed in Article 99 of this Regulation and are shown in Table 2. Feed, for this Regulation, means products of plant, animal, and mineral origin, produced naturally or industrially, which are used for the nutrition and production of premixes and mixtures.

It should be noted that as long as the parent compound AFB1 is not controlled both in food and in feed, it cannot be expected that only control of AFM1 exposure cannot be expected to lead to a significant global reduction in hepatocellular carcinoma (liver cancer), [52]. Chhaya *et al*. [8] state that in the European Union the maximum permitted level of aflatoxin B1 in feed is 0.02 mg kg−1 (moisture content 12%) or 20,000 ng kg−1, with a maximum allowable content in concentrated feed for dairy cows of 0.005 mg kg−1 (moisture content 12%) or 5000 ng kg^{-1} (Directive 2002/32/EC) [48].

Farm productivity problems caused by toxins can be prevented [53]. Early and rapid detection of aflatoxin M1 by applying a strict self-control strategy resulting in the application of mitigation measures can significantly reduce the concentration of aflatoxin M1 in milk [42].

Table 2 Limits of permitted levels of AFB1 in feed, supplementary and complete mixtures for animals, (Regulation on the quality of feed, Article 99, Official Gazette of the Republic of Serbia, No. 4 /2010, 113 /2012, 27 /2014, 25 / 2015, 39 / 2016, 54 /2017)

Undesirable substances	Products intended for feed	Maximum allowable amount expressed in mg/kg (ppm), when the moisture content of feed is calculated at 12%
Aflatoxin B1	Feeds	0,03
	Complementary and complete mixtures	0,01
	Except:	
	– mixtures (complementary and complete) for dairy cows and calves, dairy sheep and lambs, milk goats and goats, piglets and young poultry	0,005
	– Mixtures (complementary and complete) for cattle (excluding dairy cows and calves), sheep (except dairy sheep and lambs), goats (except dairy goats and goats), pigs (except piglets), and poultry (except young animals).	0,02

Aflatoxins have a significant health, nutritional, and economic impact on the nutritional chain of humans and animals. There is a need for continuous monitoring of the appearance of aflatoxins in feeds and AFM1 in milk, to protect the risks associated with their proven toxicity and carcinogenic effects. Worldwide, the possibility of contamination of the food chain with mycotoxins is permanently present, with a serious impact on human health. The presence of the persistent danger of mycotoxins and their undesirable presence in food affects that many countries have adopted a policy of rigorous controls. Therefore, ELISA methods, as well as Liquid Chromatography methods with different detectors (HPLC-FLD, HPLC-UV light-FLD, LC-MS/MS) are developed and optimized for the implementation [54]. If the primary toxin AFB1 is not controlled in both food and feed, controlling AFM1 exposure cannot be expected to lead to a meaningful global reduction. In the long term, regular farm-to-fork aflatoxin monitoring should be an essential tool to prevent the presence of aflatoxin levels in food and feed.

4. ENTERIC METHANE

Air pollution depends on many natural and human factors, and the variation of pollutants and weather changes modify the concentration of pollutants in time and space [11]. To meet the increasing demand for meat and milk, the livestock industry has to increase its production, and without improving its efficiency, raised livestock, especially ruminant animals, will worsen the environmental damage, mainly from ECH_4 emission [12]. Diary organizations worldwide announced greenhouse gas neutrality goals [13]. Mitigation of enteric methane emissions is necessary to achieve these goals. Many innovative solutions are being tested and considered. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization [14]. Addressing these challenges requires collaboration among many organizations and across different sectors, followed by cross-border and worldwide cooperation [14].

Global climate change is affecting temperature, precipitation, and water availability, which directly affects agriculture and livestock productivity [55]. Therefore, the expected decline in DMI and animal productivity and changes in water intake caused by heat stress may also affect the environmental costs of production in cattle. With the current interest in reducing ECH_4 emissions in ruminant production systems to limit global warming [56], models that predict ECH_4 emissions have become an important tool to evaluate mitigation strategies [57] when other technologies are not available to measure individual enteric CH4 emissions [55]. The agricultural sector is faced with challenges related to global warming and climate change, which affect human and animal food security. Due to climate change, periods of drought might be longer and occur more frequently, which challenges roughage production and requires changed feeding of dairy cattle by increasing the grain content of the diet, [14, 58]. Also, the feeding behavior of cattle could be managed more effectively [59]. Land plays a key role in the global cycles of GHG (i.e., carbon dioxide (CO2), methane (CH4), and nitrogen oxide (N2O), and land use change can lead to the release of such gases into the atmosphere or the removal of them from the atmosphere [60]. One of the most common forms of land use change is agricultural land conversion where agricultural lands are converted for other uses. Huang *et al.*, [60] reported that increasing agricultural land conversion to more than 8 % of available land led to increasing GHG emissions during the economic development process.

Livestock enteric CH_4 mitigation is an old feed energy efficiency problem with new dimensions, [61]. Governments and the public are interested in finding solutions to climate change, and it is believed that mitigation of agricultural greenhouse gas (GHG) emissions is part of the solution (US Government, 2021) [62]. In the United States, agricultural activities are responsible for the generation of GHG such as CO_2, CH_4, and N_2O, with the latter 2 gases being of primary interest: agriculture contributed 39% (CH_4) and 80% (N_2O) of their total emissions in 2019, on a CO_2-

equivalent basis (USEPA, 2021). Within agriculture, livestock is responsible for 94% of all CH_4 emissions in the United States (USEPA, 2021) [63].

Continuous research and development are needed to develop enteric CH_4 mitigation strategies that are locally applicable, also information is needed to calculate the carbon footprints of interventions on a regional basis to evaluate the impact of mitigation strategies on net greenhouse gas emissions [64].

Enteric methane is a major source of greenhouse gas emissions from milk and beef production systems that contribute to global warming, [65]. Enteric fermentation is the second largest source of methane emissions after natural gas and petroleum systems, and the second largest source of agricultural greenhouse gas emissions in the United States after nitrous oxide emissions from managed soils (US EPA, 2021) [66].

Methane is estimated to have a global warming potential, global warming potential (GWP), 28–30 more than carbon dioxide over a hundred years, by the United States Environmental Protection Agency (EPA, 2021) [67], and Intergovernmental Panel on Climate Change (IPCC 2021) [68], Table 1.

Table 1. IPCC Sixth Assessment Report Global Warming Potentials, 2021.

Greenhouse Gas	100 Year Time Period			20 Year Time Period		
	AR4 2007	AR5 2014	AR6 2021	AR4 2007	AR5 2014	AR6 2021
CO_2	1	1	1	1	1	1
CH_4 fossil origin	25	28	29.8	72	84	82.5
CH_4 non fossil origin			27.2			80.8
N_2O	298	265	273	289	264	273

In the AR6 report, an additional GWP for methane has been included to differentiate between methane which originates from fossil fuel sources, and methane from non-fossil fuel sources, like agriculture.

Unlike other sources of greenhouse gas emissions, such as those from fossil fuel extraction and distribution that only contribute to atmospheric greenhouse gases, milk production systems are part of the biological carbon cycle and can function as a sink for greenhouse gases, thereby contributing to reverting climate change [69]. Because emitted methane is continuously removed from the atmosphere by hydroxyl oxidation, its atmospheric warming effects depend on the rate of emissions increase or decrease over the last 20 years rather than the total cumulative amount emitted over that period [70]. Significant reduction in methane emissions, particularly from agricultural activities, would rapidly mitigate climate change and is a powerful lever to meet the European Union's 2050 climate targets [71].

Gloux et al. [72] highlight that the Intergovernmental Panel on Climate Change (IPCC 2022) [73] defines 3 different methods, to be applied to national inventories according to data availability:
- Tier 1 methods attribute default yearly enteric methane emissions factor per dairy cow;
- Tier 2 methods improve the accuracy of emission factors by including feed intake estimates of a representative diet and dairy cow;
- Tier 3 methods require a precise characterization of cows' diet to account for digestibility;

Aspects of the cost of implementing mitigation strategies have to be considered, for the adoption of mitigation strategies for livestock GHG emissions. Climate change mitigation and adaptation

policies play a crucial role in the political agendas of local authorities who have to support the development and implementation of innovative products or methods for ECH_4 mitigation.

The amount of ECH_4 that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed [14]. Ruminant livestock (e.g., cattle, sheep) are major sources of ECH_4 [74-76, 14] with moderate amounts produced from non-ruminant livestock (e.g., pigs, horses). World demand for animal-sourced foods and global warming concerns rise, safe and effective strategies for enteric methane mitigation in dairy cows are in high demand and [13] created the dataset from data collected from scientific publications identified through searches of the scientific literature for the greenhouse mitigation effects. The bibliography used by [56], covers the period from 1963 to 2018, and [13], supplemented with literature searches to cover the period between 2019 and 2022, with 797 treatments included. Mitigation strategies were classified into 3 main categories: animal and feed management, diet formulation, and rumen manipulation, and up to 5 subcategories [57]. This large dataset with descriptive data and treatment means from in vivo dairy cow enteric methane studies can be used by public and private researchers and advisors including nutritionists, environmentalists, and economists interested in cost-effective solutions to reduce global warming without compromising dairy farm sustainability [72].

Nutritional interventions to mitigate enteric CH_4 have been thoroughly investigated [14] and, likely, strategies based on supplementation with plant extracts [77, 78] or the addition of dietary fat [58] can reduce methane may have a higher acceptance by livestock producers compared with, for example, the use of antibiotics [79, 80]. The quality and the composition of silage are important elements of a ration daily for ruminant feeding, [15, 81, 53] influencing the ECH_4 emission.

The ruminant gut structure fosters extensive enteric fermentation of their diet, [15]. Enteric CH_4 emission from ruminants also reduces feed energy efficiency for the animals, [12]. Macroalgae (seaweeds) have highly variable chemical composition and have been studied by [82] for their ability to reduce enteric methane emissions of ruminants when fed as a feed supplement. Methane inhibitors (3-NOP and bromochloromethane) had the largest CH_4 mitigation effect [61]. and did not affect DMI, fiber digestibility, milk production, or ADG.

Two organizations based in the United States, the Foundation for Food and Agriculture Research and the Dairy Research Institute, have developed a collaborative program Greener Cattle Initiative to align resources and fund projects to identify, develop, and validate new and existing mitigation options for enteric methane emissions from dairy and beef cattle[65] shown in Figure1

Increased confidence in mitigation estimates is needed to develop socioeconomic innovation that encourages the adoption of mitigation options. Mitigation options need to be deployed by a substantial number of dairy farmers to achieve the desired results [65]. Antimethanogenic strategies may decrease total CH4 production (absolute emissions, g/d), CH_4 yield (g/kg of DMI), or CH_4 intensity (g/kg of meat, milk, or wool produced), [64].

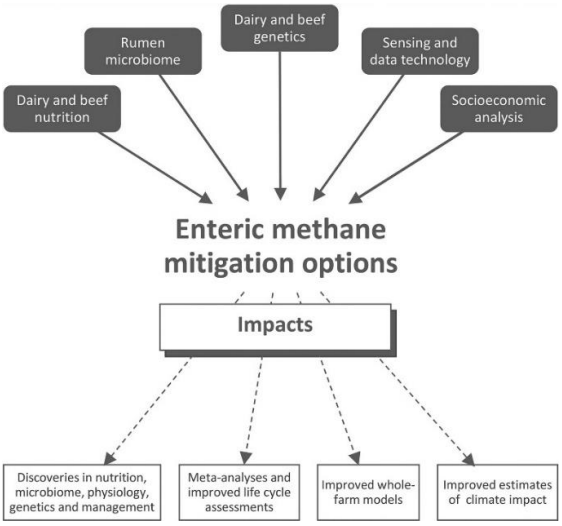


Figure 1. Areas of focus and expected impacts for research of enteric methane mitigation options for beef and dairy cattle, Tricarico *et al.* 2022.

It should be mentioned, that the number of monitoring tools and experiences is progressively increasing also due to improvements in the standardization of methods and the proliferation of research and accounting experiments, which bring about an increase in awareness of political subjects and the general public [83].

5. CONCLUSION

The safety of dairy production in these papers is featured from three aspects such as silage quality, aflatoxins feed contamination, and enteric methane emission.

The first aspect is that the improvement of dairy production is most efficiently achieved by implementing the latest technologies and innovative solutions in all production segments, but most of all in the field of feeding technology. Silage is a mandatory component of the total mix ratio for high-performing dairy cows and its quality has a great influence on the production and quality of milk. Changes in the silo mass occur practically as soon as the mass of plants is transferred from the field to the prepared silo object. What will be the course and intensity of the change depend on several factors, but mostly on those that condition the successful development of lactic acid fermentation, such as moisture in the nutrient, anaerobic environment, carbohydrate content, and temperature. One of the most common silages in the world is made from corn.

The second aspect is that most often corn is infected by mycotoxins on farms, frequently in the form of aflatoxins. Aflatoxins have a significant health, nutritional, and economic impact on the nutritional chain of humans and animals. All participants in the milk production and food chain (farm to fork), such as farmers, grain producers, distributors, crop processors, and farmers, have consequently losses. Consumers are constantly exposed to nutritional stress. The four major aflatoxins AFB1, AFB2, AFG1, and AFG2 are commonly found in a wide range of food and feed commodities. The synthesis of AFM1 occurs in the mammalian organism after the intake of contaminated feed with AFB1. Both toxins, AFB1 and AFM1 are carcinogenic. However, AFM1 is the most toxic secondary metabolite secreted in milk and is classified as a group 1 carcinogenic by the International Agency for Research on Cancer. Aflatoxins affect the quality of milk because cows metabolize AFB1. Secondary aflatoxicosis tends to introduce into the body a smaller amount of

aflatoxin for a very long period, compared to those that lead to obvious signs of poisoning and a change in the immune system. In the long term, regular farm-to-fork aflatoxin monitoring should be an essential tool to prevent the presence of aflatoxin levels in food and feed

The third aspect is that the agricultural sector is nowadays faced with challenges related to global warming and climate change, which affect human and animal food security. Increased confidence in mitigation estimation and practice is needed to develop socioeconomic innovation that encourages the adoption of mitigation options. The quality and the composition of silage are important elements of a ration daily for ruminant feeding, influencing also the ECH_4 emission. Enteric methane is a major source of greenhouse gas emissions from ruminant farms. The discovery of new enteric methane mitigation options is not enough for the dairy sector to meet its environmental stewardship goals on climate change. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization. Addressing these challenges requires collaboration among many organizations across different sectors, and is necessary to be followed by cross-border and worldwide cooperation.

6. ACKNOWLEDGMENT

The research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, on the basis of the Agreement on the realization and financing of scientific research work of SRO in 2023 No. 451-03-47/2023-01/200045.

REFERENCES

[1] Okoye, C. O., Wang, Y., Gao, L., Wu, Y., Xia, Li, Sun, J., Jiang, J. (2023). The performance of lactic acid bacteria in silage production: A review of modern biotechnology for silage improvement. Microbiological Research, 266, 127212, ISSN 0944-5013

[2] Wang, X., Cao, X., Liu, H., Guo, L., Lin, Y., Liu, X., Xiong, Y., Ni, K., Yang, F. (2021). Effects of Lactic Acid Bacteria on Microbial Metabolic Functions of Paper Mulberry Silage: A BIOLOG ECO Microplates Approach. Front Microbiol., 12:689174. doi: 10.3389/fmicb.2021.689174.

[3] Fabiszewska, A.U., Zielińska, K.J., Wróbel, B. (2019). Trends in designing microbial silage quality by biotechnological methods using lactic acid bacteria inoculants: a minireview. World J Microbiol Biotechnol., 35(5):76.

[4] Allen, Michael & Coors, J.G. & Roth, Gregory, (2003). Silage Science and Technology. Agronomy Monograph 42. Corn silage., pp.547-608

[5] Ivetić, A., Ćosić, M., Radulović, S., Cvijanović, G., Stojanović, B., Davidović, V., Jandrić, M. (2022). Application of biological waste of the food industry for animal feeding. Book of Abstracts, 5th International Scientific Conference "Village and Agriculture", Biljeljina, BIH

[6] Ćosić, M., Ivetić, A., (2022). Govedarska proizvodnja i pripremanje silaže. Monografija, Univerzitet „Bijeljina“, Poljoprivredni fakultet

[7] Kos, J. (2015). Aflatoksini: analiza pojave, procena rizika i optimizacija metodologije određivanja u kukuruzu i mleku. Doktorska disertacija, Tehnološki fakultet, Univerzitet u Novom Sadu;

[8] Chhaya, R. S., Membré, J.M., Nag, R., Cummins, E. (2023). Farm-to-fork risk assessment of aflatoxin M1 in milk under climate change scenarios – A comparative study of France and Ireland, Food Control, 149, 109713.

[9] Schincaglia, A., Aspromonte, J., Franchina, F.A., Chenet, T., Pasti, L., Cavazzini, A., Purcaro, G., Beccaria M. (2023). Current Developments of Analytical Methodologies for Aflatoxins' Determination in Food during the Last Decade (2013-2022), with a Particular Focus on Nuts and Nut Products. Foods. 2023 Jan 24;12(3):527. doi: 10.3390/foods12030527. PMID: 36766055; PMCID: PMC9914313;

[10] Ivetić, A., Grubić, G., Tončić, T. (2007a). Aflatoksin. Stručna Konferencija Saveza zdravstvenih radnika Vojvodine. Tara, 19-22. april, 2007; Zbomik radova, str. 8.
[11] Battista, G. (2017). Analysis of the Air Pollution Sources in the City of Rome (Italy), Energy Procedia,Volume 126, pp. 392-397.
[12] Wang, K., Xiong, B., Zhao, X. (2023). Could propionate formation be used to reduce enteric methane emissions in ruminants? Science of The Total Environment, 855,158867.
[13] De Ondarza Mary Beth, D-O.M., Hristov, A.N., Tricarico, J.M.(2023). A global dataset of enteric methane mitigation experiments with lactating and non-lactating dairy cows conducted from 1963 to 2022. Data in Brief, 49, 109459, doi: 10.1016/j.dib.2023.109459Dupraz, P. 2021. Policies for the ecological transition of agriculture: the livestock issue. Rev. Agric. Food Environ. Stud. 101, pp.529–538.
[14] Ivetić, A., Jovanović, R., Radulović, S., Stojanović, B., Ćosić, M., Davidović, V., Bajagić, M. (2023). Uticaj aflatoksina na zdravstvenu bezbednost i kvalitet mleka. 34 Conference Veterinarian of Serbia. Zlatibor 7-10 September 2023;
[15] Ivetić, A. (2017). Uticaj mikrobioloških inokulanata na hranljivu vrednosti i aerobnu stabilnost silaže kukuruza i senaže lucerke. Univezitet u Beogradu-Poljoprivredni fakultet, doktorska disertacija.
[16] Ferraretto, L.F., Shaver, R.D., Luck, B.D. (2018). Silage review: Recent advances and future technologies for whole-plant and fractionated corn silage harvesting, Journal of Dairy Science, 101(5), pp. 3937-3951.
[17] Cheng, Q., Li, M., Fan, X., Chen, Y., Sun, H., Xie, Y., Zheng, Y., Chen, C., Li, P., (2022). Effects of epiphytic and exogenous lactic acid bacteria on fermentation quality and microbial community compositions of paper mulberry silage. Front Microbiol. 2022, 13:973500.
[18] Kobayashi, H., Cai, Y., Uegaki, R., Shimizu, M., Nakajima, M., Kanaya, C., et al., (2010). Microorganism composition of high moisture Italian ryegrass (Lolium multiflorum lam.) and its fermentation characteristics of silage inoculated with lactic acid bacteria. JPN J. Grassl. Sci. 56, pp.39–46.
[19] McAllister, T.A., Dunière, L., Drouin, P., Xu, S., Wang, Y., Munns, K., Zaheer, R. (2018). Silage review: Using molecular approaches to define the microbial ecology of silage,
[20] Cai Yimin, Benno, Y., Ogawa, M., Kumai, S. (1999). Effect of Applying Lactic Acid Bacteria Isolated from Forage Crops on Fermentation Characteristics and Aerobic Deterioration of Silage. Journal of Diary Science, 82, pp.52-526
[21] Woolford, M.K., 1984. The Silage Fermentation. Marcel Decker, New York.
[22] Muck, R.E., Nadeau, E.M.G., McAllister, T.A., Contreras-Govea, F.E., Santos, M.C., Kung, L.. Jr. (2018). Silage review. Recent advances and future uses of silage additives. J Dairy Sci., pp. 3980-4000. doi: 10.3168/jds.2017-13839. PMID: 29685273.
[23] Coblentz, W.K., Akins, M.S. (2018). Silage review: Recent advances and future technologies for baled silages, Journal of Dairy Science, 101(5), pp.4075-4092
[24] Schingoethe, D.J. (2017) A 100-Year Review: Total mixed ration feeding of dairy cows. J. Dairy Sci., 100, 10143–10150.
[25] Bueno, A.V.I., Lazzari, G., Jobim, C.C., Daniel, J.L.P., (2020). Ensiling Total Mixed Ration for Ruminants: A Review. Agronomy, 10, 879.
[26] Mertens, D. R. (1997). Creating a system for meeting the fiber requirement of dairy cows. J. Dairy Sci. 80, pp.1463–1481.
[27] Grant, R.J., Ferraretto, L.F. (2018). Silage review: Silage feeding management: Silage characteristics and dairy cow feeding behavior, Journal of Dairy Science, 101 (5), 4111-412.
[28] Grant, R.J., Adesogan, A.T. (2018). Journal of Dairy Science Silage Special Issue: Introduction, 2018. J Dairy Sci. ,3935-3936. doi: 10.3168/jds.2018-14630. PMID: 29685270;

[29] Alonso, V.A.; Pereyra, C.M.; Keller, L.A.M.; Calcero, A.M.; Rosa, C.A.R.; Chiacchiera, S.M.; Cavaglieri, L.R. (2013). Fungi and mycotoxins in silage: an overview. J. Appl. Microbiol., 115, pp.637–643.
[30] Paradhipta, D.H.V., Lee, S.S., Kang, B., Joo, Y.H., Lee, H.J., Lee, Y., Kim, J., Kim, S.C, (2020). Dual-Purpose Inoculants and Their Effects on Corn Silage. Microorganisms 2020, 8.
[31] Wilkinson, J.M., Davies, D.R. (2012). The aerobic stability of silage: Key findings and recent developments. Grass Forage Sci., 68, pp. 1–19.
[32] Ogunade, I.M., Martinez-Tuppia, C., Queiroz, O.C.M., Jiang, Y., Drouin, P., Wu, F., Vyas, D., Adesogan, A.T. (2018). Silage review: Mycotoxins in silage: Occurrence, effects, prevention, and mitigation, Journal of Dairy Science, 101(5), pp. 4034-4059;
[33] Driehuis, F., Wilkinson, J.M., Jiang, Y., Ogunade, I., Adesogan, A.T. (2018). Silage review: Animal and human health risks from silage. J Dairy Sci., pp.4093-4110.
[34] Kleinschmit, D.H.;, Schmidt, R.J., Kung, L., Jr. (2005). The effects of various antifungal additives on the fermentation and aerobic stability of corn silage. J. Dairy Sci., 88, pp. 2130–2139.
[35] Schnürer, J., Magnusson, J. (2005). Antifungal lactic acid bacteria as biopreservatives, Trends in Food Science & Technology, 16(1–3),pp.70-78.
[36] Bernardes, T.F., Daniel, J.L.P., Adesogan, A.T., McAllister, T.A., Drouin, P., Nussio, L.G., Huhtanen, P., Tremblay, G.F., Bélanger, G., Cai, Y. (2018). Silage review: Unique challenges of silages made in hot and cold regions. J. Dairy Sci., pp. 4001-4019. doi: 10.3168/jds.2017-13703. PMID: 29685274;
[37] Bolsen, K.K. (2018). Silage review: Safety considerations during silage making and feeding. J Dairy Sci. ,4122-4131. doi: 10.3168/jds.2017-13738. PMID: 29685281;
[38] Holmes, B. J., Bolsen, K. K. (2009). What's new in silage management? Pages 61–76 in Proc. 15th International Silage Conf., Madison, WI;
[39] Ivetić, A., Ćosić, M. (2021a). Aerobic stability of silage. Scientific conference with International Participation, Village and Agriculture. Bijeljina, Republika Srpska. Proceedings, pp. 125-142.
[40] Kihal, A., Rodrigez-Prado, M., Calsamiglia, S. (2023). A network meta-analysis on the efficacy of different mycotoxin binders to reduce aflatoxin M_1 in milk after aflatoxin B_1 challenge in dairy cows. Journal of Dairy Science, 108 (8), 5378-5387.
[41] Buzás, H., Szabó-Sárvári, L.C., Szabó, K., Nagy-Kovács, K., Bukovics, S., Süle, J., Szafner, G., Hucker, A., Kocsis, R., Kovács, A.J. (2023)..Aflatoxin M1 detection in raw milk and drinking milk in Hungary by ELISA − A one-year survey, Journal of Food Composition and Analysis, 121;
[42] Giacometti, F., Tomasello,F., Savini, F., Indio, V., Bacak, A., Canever, A., Bonilauri, P., De Cesare, A., Serraino, A. (2023). Impact of the implementation of tailored management strategies to reduce the occurrence of aflatoxin M1 in milk-supply chain in Italy, Food Control, 149,109720,
[43] Kumar, A., Pathak, H., Bhadauria, S., Sudan Jebu, (2021). Aflatoxin contamination in food crops: causes, detection, and management: a review. Food Prod Process and Nutr 3, 17;
[44] Alvarado AM, Zamora-Sanabria R and Granados-Chinchilla F (2017) A Focus on Aflatoxins in Feedstuffs: Levels of Contamination, Prevalence, Control Strategies, and Impacts on Animal Health. Aflatoxin-Control, Analysis, Detection and Health Risks. InTech. DOI: 10.5772/intechopen.69468;
[45] Chavarría, G., Molina, A., Leiva, A., Méndez, G., Wong-González, E., Cortés-Muñoz, M., Rodríguez, C., Granados-Chinchilla, F. (2017). Distribution, stability, and protein interactions of Aflatoxin M1 in fresh cheese. Food Control.,73(Part B) pp.581-586;
[46] Ivetić, A., Grubić, G., Adamović, M., Tončić, T. (2007b). Uloga zeolita u dobijanju zdravstveno bezbedne hrane. Majski susreti zdravstvenih radnika Republike Srbije, sa medunarodnim učešćem. Savez zdravstvenih radnika Republike Srbije, Zlatibor, 9-13. maj 2007; Zbornik radova, str.407.

[47] IARC, International Agency for Research on Cancer, (2002). Some traditional herbal medicines, some mycotoxins, naphthalene and styrene. Monographs on the Evaluation of Carcinogenic Risks to Humans. 82, Lyon, France (2002), pp. 171-249.
[48] European Commission DIRECTIVE 2002/32/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 May 2002 on undesirable substances in animal feed (2006);
[49] Pravilnik o maksimalnim koncentracije određenih kontaminenata u hrani, (Službeni glasnik RS, br.28/2011, 81/2019, 126/2020, 90/2021, 118/2021 i 127/2022);
[50] Pravilnik o maksimalnim koncentracijama određenih kontaminenata u hrane, ((Sl. glasnik RS br. 81/19 , 126/20 , 90/21 , 118/21 , 127/22 , 110/23)
[51] Pravilnik o kvalitetu hrane za životinje („Službeni glasnik RS", br. 4/10, 113/12, 27/14, 25/15, 39/16 i 54/17);
[52] Turna, N. S., Havelaar, A., Adesogan, A., Wu,F. (2022). Aflatoxin M1 in milk does not contribute substantially to global liver cancer incidence,The American Journal of Clinical Nutrition, 115,(6), pp.1473-1480,
[53] Ivetić, A., Đorđević, N., Radin, D., Stojić, P., Grubić, G., Stojanović, B. (2013): Značaj aerobne stabilnosti silirane stočne hrane. Zbornik naučnih radova Instituta PKB Agroekonomik, 19(3-4), 47-60.
[54] Kos, J., Janić Hajnal, E., Jajić, I., Krstović, S., Mastilović, J., Šarić, B., Jovanov, P. (2016). Comparison of ELISA, HPLC-FLD and HPLC-MS/MS Methods for Determination of Aflatoxin M1 in Natural Contaminated Milk Samples. Acta Chim Slov. 2016 Dec; 63(4), 747-756.
[55] Souza, V.C., Moraes, L.E., Baumgard, L.H., Santos, J.E.P., Mueller, N.D., Rhoads, R.P., Kebreab, E. (2023). Modeling the effects of heat stress in animal performance and enteric methane emissions in lactating dairy cows, Journal of Dairy Science, 106(7);
[56] Arndt, C., A. N. Hristov, W. J. Price, S. C. McClelland, A. M. Pelaez, et al., (2022). Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5°C target by 2030 but not 2050. Proc. Natl. Acad. Sci. USA 119:e2111294119.
[57] Niu, M., Kebreab, E., Hristov, A. N., Oh, J., Arndt, C., Bannink, A. (2018). Prediction of enteric methane production, yield, and intensity in dairy cattle using an intercontinental database. Glob. Chang. Biol., 24, pp.3368–3389;
[58] Olijhoek, D.W., Hellwing, A.L.F., Noel, S.J., Lund, P., Larsen, M., Weisbjerg, M.R., Børsting, C.F. (2022). Feeding up to 91% concentrate to Holstein and Jersey dairy cows: Effects on enteric methane emission, rumen fermentation, and bacterial community, digestibility, production, and feeding behavior, Journal of Dairy Science, 105(12), 9523-9541;
[59] Ivetić, A., Grubić, G. (2007). The feeding behavior of dairy cows and their welfare. ISAH, XIII Congress, Tartu, Estonia, 1, pp. 65-68.
[60] Huang S., Ghazali, S., Azadi, H. et al., 2023.Contribution of agricultural land conversion to global GHG emissions: A meta-analysis,Science of The Total Environment, 876,162269,
[61] Hristov, A.N., Melgar, A., Wasson, D., Arndt, C. (2022). Symposium review: Effective nutritional strategies to mitigate enteric methane in dairy cattle, Journal of Dairy Science, 105(10) pp. 8543-8557.
[62] US Government. (2021). Executive Order on Tackling the Climate Crisis at Home and Abroad. Accessed Feb. 18, 2022. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/.
[63] USEPA (United States Environmental Protection Agency) (2021). Inventory of U.S. greenhouse gas emissions and sinks: 1990–2019. US EPA. 106(10), pp. 6961-6985.
[64] Beauchemin, K. A., Ungerfeld, E..M., Abdalla, A.L., Alvarez, C., et al., (2022). Invited review: Current enteric methane mitigation options, Journal of Dairy Science, 105(12), pp.9297-9326,
[65] Tricarico, J.M., de Haas, Y., Hristov, A.N., Kebreab, E., Kurt, T., Mitloehner, F., Pitta, D. (2022). Symposium review: Development of a funding program to support research on

enteric methane mitigation from ruminants, Journal of Dairy Science, 105(10), pp.8535-8542.
[66] US EPA (United States Environmental Protection Agency). 2021. Inventory of U.S. Greenhouse Gas Emissions and Sinks. Accessed Apr. 16, 2021. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.
[67] EPA, U. S. Environmental Protection Agency, (2021). Overview of Greenhouse Gases, https://www.epa.gov/ghgemissions/overview-greenhouse-gases
[68] IPCC, (2021). Climate Change (2021). The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press.
[69] Le Quéré, C., Andrew, R. M., Friedlingstein, P., Sitch, S. ,et al., (2018). Global carbon budget 2018. Earth Syst. Sci. Data 10, pp. 2141–2194.
[70] Allen, M. R., Shine, K. P., Fuglestvedt, J. S., Millar, R. J., Cain, M., Frame, D. J., Macey, A. H. (2018). A solution to the misrepresentations of CO2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. NPJ Clim. Atmos. Sci. 1:16.
[71] Dupraz, P. (2021). Policies for the ecological transition of agriculture: the livestock issue. Review of Agricultural, Food and Environmental Studies, 101(4), 529-538.
[72] Gloux, F., Le, S., Dupraz, D.P. ,(2023).Taking the diet of cows into consideration in designing payments to reduce enteric methane emissions on dairy farms. Journal of Dairy Science,
[73] IPCC (2022). Climate Change (2022). Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. P. 3056. IPCC;
[74] Ivetić, A., Radulović, S., Stojanović, B., Davidović, V., Ćosić, M. (2022a). A modification of animal feeding strategies in the green agenda. Production of enteric methane in the ruminants based on the chemical composition of food. 33 Conference Veterinarian of Serbia. Zlatibor 8-11 September 2022.
[75] Ivetić, A., Ćosić, M., Radulović, S., Jandrić, M. (2022b). Emission of Enteric Methane of Wild Ruminants. Journal of Forestry. The Association of Engineers and technicians of Serbia, and the Institute of Engineering Belgrade, University of Novi Sad Belgrade,.1-2
[76] Ivetić, A., Ćosić, M. (2021b). Enteric methane. 25. International Eco-Conference, Environmental protection of urban and suburban settlements. Proceedings, pp. 60-66. Novi Sad;
[77] Kozlowska, L, Mizera, O., Mroz, A. (2020). An Untargeted Metabolomics Approach to Investigate the Metabolic Effect of Beetroot Juice Supplementation in Fencers—A Preliminary Study. Metabolites, 10, 100.
[78] Jayanegara, A., Leiber, F, Kreuzer, M. (2012). Meta-analysis of the relationship between dietary tannin level and methane formation in ruminants from *in vivo* and *in vitro* experiments., 96(3), 365–375. doi:10.1111/j.1439-0396.2011.01172.x
[79] Silvestre, T., Räisänen, S.E., Cueva, S.F., Wasson, D.E., Lage, C.F.A., Martins, L.F., Wall, E., Hristov, A.N. (2022). Effects of a combination of Capsicum oleoresin and clove essential oil on metabolic status, lactational performance, and enteric methane emissions in dairy cows, Journal of Dairy Science, 105(2), pp. 9610-9622,
[80] Silvestre, T., Martins, L.F., Cueva, S.F., Wasson, D.E., Stepanchenko, N., Räisänen, S.E., Sommai, S., Hile, M.L., Hristov, A.N. (2023). Lactational performance, rumen fermentation, nutrient use efficiency, enteric methane emissions, and manure greenhouse gas-emitting potential in dairy cows fed a blend of essential oils. Journal of Dairy Science, ISSN 0022-0302.
[81] Ivetić, A. (2018). New ensiling technology. World Intellectual Property Organization (WIPO), Geneva, Switzerland i Inventors Association of Vojvodina, Serbia;

[82] Muizelaar, W., van Duinkerken, G., Khan, Z., Dijkstra, J. (2023). Evaluation of 3 northwest European seaweed species on enteric methane production and lactational performance of Holstein-Friesian dairy cows, Journal of Dairy Science, 106(7), 4622-4633.
[83] Marchi, M., Capezzuoli, F., Fantozzi, P.L., Maccanti, M., Pulselli, R.M., Pulselli, F.M., Marchettini, N. (2023). GHG action zone identification at the local level: Emissions inventory and spatial distribution as methodologies for policies and plans,Journal of Cleaner Production,Volume 386,2023,135783,ISSN 0959-6526;

THE IMPORTANCE OF FOOD SYSTEMS FOR CEREAL APPLICATION IN HUMAN AND ANIMAL NUTRITION

ВАЖНОСТА НА СИТЕМИТЕ ЗА ХРАНА ВО ПРИМЕНАТА НА ЖИТАТА ВО ХУМАНАТА И АНИМАЛНАТА ИСХРАНА

Mirjana Menkovska, full professor[1]
Natasha Gjorgovska, full professor[2]
Vesna Levkov, full professor[3]
Desimir Knežević, full professor[4]
Nikola Pacinovski, full professor[5]

Abstract: *Cereals have a great importance for human and animal nutrition, due to the composition of their kernel. With the aim to investigate the influence of the food system on the content of cereal nutritional components (protein, minerals, fat, and dry matter), we investigated different kind of cereals (wheat, barley, oat and millet) that were grown in three regions by two production models: conventional and organic. Standard AOAC methods for analysis were applied and the obtained values were expressed by mean values ± S.D. Most of the analyzed quality properties of organic cereals have shown maximal values among the cereals. It was concluded that organic production could improve nutritive value of cereals, what is important for human and animal nutrition.*

Key words: *cereals, nutritive components, content, organic food system, conventional food system*

Абстракт: *Житарките имаат големо значење за исхраната на луѓето и животните заради составот на нивното зрно. Со цел да се истражи влијанието на системот на храна врз содржината на хранливите компоненти (протеини, минерали, масти и сува материја),истражувавме различни видови житарки (пченица, јачмен, овес и просо) кои се одгледуваа во три региони по два производни модели: конвенционален и органски. Применети се стандардни АОАС методи за анализа и добиените вредности се изразени со средни вредности ± S.D. Повеќето од анализираните квалитетни својства на органските житарки покажаа максимални вредности меѓу анализираните житарки. Беше заклучено дека органското производство може да ја подобри хранливата вредност на житариците, што е важно за исхраната на луѓето и животните.*

Клучни зборови: *житарки, нутритивни компоненти, содржина, органски систем на храна, конвенционален систем на храна*

[1] University Ss.Ciril and Methodius in Skopje, Institute of Animal Science and Fishery, Skopje, N. Macedonia, e-mail: menkovska06@yahoo.com
[2] University Ss.Ciril and Methodius in Skopje, Institute of Animal Science and Fishery, Skopje, N. Macedonia, e-mail: natasha.gjorgovska@istoc.ukim.mk
[3] University Ss.Ciril and Methodius in Skopje, Institute of Animal Science and Fishery, Skopje, N. Macedonia, e-mail: vesna.levkov.1@istoc.ukim.mk
[4] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kosovo and Metohia, Serbia, e-mail: deskoa@ptt.rs
[5] University Ss.Ciril and Methodius in Skopje, Institute of Animal Science and Fishery, Skopje, N. Macedonia, e-mail: nikola.pacinovski@istoc.ukim.mk

1. INTRODUCTION

A food system includes all processes and infrastructure involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consumption, and disposal of food and food-related items. A food system operates within and is influenced by social, political, economic and environmental contexts. It also requires human resources that provide labor, research and education. Food systems are either conventional or alternative [1][2][3], according to their model of food lifespan from origin to plate. Food systems exist at global, regional, national and local scales. They are very diverse and location-specific.

Conventional food systems
Conventional food systems operate on the economies of scale, and are geared towards a production model that requires maximizing efficiency in order to lower consumer costs and increase overall production. They utilize economic models such as vertical intergration, economic specialization, and global trade. The term “conventional” when describing food systems is large part due to comparisons made to it by proponents of other food systems, collectively known as alternative food systems.

Alternative food systems
Alternative food systems are those that fall outside the scope of conventional agriculture.

Represent networks of food production and consumption that aim to be geographically and economically accessible and direct. They differs from industrial food systems by operating with reduced food transportation and more direct marketing, leading to fewer people between the farmer and the consumer.

Organic food systems
Organic food systems are characterized by a reduced dependence on chemical inputs and an increased concern for transparency and information. Organic produce is grown without the chemical pesticides and fertilizers of industrial food systems, and livestock is reared without the use of antibiotics or growth hormones. The reduced inputs of organic agriculture can also lead to a greater reliance on local knowledge [4][5], creating a stronger knowledge community amongst farmers.

The term "sustainable agriculture" was defined in 1977 by the USDA as an integrated system of plant and animal production practices having a site-specific application that will, over the long term [6] satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agriculture economy depends, make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls, sustain the economic viability of farm operations and enhance the quality of life for farmers and society as a whole.

Principles of organic food production are biodiversity, ecological balance, sustainability, natural plant fertilization, natural pest management, and soil integrity.

Organic food products
Organic food products are grown or raised by a producer who uses practices in balance with the natural environment, using methods and materials that minimize negative impact on the environment. The organic farmer is committed to replicating the ecology of the natural environment by maintaining biodiversity and fostering healthy soil and growing conditions.

Food products that are produced organically they are produced on land that has been free of known and perceived toxic and persistent chemical pesticides and fertilizers for at least three years prior to certification, and synthetic fertilizers and pesticides are not used in production. Organic food

products are planted on a rotating basis within the farm system. Crops are rotated from field to field, rather than growing the same crop in the same place year after year. .

Organic products such as meat, poultry and egg products come from farms that use organic feed, do not administer added hormones to promote growth or any antibiotics and they allow animals the space and freedom to behave naturally.

Organic agriculture can be defined as an integrated farming system that strives for sustainability [7][8][9][10], the enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones.

Developing sustainable food systems **c**ontributes to the sustainability of the human population. Sustainable agriculture provides a potential solution to enable agricultural systems to feed a growing population within the changing environmental conditions [11]. Besides sustainable farming practices, dietary shifts to sustainable diets are an intertwined way to substantially reduce environmental impacts.[12][13][14][15]. A sustainable food system is one that contributes to food security and nutrition for all in such a way that the economic, social, cultural, and environmental bases to generate food security and nutrition for future generations are safeguarded [16].

Sustainable diets and sustainable food systems are increasingly explored by diverse scientific disciplines. They are also recognised by the international community and called upon to orient action towards the eradication of hunger and malnutrition and the fulfilment of sustainable development goals.

Food systems need to be better managed and governed to ensure that food system transformation is redesigned to improve nutrition and health, ensure environments are sustainable and resilient, promote fair and equitable livelihoods, and mitigate climate change [17][18].

Climate change is affecting food systems and agricultural productivity. The effects of climate change are a potentially destabilizing factor in ensuring sufficient food consistently as well as the nutritional quality of crops [19-21]. There are different ways to understand how climate will affect food security and nutrition outcomes by pulling together different data types at different scales, including individual nutrition information [22]. Many studies have demonstrated the impacts of climate change on crop nutrient quality, food production, food security, diet, and nutrition outcomes [23][24][25].

There are numerous sustainability standards and certification systems, including organic certification such as Rainforest Alliance, Fair Trade, UTZ Certified, GlobalGAP, Bird Friendly, and the Common Code for the Coffee Community [26].

Regulations

In 1992 the European Community developed organic standards and a certification scheme [27].

The International Federation of Organic Agriculture Movements (IFOAM)9 also has a set of organic principles which were the basis of the guidelines for organically produced foods of the internationally recognized [28].

Codex Alimentarius10 of the World Health Organization and Food and Agriculture Organization of the United Nations (WHO/FAO food standards). Codex Alimentarius is the internationally accepted food safety standard for all food products traded worldwide. There is a set of standards within the Codex Alimentarius that covers organic food [29].

In October 2002, the production and marketing of organic food came under regulation by the US Department of Agriculture's (USDA) National Organic Program. The National Organic Standards Board, a federal advisory panel to the USDA for developing organic legislation [30].

Cereals in human and animal nutrition

Cereals have a great importance for human and animal nutrition to our posts in Europe and beyond part of the world due to the composition of their kernel. Bread-making quality and quality of other bakery products depend on the quality and quantity of wheat proteins [31-34].

Gluten, the elastic and plastic mass formed from the protein fractions gliadin and glutenin during flour mixing water is a reliable indicator of dough strength. The gluten proteins gliadins and glutenins compose the major part of wheat storage proteins [35-36]. The genetic studies on chromosomal locations of the genes that control the synthesis of gluten proteins have determined that gliadins are controlled by the complex gene loci, enabling their genetic classification by blocks of gliadins [37]. The genes for gliadin synthesis are determined on the chromosomes 1A, 1B and 1D, 6A and 6D [38-39]

The synthesis of HMW subunits of glutenins is controlled by the gene loci *Glu-A1*, *Glu-B1* and *Glu-D1* located on the long arms of chromosomes 1A, 1B and 1D, respectively [40]. The glutenin loci have many allelic variants [41]. Many reserachers pointed out to the possibility of relationship between wheat quality properties and gluten proteins-gliadins and HMW glutenins [42][43][44-49][50-51]. The influence of agro-ecological conditions [52-55][56] [57-58] on wheat quality and quality of wheat bread-making properties was investigated.

The aim of this work was a comparative analysis of some quality properties of the cereal crop collected from different geographical locations in Republic of N. Macedonia to be conducted in order to find out the influence of the farming method (organic versus conventional) on the cereal quality properties.

2. MATERIAL AND METHODS

The choice of cereal samples depended on the cereal organic and conventional production available. So, 7 samples of wheat (*Triticum aestivum* L.), 7 samples of barley, (*Hordeum vulgare*), 5 samples of oats (*Avena sativa*), 3 samples of rye (*Secale cereale*) and 3 samples of millet (*Pennisetum glaucum*) were used for analysis of content of moisture, ash, crude protein and crude fat. Cereals were grown in three different agro-ecological regions in Republic of Macedonia: Štip–Ovče Pole, Veles and Negotino. Organic and conventional method of farming was applied for cereals during 2013. For wheat, barley and oat, the samples were collected from conventional, organic and in conversion production, while for rye and millet the samples were collected from conventional and organic production. Wheat, barley and oat were produced organically, conventionally and in conversion. Rye and millet were produced by organic and convectional method.

The following quality properties of cereals were analyzed: minerals (crud ash), crude proteins, crude fat, and dry matter. Content of nutritive components in cereals was analysed with standard AOAC methods of analysis. The values of the determined quality properties were expressed in mean values ± S.D.

Analytical method for analysis were already described previously [59].

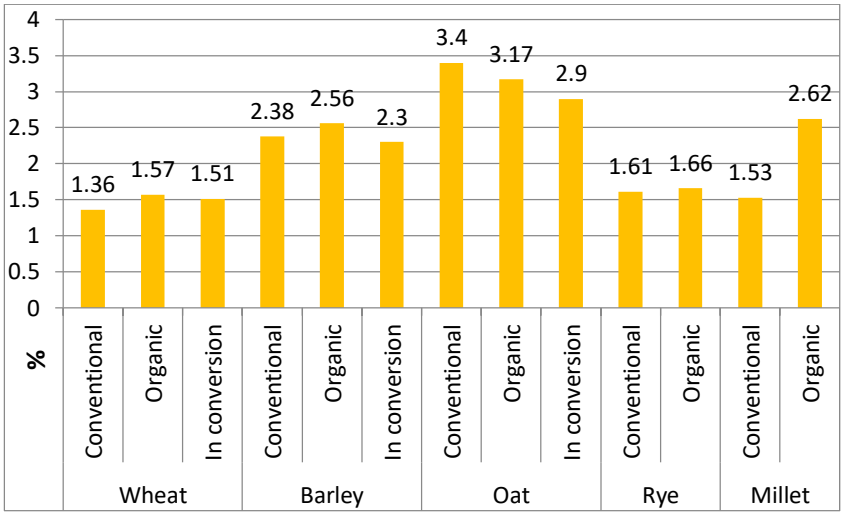
3. RESULTS AND DISCUSSION

The results obtained from the investigations have shown an significant increase in the content of minerals, dry matter, proteins and fat in cereals produced organically compared

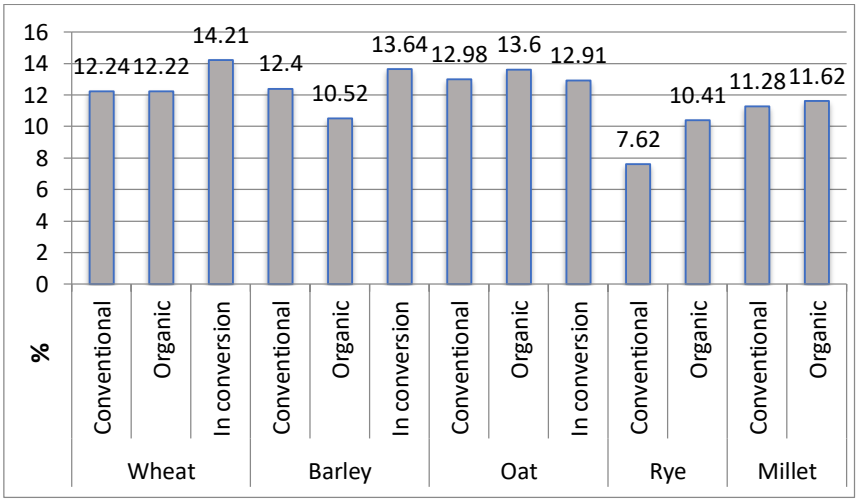
to those produced conventionally or in conversion (Graphs 1-4), according to data results presented in the previous paper [50].

Most of the analyzed quality properties of organic cereals have shown maximal values almost in the all analyzed cereals, while some were in conversion (proteins, fat and dry matter) with wheat, barley and oat. The all quality properties were higher with rye and millet.

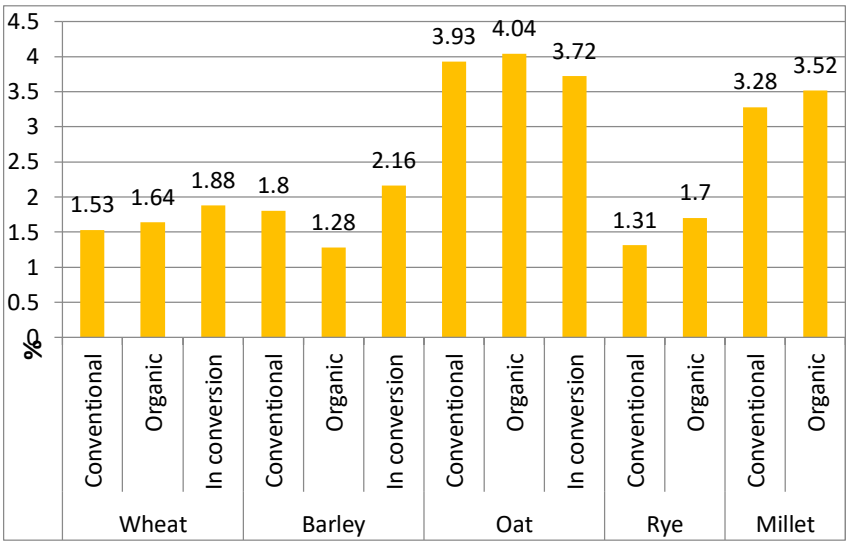
The increase of mineral content was 15% with wheat, 7% with barley and 71% with millet. The increase of protein content was 37% with oat and 3% with rye, while an decrease of 15% was noticed with barley. The increase of crude fat was 15% with wheat, 3% with oat, 29% with rye and 7% with millet. Barley produced conventionally or in conversion, has shown the maximal content of dry matter. Organically produced oat has shown the maximal content of fat, protein and minerals.



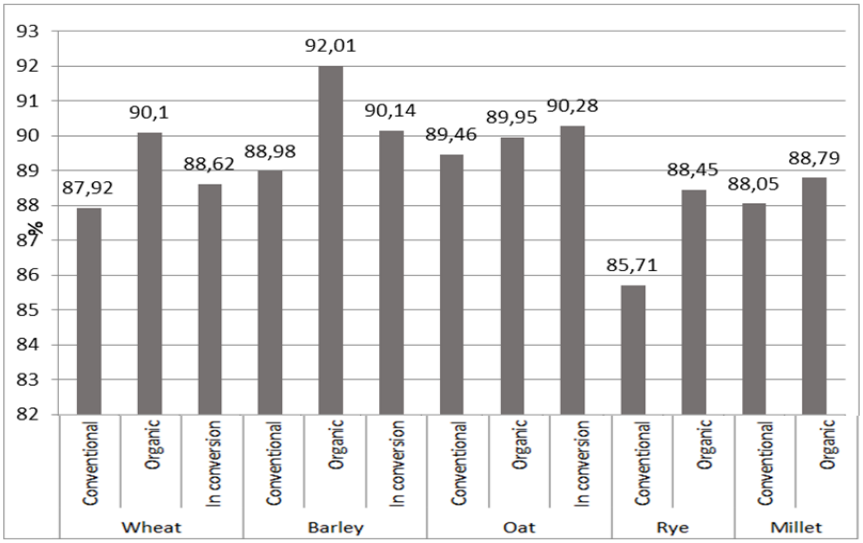
Graph. 1. Content of minerals with organically and conventionally produced cereals



Graph. 2. Content of dry matter with organically and conventionally produced cereals



Graph. 3. Content of crude fat with organically and conventionally produced cereals



Graph. 4. Content of dry matter with organically and conventionally produced cereal

4. CONCLUSION

The results obtained from the research conducted revealed that there was a significant increase in the content of minerals, dry matter, protein and fat in organic produced cereals that were compared to those produced either by conventional farming or in conversion. Most of analyzed quality parameters have shown maximal values almost in the all cereals analyzed, some were in conversion for wheat, barley and oat, while the all were higher for rye and millet.

Doubtless, besides the farming type, the influence on cereal quality has also the cereal kind, genotype, as well the production region. These results have confirmed the potential for improving

the quality parameters of organic cereal grains, besides safety which is guaranteed in organic cereals and cereal food. This is very important for the application of organic cereals in the human and animal nutrition, for improving diet quality and health, as well as for food and feed industry. This leads to the opinion that transformation of food systems is possible and needed, and that the nutrition and health communities should have a significant role in the transformative process.

5. ACKNOWLEDGMENT

The research presented in this paper has been undertaken in the frame of a scientific project "Comparative analysis of cereals produced by organic and conventional farming" supported by Ss. Cyril and Methodius University in Skopje.

REFERENCES

[1] The State of Food and Agriculture, (2021), Making agrifood systems more resilient to shocks and stresses, In brief. Rome: FAO.
[2] "A Primer on Community Food Systems: Linking Food, Nutrition and Agriculture" (PDF). Farmland Information Center. n.d. Retrieved 2019-01-12. all processes involved in keeping us fed: growing, harvesting, processing (or transforming or changing), packaging, transporting, marketing, consuming and disposing of food and food packages.
[3] Ericksen, P. J. (2008), "Conceptualizing food systems for global environmental change research". Global Environmental Change, 18 (1), pp. 234–245.
[4] Welch, R., Graham, R. (1998), "A new paradigm for world agriculture: meeting human needs, Productive, sustainable, nutritious", Field Crops Research #60.
[5] Nestle, M. (2013), Food Politics: How the Food Industry Influences Nutrition and Health", Los Angeles, California, University of California Press.
[6] Organics at a glance - European Commission (europa.eu).
[7] Treadwell, D., Riddle, J., Barbercheck, M., Cavanaugh-Grant, D., Zaborski, Ed., (2009), Cooperative Extension System, What is organic farming?
[8] Martin, H. (2014), ''Ontario Ministry of Agriculture, Food and Rural Affairs Introduction to Organic Farming, ISSN 1198-712X.
[9] Rhoads, D., Purdue Extension Service, What is organic farming? Archived /.2016-06-10 at the Wayback Machine.
[10] Gold, M. " Rhoads, D., Purdue Extension Service, What is organic farming? Archived /.2016-06-10 at the Wayback Machine.What is organic production?". National Agricultural Library. USDA. Retrieved 1 March 2014.
[11] Line Gordon, Hanna Wetterstrand, Fabrice DeClerck, Mihir Shah, Pasquale Steduto, Charlotte de Fraiture, Nuhu Hatibu, Olcay Unver, Jeremy Bird, Lindiwe Sibanda, Jimmy Smith (2017), "Sustainable intensification of agriculture for human prosperity and global sustainability". Ambio, 46 (1), pp. 4–17.
[12] "Shifting to Sustainable Diets", United Nations. Retrieved 26 April 2022.
[13] Donald, R., Heller, M. C., Christina A. R. (2019), "Position of the Society for Nutrition Education and Behavior: The Importance of Including Environmental Sustainability in Dietary Guidance", Journal of Nutrition Education and Behavior, 51, (1), pp. 3–15.e1.
[14] Meybeck, A., Gitz, V. (2017), "Sustainable diets within sustainable food systems". Proceedings of the Nutrition Society. 76 (1), pp. 1–11.
[15] Sun, Z., Scherer, L., Tukker, A., Spawn-Lee, S. A., Bruckner, M., Gibbs, H. K., Behrens, P. (2022), "Dietary change in high-income nations alone can lead to substantial double climate dividend",,Nature Food. 3 (1), pp. 29–37.
[16] Haddad, L., Hawkes, C., Waage, J. et al., (2016), Food systems and diets: Facing the challenges of the 21st century. London, UK: Global Panel on Agriculture and Food Systems for Nutrition.

[17] Global Panel on Agriculture and Food Systems for Nutrition (Glopan) (2020), Future food systems: for people, our planet, and prosperity. London, United Kingdom, Glopan.
[18] Gillespie, S., Haddad, L, Mannar, V., Menon, P., Nisbett, N., (2013), Maternal and Child Nutrition Study Group, The politics of reducing malnutrition: building commitment and accelerating progress, Lancet. 382(9891), pp. 552–69.
[19] Myers, S.S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A.D B., Bloom, A.J., Carlisle, E., Dietterich, LH, Fitzgerald, G, Hasegawa T et al. (2014), Increasing CO2 threatens human nutrition. Nature. 510 (7503), pp.139–42.
[20] Scheelbeek, P.F. D., Tuomisto, H.L., Bird, F.A., Haines, A., Dangour, A.D. (2017), Effect of environmental change on yield and quality of fruits and vegetables: two systematic reviews and projections of possible health effects, Lancet Glob Health, 5, S21.
[21] Beach, R.H., Sulser, T.B., Crimmins, A., Cenacchi, N., Cole, J., Fukagawa, N.K., Mason-D'Croz, D.,Myers, S., Sarofim, M.C., Smith, M., et al. (2019), Combining the effects of increased atmospheric carbon dioxide on protein, iron, and zinc availability and projected climate change on global diets: a modelling study, Lancet Planet Health, 3(7), pp. 307–17.
[22] DHS Program, Rockville, MD: ICF.
[23] Fanzo, J., Davis, C., McLaren, R., Choufani, J. (2018), The effect of climate change across food systems: implications for nutrition outcomes. Glob Food Sec., 18, pp. 12–19.
[24] Myers S.S., Smith M.R., Guth, S, C.D., Vaitla, B, Mueller, N.D., Dangou,r A.D, Huybers, P. (2017), Climate change and global food systems: potential impacts on food security and undernutrition. Annu Rev Public Health., 38, pp. 259–77.
[25] Fanzo, J., Hood, A., Davis, C. (2017), Eating our way through the Anthropocene, Physiol Behav., 222, pp.112929.
[26] Meybeck, A., Gitz, V. (2017), Sustainable diets within sustainable food systems Proc Nutr Soc. 76(1), pp. 1-11.
[27] The EU regulation on organic production and labelling- development and future of the organic framework, (2017).
[28] Geier, B. (2007), "IFOAM and the history of the International Organic Movement". IFOAM and the history of the International Organic Movement, Organic farming: an international history, pp. 175–186.
[29] Codex Alimentarius10 of the World Health Organization and Food and Agriculture Organization of the United Nations (WHO/FAO food standards) (1999), Codex Alimentarius is the internationally accepted food safety standard for all food products traded worldwide. There is a set of standards within the Codex Alimentarius that covers organic food.
[30] The production and marketing of organic food came under regulation by the US Department of Agriculture's (USDA) National Organic Program, (2002), The National Organic Standards Board, a federal advisory panel to the USDA for developing organic legislation.
[31] Finney, K.F. (1945), Methods of estimating and the effect of variety and protein level on the baking absorption of flour. Cereal Chem. 22, pp. 149–158.
[32] Hoseney, R.C. and K.F. Finney (1971), Functional (breadmaking) and biochemical properties of wheat flour components. XI. A review, Baker's Dig., 45 (4), pp. 30–36.
[33] Pomeranz, Y.(1985), Functional properties of food components, Orlando, Fla., Academic Press.
[34] Knezevic, D., Rosandic, A., Kondic, D., Radosavac, A., Rajkovic, D. (2016): Impact of quality of grain wheat on food value. Növénytermelés, 65, pp.99-102.
[35] Kasarda, D.D., Bernardin, J.E., Qualset, C.O. (1976), Relationship of gliadin protein components to chromosomes in hexaploid wheats (*Triticum aestivum* L.), Proc Natl Acad Sci USA, 73(10), pp. 3646-50.
[36] Knezevic, D., Rosandic, A., Kondic, D., Radosavac, A., Rajkovic, D. (2017), Effect of gluten formation on wheat quality. Columella – Journal of Agricultural and Environmental Sciences, 4. (1), pp.169-174

[37] Metakovsky, Y.E.V., Novoselkaya, A.Yu., Kopus, M.M., Sobko,T.A., Sozinov, A.A. (1984), Blocks of gliadin components in winter wheat detected by one dimentional polyacrylamide gel electrophoresis, Theor. Appl.Genet., 67, pp 559.
[38] Metakovsky, E.V. (1991), Gliadin allele identification in common wheat. II. Cataloque of gliadin alleles in common wheat, J. Genet. Breed. 45, pp. 325.
[39] Novoselskaya-Dragovich, A.Yu., Knežević, D., Fisenko, A.V. (2005), Dynamics of genetic variation at gliadin-coding loci in bread wheat cultivars developed in small grains Research Center (Kragujevac) during last 35 years. Plant breed. and Seed Produc., Novi Sad, 11(1-4), pp. 51-56.
[40] Payne, P.I., Holt, L.M., Law, C.N. (1981), Structural and genetic studies on the high-molecular-weight subunits of wheat glutenin, Theor. Appl. Genet. 60, pp. 229.
[41] Payne, P.I., Lawrence, G.J. (1983), Cataloque of alleles for the complex gene loci, *Glu-A1*, *Glu-B1* and *Glu-D1* which code for the high-molecular-weight subunits of glutenin in hexaploid wheat, Cereal Res. Comm. 11, pp. 29.
[42] Payne, P.I., Corfield, K.G., Blackman, J.A., (1979), Identification of a high-molecular-weight subunits of glutenin whose presence correlelates with breadmaking quality in wheat of related pedigree. Theor. Appl. Genet. 55, pp.153.
[43] Wrigley, C.W., Robinson, P.J., Williams, W.T. (1982), Association between individual gliadin proteins and quality, agronomics and morphological properties of wheat cultivars, Aust.J.Agric.Res. 33, pp. 409.
[44] Menkovska, M., Lookhart, G.L., Pomeranz, Y. (1987), Changes in the gliadin fractions (s) during breadmaking: Isolation and characterization by high-performance liquid chromatography and polyacrylamide gel electrophoresis. Cereal Chem. 64, pp. 31.
[45] Menkovska, M., Pomeranz, Y., Lookhart, G.L., Shogren, M.D. (1988), Gliadin in crumb of bread from high-protein wheat flours of varied bread-making potential, Cereal Chem., 653, pp. 198.
[46] Menkovska, M., Knežević, D., Maksimović, M., Milovanović, M. (1995-a), Technologycal quality of some bread wheat varieties: I. Relation with gliadin proteins. Bull. Chem. Tecnol. Macedonia 14, pp. 31.
[47] Menkovska, M., Knežević, D., Maksimović, M., Milovanović, M. (1995-b). Technologycal quality of some bread wheat varieties: II. Relation with HMW glutenin subunits. Bull. Chem. Tecnol. Macedonia 14, pp. 35.
[48] Menkovska, M. (2003), Technological quality of Macedonian wheat-Biochemical approach, Recent instrumental techniques and methods, Intrnational standards, Institute of Animal Science, Ss.Cyril and Methodius University in Skopje, pp. 216.
[49] This Dominique, Knežević, D., Javornik, B., Teulat, B. Monneveux P., Janjić, V. (2001): Genetic markers and their use in cereal breeding. In: Monograph Genetic and Breeding of Small Grains. (eds. S.Quarrie et all) pp. 51-89.
[50] MacRitchie, R., Kasarda, D.D., Kuzmicky, D.D. (1991), Characterization of wheat protein fractions differing in contributions to breadmaking quality, Cereal Chem. 68, pp. 122.
[51] MacRitchie, F., (1999), Wheat proteins: characterization and role in flour functionality, Cereal Foods World 44, pp. 188.
[52] Ivanoski, M., Menkovska, M. (1990). Influence of climate factors during the formation of some wheat quality properties, Żyto Chleb, 17 (3), pp. 71–74.
[53] Zečević, V., Knežević, D., Bošković, J., Madić, M. (2009), Effect of genotype and environment on wheat quality. Genetika, 41 (3), pp.247-253.
[54] Šekularac, A., Torbica, A., Živančev, D., Tomić, J., Knežević, D. (2018), The Influence of Wheat Genotype and Environmental Factors on Gluten Index and the Possibility of Its Use as Bread Quality Predictor. Genetika, 50 (1), pp.85-93.
[55] Knežević, D., Novoselskaya-Dragovich, A.Yu., Kudryavtsev, A. M., Aleksandar Paunović, A., Menkovska, M., Adriana Radosavac, A., Matković Stojšin, M., Roljević Nikolić, S. (2022), Protein quality of bread wheat..Journal of Agricultural, Food and Environmental Sciences, 76, 6, pp. 1-10.

[56] Knežević, D., Laze, A., Paunović, A., Djurović, V., Đukić, N., Valjarević, D., Kondić, D., Mićanović, D., Živić, J., Zečević, V. (2020), Approaches in cereal breeding. Acta Agriculturae Serbica, 25(50): pp. 179-186.
[57] Laze, A., Arapi, V., Brahushi, F., Pezo, L., Kristl, J., Riciputi, Y., Knezevic, D. (2018), Assessment of Microelements Content in Organic Soft Albanian Wheat Genotypes. International Journal of Innovative Approaches in Agricultural Research, 2(4), pp. 295-306.
[58] Zečević, V., Milenković, S., Bošković, J., Roljević Nikolić, S., Luković, K., Đorđević, R., Knežević, D. (2021), Influence of foliar nutrition on yield and yield components of durum wheat (*Triticum durum* Desf.) grown in system of organic production. Applied Ecology and Environmental Research, 20(1), pp. 171-187.
[59] Menkovska, M., Levkov, V., Gjorgovska, N., Nikolova, N., Pacinovski, N., Stanoev, V., Nikolovski, M. (2014), Quality properties of cereal crop in relation with organic versus conventional farming, Macedonian Journal of Animal Science, Vol. 4, 1, pp. 23–26.

SUSTAINABLE BUSINESS PRACTICES THROUGH THE IMPLEMENTATION OF GREEN PUBLIC PROCUREMENT

ОДРЖИВА ПОСЛОВНА ПРАКСА КРОЗ ИМПЛЕМЕНТАЦИЈУ ЗЕЛЕНИХ ЈАВНИХ НАБАВКИ

Danijela Vujić, independent researcher[1]

Abstract: *In the context of modern business challenges, sustainability becomes a key component of organizational strategies. This paper explores how organizations can achieve sustainable business practices through the implementation of green public procurement. Focusing on the theoretical framework of sustainability in business, the role of public procurement in sustainability, the definition of green public procurement and the steps towards their implementation, the paper aims to provide a comprehensive insight into the key aspects of this transformation process.*

Key words: *green public procurement, sustainability, procurement, sustainable business, sustainable practices.*

Apstrakt: *U kontekstu savremenih poslovnih izazova, održivost postaje ključna komponenta organizacionih strategija. Ovaj rad istražuje kako organizacije mogu postići održivu poslovnu praksu kroz implementaciju zeleni javnih nabavki. Fokusirajući se na teorijski okvir održivosti u poslovanju, ulogu javnih nabavki u održivosti, definiciju zelenih javnih nabavki i korake ka njihovoj implementaciji, rad ima za cilj da pruži sveobuhvatan uvid u ključne aspekte ovog procesa transformacije.*

Ključne reči: *zelene javne nabavke, održivost, nabavke, održivo poslovanje, održive prakse.*

1. INTODUCTION

In the modern business environment, sustainability issues are becoming a key factor in shaping business strategies and practices. One of the key instruments that enables organizations to achieve sustainable business practices is the implementation of green public procurement. This paper explores how organizations can successfully integrate sustainable business practices through the implementation of green public procurement, exploring the steps, challenges and potential benefits arising from this transformation [1].

Sustainability in business is becoming more and more imperative, not only due to the growing awareness of environmental challenges but also due to the demands of the market and regulatory bodies. In this context, public procurement as a key element of business becomes a field where organizations can achieve a real and measurable impact on environmental protection and social responsibility. This paper explores how sustainable business practices can be incorporated into procurement strategies, with a particular focus on green public procurement [2,3].

Through an analysis of the theoretical framework on sustainable business practices, an overview of previous research and relevant case studies, this paper aims to provide a comprehensive insight into

[1] Military Medical Academy, Crnotravska 17, e-mail: danijela.76@outlook.com

the key aspects of the implementation of green public procurement. Issues to be explored include the definition of green public procurement, legal and regulatory frameworks, steps towards successful implementation, as well as measurement and evaluation of the impact on the sustainability of organizations [3,4].

By understanding how organizations can transform their business practices through green public procurement, this paper contributes to the development of strategies that not only support sustainability, but also create value for the organization and wider society.

Through the achievement of goals, the paper aims to provide comprehensive insight and practical guidance for organizations that strive to achieve sustainability through the implementation of green public procurement:

- Analysis of the Theoretical Framework of Sustainability in Business (Understand the concepts and principles of sustainability in business; Identify key elements of sustainable business practices)
- Examining the Role of Public Procurement in Sustainability (To study the importance of public procurement in the context of promoting sustainability; To analyze previous successful examples of organizations that managed to integrate sustainable practices in their procurement)
- Defining Green Public Procurement (Define the concept of green public procurement and identify key characteristics.
- Examine relevant legal and regulatory frameworks related to green procurement; Consideration of Steps to Implementation (Identify key steps for organizations that want to successfully integrate green procurement;Consider the role of leadership and employee training in the implementation process)
- Impact Measurement and Evaluation (Develop methods for measuring the impact of green public procurement on sustainability;Analyze how organizations can monitor key performance and success indicators)
- Analysis of Challenges and Opportunities (Identify challenges in the implementation of green public procurement;Consider the potential benefits and opportunities arising from sustainable business practices through procurement)

2. SUSTAINABILITY IN BUSINESS

Sustainability in business is a complex concept that permeates the economic, environmental and social aspects of organizations. The basic concepts of sustainability in business include a wide range of definitions that emphasize the long-term balance between economic profit, environmental protection and social responsibility. The identification of the key components of sustainability lays the foundation for understanding its complexity and importance in the context of modern business [5].

Sustainable development, as a key component of business strategy, explores how organizations can prosper in the long term while contributing to economic growth, environmental preservation and social well-being. This segment of the analysis highlights the importance of aligning business objectives with broader social and environmental imperatives.

The role of leadership in achieving sustainability is essential. Leaders play a key role in setting the vision, guiding organizational values and supporting initiatives that promote sustainability. Examples of successful leaders in implementing sustainable practices provide insights into key leadership characteristics and strategies in this area [6].

Green innovations and sustainable technologies are becoming drivers of change towards more sustainable business practices. Understanding the role of innovation in creating sustainable solutions is crucial for organizations striving to use resources more efficiently and reduce their environmental footprint.

Figure 1: The six Sustainable Business Value (SBV) dimensions [6].

In this analytical chapter, gaining a deeper insight into the theoretical framework of sustainability in business lays the foundation for further research into ways of implementing sustainable business practices, with a special focus on green public procurement.

Sustainable Business Value (SVB) as shown in Fig. 1. represents a business approach aimed at creating long-term value through a balance of economic performance, social responsibility and environmental sustainability. Business organizations that adhere to this concept strive to achieve economic profit while simultaneously promoting positive social impacts and reducing negative environmental contributions. This includes careful management of resources, support to the local community, social responsibility towards employees and long-term planning strategies to ensure business sustainability and positive contribution to society. This approach recognizes the importance of balancing profitability, ethical business and environmental care to achieve holistic and long-term business value.

3. THE IMPACT OF PUBLIC PROCUREMENT ON SUSTAINABILITY: TOWARDS ENVIRONMENTALLY, SOCIALLY RESPONSIBLE AND ECONOMICALLY SUSTAINABLE BUSINESS

Public procurement plays a key role in shaping sustainable practices in the business world. This complex process of government procurement of goods, services and works has the potential to significantly contribute to the achievement of economic, social and environmental sustainability goals. In the analysis of the impact of public procurement on sustainability, the direction towards the integration of ecological, socially responsible and economic aspects is highlighted in order to shape sustainable business [7].

When we consider the environmental aspect of public procurement, the focus on green procurement is key. Governments have the power to encourage sustainability by choosing goods and services with a smaller ecological footprint. This implies a preference for products that are more energy efficient, have a smaller carbon footprint or are produced from environmentally friendly materials. Also, public procurement can become a catalyst for waste reduction by encouraging suppliers to implement sustainable practices such as recycling and the use of sustainable packaging.

Social responsibility also plays a key role in sustainable public procurement. Increasing fairness in business practices is achieved by preferring suppliers that respect fair working conditions. This approach includes ensuring safe workplaces, fair wages and benefits for employees. Through the selection of suppliers that promote social responsibility, public procurement can have a positive impact on the workforce and contribute to building an ethical business environment.

In an economic context, public procurement has the ability to shape a sustainable market and encourage competition among suppliers. This approach not only supports the government's economic goals, but also creates an incentive for innovation that supports sustainability. The increased demand for ecological and socially responsible products encourages companies to develop sustainable business models, laying the foundations for long-term economically sustainable operations.A comprehensive approach to sustainable public procurement also implies long-term planning. Countries that adopt long-term planning strategies in their procurement processes create a foundation for achieving the longevity of sustainable practices. This strategy includes aligning with long-term environmental goals, developing long-term relationships with social stakeholders, and ensuring economic sustainability over time [8].

The analysis of the role of public procurement in sustainability indicates the need for an integrated approach that takes into account the economic, social and environmental aspects of business. By promoting green procurement, supporting socially responsible practices, and achieving economic sustainability, public procurement can play a key role in shaping a sustainable business environment that meets the needs of current and future generations.

Long-term planning as a key component of sustainable public procurement was also highlighted. The text emphasizes the importance of aligning with long-term environmental goals and developing long-term relationships with stakeholders. But in order to look critically at this point, it would be useful to consider how long-term planning can be integrated into a dynamic business environment, especially in light of changing economic conditions and social needs.

One of the challenges of the text is the relatively general nature of certain statements, such as calls for supporting socially responsible practices or promoting long-term planning. Concrete examples or guidelines could strengthen the argument and provide readers with a clearer path towards the implementation of sustainable public procurement.

Overall, this part of the paper provides a significant contribution to understanding the importance of public procurement in achieving sustainability. The critical review highlights the need for additional specificity, more detailed examples and research in order to strengthen the argumentation and provide relevant guidance for the implementation of sustainable practices in public procurement.

4. DEFINING GREEN PUBLIC PROCUREMENT

Defining Green Public Procurement (GPP) represents a key step towards establishing a more sustainable approach to procurement in the public sector. This concept includes the integration of environmental criteria into the procurement process in order to encourage the production and consumption of goods and services that are less harmful to the environment. The following explores the key aspects and importance of Green Public Procurement.

It’s important to highlight the following:

1. Economic Sustainability: Green Public Procurement has a significant impact on economic sustainability. Favoring ecological products and services encourages the market to orient itself towards sustainable practices. This creates opportunities for environmentally conscious suppliers and encourages innovation in environmentally friendly technologies, contributing to long-term economic prosperity.

2. Environmental Aspects: Defining Green Public Procurement focuses on reducing negative impacts on the environment. This approach includes assessing the life cycle of products, from raw materials to disposal, encouraging suppliers to choose products with a smaller ecological footprint. This creates a positive chain of influence, reducing the resources and energy needed for production.
3. Social Responsibility: Along with economic and environmental aspects, Green Public Procurement also promotes social responsibility. Preference for suppliers who apply fair working conditions and support ethical business practices contributes to creating a balance between profitability and social welfare. This supports a positive impact on the workforce and wider society.
4. Impact on Innovations: Defining Green Public Procurement encourages innovation. By setting high environmental standards in public procurement, governments and organizations encourage suppliers to develop sustainable products and services. This creates a market that values innovation that supports sustainability, encouraging competition and improving the quality of available products.
5. Implementation of the Standard: A key part of defining Green Public Procurement is setting clear and measurable environmental criteria. The implementation of standards enables consistency in the application of sustainable practices. This also allows easy monitoring of progress and evaluation of the success of the Green Public Procurement programme.
6. Education and Awareness: One of the key elements of Green Public Procurement is education and raising awareness among all stakeholders involved in the process. Training public officials, suppliers and consumers on the benefits of sustainable procurement plays a key role in successful implementation. Education helps create an understanding of how to choose products and services that support environmental and social goals.
7. Global Dimension: Taking globalization into account, Green Public Procurement can also have an international impact. Setting standards that encourage sustainability in procurement can encourage global supply chains to adapt their practices. This has the potential not only to reduce negative impacts on the environment but also to improve international relations and cooperation in the field of sustainability.
8. Transparency and Performance Monitoring: Transparency in the Green Public Procurement process is key to building trust and ensuring consistent application of sustainable practices. Setting clear criteria and publishing information on procurement increases transparency, allowing the public to monitor the results achieved. Performance monitoring facilitates the evaluation of program success and the identification of areas for improvement.
9. Challenges of Implementation: Despite numerous advantages, the implementation of Green Public Procurement faces challenges. These include the selection of reliable suppliers, the costs of adapting existing procurement processes, and the need for monitoring and audits to ensure consistent application of sustainable criteria. Understanding and addressing these challenges is critical to the long-term success of the program.

Overall, the definition of Green Public Procurement represents a necessary step towards more sustainable business in the public sector. This approach not only supports economic goals, but also plays a key role in reducing negative environmental impacts and promoting social responsibility. Through the implementation of standards, Green Public Procurement lays the foundations for the transformation of public procurement into a tool that supports long-term sustainability and reflects social values.

5. LEGAL AND REGULATORY FRAMEWORKS RELATED TO GREEN PROCUREMENT

Defining legal and regulatory frameworks related to green procurement plays a key role in shaping sustainable practices in public procurement. These frameworks provide a structure that enables the

incorporation of environmental criteria into procurement processes and ensures that public institutions respect sustainability standards. Green procurement laws typically define requirements for environmentally desirable products, set targets for sustainable procurement, and establish mechanisms to monitor and report on progress [9].

These laws often mandate the inclusion of environmental criteria in tender documents and procurement specifications. This may include setting standards for energy efficiency, emissions or the use of renewable materials, ensuring that environmental aspects are integrated into procurement processes.

In addition, green procurement laws seek to standardize sustainable practices to ensure consistency and clarity in the application of environmental criteria. These frameworks may include the establishment of certification systems or standards that facilitate the assessment and comparison of the environmental performance of bidders.

Legal frameworks often set requirements for monitoring and reporting of results related to the implementation of green procurement. This includes setting up a system to monitor the impact of procurement on the environment and regular reporting on achieved sustainability goals.

Within the framework of green procurement, provisions related to the training of employees in public institutions are also possible in order to ensure the understanding and proper application of the rules on green procurement. This contributes to improving awareness of environmental issues among key procurement
actors.
Also, green procurement laws can include punitive sanctions for non-compliance with environmental criteria, as well as positive incentives or benefits for organizations that excel in implementing sustainable practices.
In addition to the above elements, legal and regulatory frameworks for green procurement may also contain provisions related to the promotion of innovation and technological progress in line with sustainable practices. These provisions encourage suppliers to develop environmentally friendly technologies and products, thus contributing to the expansion of the market for sustainable solutions [10].

Transparency is another key aspect of legal frameworks. Setting clear standards and reporting requirements enables the public, civil society and other stakeholders to monitor and evaluate the results achieved in relation to sustainable procurement. This aspect contributes to responsibility and is reflected in the wider social context.

It is also important to note that legal frameworks can be dynamic, adapting to the evolution of environmental and social norms. The constant review and improvement of these frameworks ensures that the rules on green procurement remain relevant and in line with the latest knowledge on sustainability [11].
Finally, legal frameworks for green procurement have the potential to become a catalyst for change not only at the local level, but also at the global level. Through collaboration and alignment with similar initiatives around the world, countries can work together to improve procurement practices and achieve a more sustainable economic and environmental future.
In sum, legal and regulatory frameworks play a key role in achieving green procurement, laying the foundation for the implementation of sustainable practices and business improvement in line with environmental and social values. These frameworks are not only a means of guidance, but also an instrument for building a more sustainable society.

Legal and regulatory frameworks are key to achieving green procurement in the public sector, providing clear rules that support sustainable practices and contribute to environmental protection

and responsible business. Continuous updating of these frameworks to reflect the latest environmental and social norms is important.

6. IMPACT MEASUREMENT AND EVALUATION

Impact measurement and evaluation in green procurement represent key steps in assessing efficiency and achieving set goals in the field of sustainable procurement. These processes enable the analysis of the actual impacts of procurement on the environment, economy and society, providing relevant data to improve sustainability in the future. Here's a closer look at impact measurement and evaluation in the context of green procurement:

1. Defining Goals and Indicators: Before starting procurement, it is crucial to set clear objectives related to environmental, economic and social aspects. Defining measurable indicators enables accurate measurement of achieved results and impact.
2. Data Collection: This phase includes the collection of relevant data throughout the entire life cycle of a product or service, starting from raw materials, through production, use, and up to recycling or disposal. This data allows for a comprehensive analysis of the impact of procurement.
3. Impact Analysis: After data collection, an impact analysis is performed to determine how procurements have contributed to or reduced negative impacts on the environment. This analysis includes an assessment of energy efficiency, greenhouse gas emissions, resource consumption and other environmental factors.
4. Evaluation of Socioeconomic Aspects: In addition to environmental aspects, impact measurement also includes an assessment of the social and economic effects of procurement. This may include an analysis of the impact on the local community, employment, compliance with workforce standards and other social factors.
5. Assessment of Achieved Goals: Based on the collected data and analysis, an assessment of the achieved goals is made in relation to the set parameters. This phase enables the identification of successful practices, but also areas that require improvement.
6. Tracking Through Time:Continuous impact monitoring and evaluation enables the assessment of the long-term effects of green procurement. This is crucial for adjusting strategies and setting new goals to maintain continuous improvement.
7. Reporting and Transparency:Reporting on impact measurement results is important for transparency and accountability. Organizations should regularly report on the results achieved to inform stakeholders, including government agencies, suppliers, employees and the general public.

Impact measurement and evaluation in green procurement not only enable monitoring of achieved results but also provide data to support informed decisions and the improvement of sustainable practices in the future. These processes are key to making a real difference and achieving sustainability goals in procurement.

7. CHALLENGES AND OPPORTUNITIES

An analysis of the challenges and opportunities in green procurement reveals the complex landscape of sustainable procurement, illuminating the obstacles organizations may face and potential avenues for improving business practices. Green procurement, aimed at fostering sustainability within supply chains, faces a number of challenges while simultaneously providing numerous opportunities for organizations to make a positive contribution to environmental protection, social well-being and economic resilience.Here is a comprehensive exploration of these aspects:

- Challenges:

1. Consideration of Costs: One of the main challenges in green procurement is the potential increase in costs associated with environmentally friendly products and services.

Sustainable alternatives, while good for the planet, can sometimes be more expensive, presenting a financial barrier to organizations, especially those with limited budgets.

2. Limited Availability of Green Products: The market for green products and services may not always be as extensive or developed as the conventional market. The limited availability of sustainable options can hinder organizations from finding environmentally friendly alternatives, affecting the feasibility of green procurement practices.
3. Integration into Existing Procurement Processes: Integrating green procurement into existing supply chains and procurement processes can be challenging. Organizations may face resistance or inertia when trying to modify established practices, requiring a strategic approach to seamlessly incorporate sustainability.
4. Lack of Awareness and Education: A significant challenge is the lack of awareness and education among participants in procurement processes. Key decision makers and procurement professionals may not be adequately informed about sustainability principles, making it difficult to prioritize green criteria in procurement decisions.

- Opportunities:

1. Improvement of Corporate Reputation: Adopting green procurement practices provides organizations with an opportunity to improve their corporate reputation. Consumers and clients increasingly value sustainability, and organizations that align with environmentally responsible practices often enjoy improved brand perception and customer loyalty.
2. Innovations and Market Development: Green procurement encourages innovation in product development

8. CONCLUSION

In conclusion, the implementation of green public procurement is a key mechanism for achieving sustainable business practices. By adopting this approach, organizations not only contribute to environmental protection and social responsibility, but also realize economic benefits and improve their corporate reputation. Green public procurement provides concrete guidelines for integrating environmental and social criteria into procurement processes, laying the foundations for long-term sustainability and a balance between economic goals and responsible business.

By identifying challenges and providing opportunities, this strategy enables organizations to recognize their role in the global environmental context. Education, transparency and performance monitoring are key elements of successful implementation of green public procurement. Although there are challenges, such as costs and adjustments to existing processes, the long-term benefits in terms of reducing the ecological footprint and creating social value justify the efforts invested in this transformation.

In light of the growing awareness of environmental issues and the growing need for a sustainable approach to business, green public procurement is becoming a key instrument for achieving sustainable development goals. Its impact is not limited to the local level, but has the potential to shape global supply chains according to sustainability principles. Therefore, organizations that commit to green public procurement not only achieve concrete benefits for their business, but also actively contribute to the global effort to build a more sustainable future.

REFERENCES

[1] Khan, S. A. R., Yu, Z., Farooq, K. (2023), Green capabilities, green purchasing, and triple bottom line performance: Leading toward environmental sustainability, Business Strategy and the Environment, 32(4), pp. 2022-2034.

[2] Albitar, K., Borgi, H., Khan, M., Zahra, A., (2023), Business environmental innovation and CO2 emissions: The moderating role of environmental governance, Business strategy and the environment, 32(4), pp. 1996-2007.
[3] Etse, D., McMurray, A., Muenjohn, N., (2023), Sustainable Procurement Practice: The Effect of Procurement Officers' Perceptions, Journal of business ethics, 184(2), pp. 525-548.
[4] Pocol, C. B., Stanca, L., Dabija, D. C., Pop, I. D.,Mișcoiu, S., (2022), Knowledge co-creation and sustainable education in the labor market-driven university–business environment, Frontiers in Environmental Science, 10, pp. 781075.
[5] Martínez-Martínez, A., Cegarra-Navarro, J. G., Garcia-Perez, A., Wensley, A., (2019), Knowledge agents as drivers of environmental sustainability and business performance in the hospitality sector, Tourism management, 70, pp. 381-389.
[6] Buchholz, H., Eberle, T., Klevesath, M., Jürgens, A., Beal, D., Baic, A., Radeke, J., (2020), Forward thinking for sustainable business value: A new method for impact valuation, Sustainability, 12(20), pp. 8420.
[7] Timm, J. F. G., Maciel, V. G., Passuello, A., (2023), Green public procurement model for environmental assessment of constructive systems, International Journal of Construction Management, 23(4), pp. 718-728.
[8] Schoenmaekers, S, (2023), The influence of sustainable reporting obligations on public purchasing, In ERA Forum (Vol. 23, No. 3, pp. 377-395). Berlin/Heidelberg: Springer.
[9] Fuguo, C., Fen, Z., (2014), Towards sustainable public procurement in China: policy and regulatory framework, current developments and the case for a consolidated green public procurement code, JMCL, pp. 41, 43.
[10] Ahmed, S. U., Ali, A., Memon, A. H.,Hussain, A., (2021), Policy framework for implementation of sustainable procurement practices in healthcare industry, Environment, Development and Sustainability, 23, pp. 3929-3945.
[11] Telles, P., Ølykke, G. S., (2017), Sustainable Procurement. European Procurement & Public Private Partnership, Law Review, 12(3), pp. 239-252.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

ENERGY EFICIENCY WITHIN GREEN SOLUTIONS FOR MANAGEMENT OF WATER-ENERGY-FOOD-ENVIRONMENT NEXUS

ENERGETSKA EFIKASNOST U OKVIRU ZELENIH REŠENJA ZA UPRAVLJANJE NEKSUSOM VODA-ENERGIJA-HRANA-ŽIVOTNA SREDINA

Ivan S. Stevović,[1]
Jovana Jovanović,[2]

Abstract: *Energy efficiency is one of the most important research subjects in the process of optimal utilization of energy and water for food production, taking care of the environment. This is the requirement of efficient production and use of green renewable enegy within the nexus water-energy-food-environment. Increasing number of inhabitants on the Globe require more energy, water and food. All technologies for energy, water and food production mast respect the criteria of environmental protection. The hydro, solar and wind energy are renewable resources and on the same time they are one of the most sustainable ways of electric energy production. Besides the benefit of clean green energy, the landscape of big solar or wind power plants, or big hydro accumulation and their impact on the environment mast also be the subject for analyses. The aspect of land occupying is a cutting edge research in correlation with the complex goal of using land for food production. This paper presents a green solution for management of the nexus water-energy-food-environment, using renewable resources.*

Key words: *Energy efficiency, green solutions, nexus, water-energy-food-environment, management.*

Apstrakt: *To je jedna od najvažnijih istraživačkih tema u procesu optimalnog korišćenja energije i vode za proizvodnju hrane, vodeći računa o životnoj sredini. Ovo je zapravo zahtev efikasne proizvodnje i korišćenja zelene obnovljive energije u okviru neksusa voda-energija-hrana-okruženje. Sve veći broj stanovnika na Zemlji zahteva više energije, vode i hrane. Sve tehnologije za proizvodnju energije, vode i hrane moraju uvažavati i kriterijume zaštite životne sredine. Hidro, solarna i energija vetra su obnovljivi izvori i istovremeno jedan od najodrživijih načina proizvodnje električne energije. Pored koristi od čiste zelene energije, predmet analize su i pejzaž velikih solarnih ili vetroelektrana, ili velike hidroakumulacije i njihov uticaj na životnu sredinu. Aspekt zauzimanja zemlje je izuzetno zanimljivo istraživanje u korelaciji sa složenim ciljem direktnog korišćenja zemljišta za proizvodnju hrane. Ovaj rad predstavlja zeleno rešenje za upravljanje neksusom voda-energija-hrana-okruženje, uz korišćenje obnovljivih izvora energije.*

Ključne reči: *Energetska efikasnost, zeleno rešenje, neksus, voda-energija-hrana-životna sredina.*

1. INTRODUCTION

More than 70% of fresh water is used for food production [1]. This water often has to be transported from one location to the other, or pumped, which require energy consumption. Water needed for food production can come from the rivers directly, or from artificial accumulations. The water

[1] Innovation centre of the Faculty of Mechanical engineering, University of Belgrade, Kraljice Marije 16, Serbia, e-mail: istevovic@mas.bg.ac.rs
[2] Faculty of civil engineering management, University Union Nikola Tesla,
e-mail: jovanaj90@yahoo.com

behind a dam can be used for energy production, or for irrigation, if the fertile land is upstream from the accumulation. If the fertile land is downstream from the dam and accumulation, water passing through the turbines can be used afterwards for food production if the daily diagram of electriciti production is identical with the diagram of water needs for irrigation and food production. So, all the problems are complex and require to be solved as a green optimal solution, taking care of the environment and climate change on the same time. This subject also requires interdisciplinary research and holistic approach.

Today, in the world, numerous wind power plants and solar power plants are installed above fertile arable land. There is not enough space on the globe for all the activities necessary in the process of providing the basic needs of humanity in terms of the needs for water, energy, food and a clean environment.

Optimal management of resources is and will always be a complex and demanding problem for scientists, engineers, managers and decision makers. The first level of optimization can be related to the question of how much area of fertile land should be allocated for installations of renewable energy sources, and how much for agriculture, i.e. food production.

The problem is complicated when you learn that it is possible to install a wind power plant and/or a solar power plant on the same agricultural land.

When the research topic is hydropower, the problem is defined as either/or. In that case, the land surface can be used either for the construction of a dam and reservoir, or for planting agricultural crops.

Electricity is needed by mankind, but also for the improvement of agricultural production, which makes the problem two-layered, complex and interdisciplinary.

2. MATERIALS AND METHODS

The methodology applied within this research is related to the research on three the most implemented renewable resources (solar, wind and hydro energy) in correlation with the fertile land use, within the nexus water-energy-food-environment (WEFE) nexus. Methodology encompasses:

- Collection and review of all existing engineering designs, documentation and published scientific articles in the field of water-energy-food-environment nexus
- Desk research,
- Expert's analyses,
- Conducted questionnaire method,
- Survey method,
- Interview method (with key authorities and affected communities) and
- Site inspection method.

Solar and hydro energy in correlation with fertile agriculture land use were researched by first three above mentioned methods. Last four methods were applied for wind energy interaction in WEFE nexus.

Research into the acceptance of developing more efficient application of solar, wind and hydro energy in the context of WEFE nexus synergy was done. The methodological holistic approach also includes methods of induction and deduction, analysis and synthesis, as well as the analogy method. Examples of positive world practice are also given. The results were completed and mixed with the research method - interview, where public and expert hearings were examined.

Experimental research was carried out in June and July 2023 in southern Banat in Serbia and in Belgrade. In order to cover as high a population as possible and to generate quantitative data, the questionnaire as a research instrument was conducted on a representative sample of 105 respondents. Respondents' answers were processed using statistical methods. The data collected were processed using Microsoft Excel and SPSS for Windows 13.0 software packages. Additionally, a mixed method was applied and the research completed with an interview. In order to quantify the indication (validated) by qualitative information, the author interviewed 10 sample respondents. An interview was conducted with the same questions, but the answers were explained in detail by the respondents. These 10 respondents were mainly experts in the domain, or persons in executive positions.

The site inspection of a wind power plant Čibuk 1 is organized. Power plant Čibuk 1 is on fertile agriculture land. Questionnaire is presented in the Table no 1. Survey is organized within 105 inhabitants. Interview with key authorities in Belgrade, in Mramorak and in Kovin was conducted, as well as the interview with affected communities and non government organization (NGO). The results are presented in the next chapter.

Table 1. Questionnaire on implementation of solar or wind energy for electricity production in Serbia with WEFE nexus

Full name	
Occupation, title, education	
Position in the employment	
Job description	
1. Do you know any solar plant or installed photovoltaic panels, or wind farm in Serbia?	➢ yes Be specific. Add technical detail, if possible. ➢ no
2. Does legislation in the domain of RE energy application in Serbia follow EU legislation?	➢ yes ➢ no
3. Why have not more people invested in solar, wind or other mode of RE in Serbia so far?	➢ Shortage of money ➢ Insufficient incentive tariffs ➢ Unstable incentive tariffs ➢ General market instability ➢ Open answer
4. Would you, if you had the necessary funds, invest in solar, wind or other RE power plants in Serbia?	➢ yes (Where?) ➢ no
5. Would you invest in another country? Which ones?	➢ yes (Where?) ➢ no
6. What is blocking greater application? What are the obstacles for faster development and greater use of RE energy in Serbia?	Open answer If necessary, continue on the back of the sheet.
7. Do you think the construction of the solar or wind power plant threatens the agricultural land below?	➢ yes ➢ no
8. Do You know what is WEFE nexus	➢ yes ➢ no
9. Would you rather use water to produce energy, or to produce food?	➢ water for energy production ➢ water for food production
10. Additional comments	

This questionnaire refers to researching whether there is higher interest in Serbia for investing in solar, wind or hydro RE, as well as what is the level of knowledge about their interaction in the context of WEFE nexus.

3. RESULTS AND DISCUSION

This chapter encompasses results of solar, wind and hydro renewable energy implementation and their interaction with fertile agricultural land usage within WEFE nexus.

3.1. SOLAR ENERGY

Global environmental concerns and the escalating demand for energy, coupled with steady progress in renewable energy technologies, are opening up new opportunities for utilization of renewable energy resources. Solar energy is the most abundant, inexhaustible and clean of all the renewable energy resources till date. The power from sun intercepted by the earth is about 1.8 × 1011 MW, which is many times larger than the present rate of all the energy consumption. Photovoltaic technology is one of the finest ways to harness the solar power. This paper reviews the solar energy potential in the world and in Serbia, as well as its environmental aspect coupled with a variety of its applications and landscape management, related to the big solar power plants development in correlation with the land occupation [2].

Two-thirds of the pollution on the globe comes from the production of electricity. The production of healthy food requires a healthy environment, unpolluted agricultural land, clean air, and clean surface and underground water.

Solar photovoltaic have great promise for a low-carbon future but remain expensive relative to other technologies. The 21st century will be characterized by a huge energetic demand: world population is steadily increasing (65 billion in 2005, an estimated 75 billion in 2020 and 9 billion in 2050) [3], and there are hundreds of millions of people in emerging countries (China and India in particular) which are rapidly reaching the welfare of Western countries. The world's total energy consumption for 2030 was estimated at about 181014 KWh [4], of which about 1/10 was used as electricity. Fossil fuels, in particular coal, oil and gas, contributed with about 80% and 65% to the generation of world total energy and electricity, respectively. It is obvious that these resources on Earth are finite, and it is also clear that their use is causing great social and economical problems for the world, in relation to geopolitical instabilities in controlling energy sources and global climate: greenhouse gases, which are thought to be the main reason for global warming and climate change, are mostly produced by burning fossil fuels.

In order to preserve human civilization and enable the social and economic development of billions of people in the third world, the answer to the "energy problem", the problem of food and water shortages must be found in the coming decades and should be considered the main topic of political, scientific and engineering discussions in all countries.

Nevertheless, electricity is the basis of all civilized countries and industrialization, and its access is a fundamental step towards achieving people welfare, including the goal of sufficient food and enough water. As reported in[5], 65% of the World's total electricity consumption is obtained from fossil fuels; about 20% comes from nuclear power plants and the rest is produced by means of renewable sources, such as hydropower [6], biomasses, PV, eolic and geothermal sources: these sources are seen as the most promising ways of granting electricity to the whole world, and can help to reach a self-sustaining energy system.

Currently, solar power plants, is still expensive (although prices per kWh have rapidly decreased fast in the past years), comparing with wind power plant, has a longer money payback rate (8–10 years even with a feed-in tariff) and poses important technological challenges, but can be directly used by the final client even in remote locations, does not necessarily require a grid connection (or work in a "net metering' buyback, if a grid is present), is noiseless, maintenance free, reliable for more than 20 years and can be integrated in consumer electronics for low-power applications [7].

Moreover, solar irradiation in third world countries is extremely high and is seen as the most obvious way to electrify isolated communities. Since the total amount of solar energy reaching the Earth's surface has been calculated at more than 10 000 times the world's total energy consumption, it is obvious that this source, if correctly and efficiently used, can supply the substantial part or even all of our future energetic needs. Nevertheless, markets and clients are still dubious regarding the adoption of eolic energy and PV modules, as their price is perceived as being too high compared to fossil fuels. But it has to be stressed that current energy rates do not include externalities, i.e. 'The major impact and costs originating from the production and consumption of energy related activities such as fuel cycles' [8].

These costs arise when an activity with a specified price has an impact on another activity, and imposes on the latter an additional cost that was not accounted for in the former price. Greenhouse gases, car exhaust and chemical waste are typical examples of externalities of fossil fuel use [9], because their social costs (not only monetary, but also related to global warming, cancer, illness, etc) are not considered in the market price. If the price of electricity generated by fossil fuels included externality costs, renewable sources could become more competitive. The adoption of renewable for power generation is slow because of the existence of several development and market penetration barriers, most of which are not scientifically related [10]. Some of these impediments are:

- Economic (lack of competitiveness and internalization of external costs of energy use),
- Institutional (lack of co-ordination in governments and institutions, long-term planning policy requirements),
- Network (monopoly of generation, transmission and distribution of electricity),
- Social (lack of interest in future energy development and sustainability, doubts about new technologies),
- Financial (lack of funding for research or pilot-installation).

Only a long-term policy can aid a niche market in developing, expanding and gaining the political and economical power needed to bring a new technology out of the niche and distribute it to everyone. This road was followed by Germany, now the second world leader in the installation of PV solar panels, also thanks to the feed-in tariff introduced in 2000. There are several reports and market studies that analyze the trend in PV installation all over the world [11].

During the past 4 years Japan, Germany and USA have emerged as leaders in the total kWp installed, sharing together about 90% of the world market. Globally, in 2003 about 753 MWp PV systems were installed, and the 1 GWp barriers was exceeded in 2004. The trend in the PV market has shown an annual increase of about 30% from 2000 until now, making PV one of the fastest growing industries.

Consequently, PV is attracting more and more actors, even if the 10 biggest companies alone share about 90% of the global market; according to some studies, a demand increase is expected thanks also to the introduction of feed-in tariff in more and more countries (e.g. Italy and Spain) and the fulfillment requirements of the Kyoto Protocol. In order to reduce CO_2 emission, the European Council has stated that in 2030 up to 4% of the World's electricity should be generated by PV.

Estimates suggest that world energy consumption in 2050 will be about 25 Gtoe, or 271014 kWh and, if the world wants to avoid social, economic and environmental problems, the largest part of this energy should be produced by renewable. Moreover, the development of emerging countries as well as their energy policy should not follow the development trend of today's civilized countries, particularly with regards to electricity generation.

Concerning PV (and renewable in general), a very long policy planning period is most definitely needed, in order to support the creation of market demand, the assignment of public funding (with feed-in tariffs), and in order to continue a heavy research and development process [12].

3.2. SOLAR POWER PLANTS AND LANDSCAPE MANAGEMENT

Large-scale solar power plants are being developed at a rapid rate, and are setting up to use thousands or millions of acres of land globally. The environmental issues related to the installation and operation phases of such facilities have not, so far, been addressed comprehensively in the literature [13]. It is identified 32 impacts from these phases, under the themes of land use intensity, human health and well-being, plant and animal life, geohydrological resources, and climate change. Appraisals assume that electricity generated by new solar power facilities will displace electricity from traditional generation technologies, which are not clean. Altogether in the scientific literature [14] it is find 22 of the considered 32 impacts to be beneficial. Of the remaining 10 impacts, 4 are neutral, and 6 require further research before they can be appraised.

None of the impacts are negative relative to traditional power generation. In quantitative terms, large-scale solar power plants occupy the same or less land per kWh than coal power plant life cycles. Removal of forests to make space for solar power causes CO2 emissions as high as 36 g CO2 kWh−1, which is a significant contribution to the life cycle CO2 emissions of solar power, but is still low compared to CO2 emissions from coal-based electricity that are about 1100 g CO2kWh−1 [15].

Solar energy for the production of electric energy is one source of renewable energy which is experiencing most development in recent years. In countries with high solar radiation indices, as is the case of Spain, expectations of installation of large solar power plants are increasing.

Most solar power plants are located in rural environments [16], where the landscape has remained practically unaltered ever since extensive agriculture was introduced. Because of this, one of the most significant environmental impacts of this type of installation is the visual impact derived from the alteration of the landscape. In the literature [17] an indicator is proposed for the quantification of the objective aesthetic impact, based on four criteria: visibility, color, fractality and concurrence between fixed and mobile panels.

The relative importance of each variable and the corresponding value functions are calculated using expert contribution. A study of the subjective aesthetic impact is carried out using the semantic differential method [18], to obtain the perception of a sample of individuals of the initial landscapes and of the landscapes altered through the installation of a solar power plant. The combined use of objective indicator and subjective study, faithfully explains user preferences corresponding to the combined comparisons. The tools proposed for the evaluation of the aesthetic impact of solar power plants can be useful for the selection of optimal plant location and most adequate use of panel technology, to minimize aesthetic impact [19].

Renewable energy has developed spectacularly in Spain since the European Union started a process of energy policy reform. A review of Spanish State legislation on renewable energies confirms that the success in installing renewable energy is attributable to public aid. Andalusia is one of the autonomous communities, which has simultaneously developed the legal framework and very successfully implemented the introduction of renewable power. When implementing the central government's policy, the Andalusia regional government prioritized increases in surface cover by solar plants (thermal and photovoltaic energy) and in the number of companies involved [20]. However, this development of renewable energies took place without any proper integration into regional spatial and landscape planning. That is why it is necessary to investigate renewable power implementation through regulatory measures put in place over the last decade to develop renewable

energy systems and the way they can be managed alongside planning issues, especially in correlation with the area of occupied fertile land, which can be used for food production [21].

3.3. SOLAR POWER PLANTS AND INTERACTION WITH FERTILE AGRICULTURAL LAND

There are many solar power plants in the world occupying hectares of fertile agriculture land. For example solar power plant Shams 1 in the United Arab Emirates. The power plant was built three years. It reaches the electrical power of 100 MW by consisting of 258,000 mirrors arranged at 768 cilindro-directional parabolic collector. Occupying an area of about 285 football fields, this power plant provides electricity for 20,000 Emirates households and saving the emission of around 175,000 t of CO_2, which is equivalent to planting 1.5 million trees, or removing 150,000 cars from the roads of Abu Dhabi. In addition, the power plant Shams 1 has a modern system of air cooling, which will significantly reduce water consumption, which is the most valuable resource in the desert regions of the Middle East. Possible improvement in the direction of WEFE nexus would be if the energy produsedby this solar power plant would be used for pumping water from underground layers and irrigating the desert with the goal of food production.

One other large-scale solar power plant was solar thermal power plants with a central receiver, constructed in Ivanpah, in the Mojave Desert in California. The plant occupies an area of 1,400 hectares. It was built three years ago and put into operation in early 2014. Total investment costs for this solar power plant Ivanpah amounted to 2.2 billion USD. This solar plant can annually supply with electricity about 140,000 California households.

Positive practice to be followed is the interactive green solution of solar energy implementation with agriculture development in synergy, as it is presented on the Figure no 1.

Figure 1: Agrivoltaics - solar renewable energy in synergy with agriculture as WEFE nexus

Renewable energy produced in solar power plant with the facilities developed on fertile agricultural land, could be used for households in the nearest villages. This energy could also be used on the spot for irrigation purposes for supplying different agriculture equipment with the electricity, as well as for pumping the water for irrigation from the underground or from certain surface water courses.

3.4. WIND ENERGY IN SYNERGY WITH FERTILE AGRICULTURAL LAND

Wind energy is clean, green, renewable and sustainable energy. Numerous wind farms are being built around the world in suitable locations. One of the most negative possible impacts on the environment is the impact on migratory birds. Therefore, along with technical projects, environmental impact studies must also be developed. There is also the question of land occupation and the use of fertile agricultural land under the wind turbines. Figure 2 present possible synergy between wind power energy production and agriculture fertile land use.

Figure 2: Wind power plant and positive interaction with agriculture

The latest research has shown that under wind turbines it is possible not only to develop agriculture, but even that wind turbines can have a positive effect on agricultural yields. So, wind power plants may do more than improve farm income. When sited in agricultural fields, turbines' churning of air may help crops to grow.

Renewable energy produced in wind power plants with the facilities developed on fertile agricultural land, also could be used for households in the nearest villages, as well as for irrigation purposes for supplying different agriculture equipment with the electricity, or for pumping the water for irrigation from the underground or from nearest surface water channel.

More and more big wind farms are being built in Serbia. One of them is "Čibuk 1". Čibuk 1 wind farm is the largest commercial energy project in the field of wind energy in Serbia and the Western Balkans, with 158MW installed power. This wind power plant has 57 turbines. The pillars of the wind turbines are arranged so that they are at a distance of four pillar heights in width and seven column heights in depth in the direction of the wind. In this way, wind turbulence is avoided and the highest energy efficiency is achieved.

Čibuk 1 wind power plant can prevent more than 370,000 tons of carbon dioxide emissions per year. The investment worth about 300 million Euros was supported by the International Finance Corporation (IFC), a member of the World Bank group, and the European Bank for Reconstruction and Development (EBRD). The conducted questionnaire showed that the investor has followed all the technical, regulatory and environmental requirements.

Within this research, a questionnaire was conducted on a representative sample of 105 respondents, with the aim of exploring the interest of extending production of electricity from wind power in Serbia. 52 subjects from the subgroup *a*, are experts in the domain of wind energy production. In 98% of the cases they are doctors of science. Subgroup *b*, consisting of 53 respondents of different educational levels, age and gender, were randomly selected. The average age of subjects from the subgroup *a*, was on average 59 years, and from subgroup *b*, 37 years. The representation of women in subgroup *a*, is 3%, and in subgroup *b*, the target was 50%. The level of education in subgroup *b* was: 37% high school, 33% secondary school and 30% basic education.

Respondents from subgroup *a*, have of course shown as expected, a very high level of knowledge about wind power plants and all related technical details. It is interesting that subjects from subgroup *b*, also showed a relatively high level of knowledge about wind energy. 68% of subjects from subgroup *b*, had knowledge about the installed wind power plants, which means that in Serbia have been activities on informing and raising awareness about the importance of using wind energy. 93% of respondents from subgroup *a*, responded that Serbian legislation generally follows EU regulations within the domain. The questionnaire supplemented with interview method showed that all key authorities were involved in the decision-making process correctly and adequately, as well as the affected community and NGO.

3.5. HYDRO ENERGY, WATER AND AGRICULTURE LAND USE WITHIN WEFE NEXUS

Energy efficiency is not only related to the saving of the energy in the households and buildings. It is also one of the most important subjects in the process of optimal utilization of water and energy for food production, taking care of the environment. This is actually the requirement of efficient production and use of green renewable energy within the WEFE nexus.

Model of WEFE nexus will be presented through case study of Drina River. The countries that share the Drina river basin are Bosnia and Herzegovina, Montenegro and Serbia. That is why joint development plans must be made, especially development plans related to the planning of a large number of new hydropower plants, because they can significantly affect the environment, but also affect other sectors, especially energy, agriculture and water management. Likewise, the commitments undertaken by all countries in relation to environmental protection, climate change mitigation and GHG reduction are changing economic perspectives. All these influencing factors should be taken into account when discussing plans through the prism of the WEFE nexus, see Figure 3.

Figure 3: Water for energy and food in clean environment - WEFE nexus

An integral assessment of resources has shown that the coordination of the operation of power plants along the Drina River and its tributaries can significantly increase electricity production downstream, as well as agricultural production. The power system model was developed for three states in the river basin as part of a systematic cross-sectoral connectivity project, a nexus covering water, energy, food and environment.

If such complex approaches to water management had been implemented in a timely manner, such level of flooding would not have occurred, nor would there have been damage to the fertile agricultural land of Mačva and Semberija. Dams built upstream in the basin of each river contribute to increasing the degree of flood protection, because in the pre-discharge mode, the flood wave can be significantly reduced and mitigated.

4. CONCLUSION

The goal of this interdisciplinary research was to raise the level of knowledge about the WEFE nexus and thereby contribute to the improvement of the integrated management of natural resources and greater energy efficiency during the implementation of RE.

The WEFE nexus concept helps identify benefits and synergies in natural resource management, in order to achieve:

- Security of water, energy and food
- Preservation of the environment and its functions
- Increased resistance to the climate change and
- Reduced GHG emissions

This research also supports the implementation of the 2030 Agenda, accelerates the transition to a green economy, and also strengthens the dimension of sustainable development and the strategy of energy, water and food for all, while preserving the environment.

5. AKNOWLEDGEMENT

The results shown here are the result of research supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under Contract no 451-03-47/2023-01/ 200213 dated 02/03/2023 year.

REFERENCES

[1] Singh, N., Kamboj, S., Siwal, S. S., Srivastav, A. L., & Naresh, R. K. (2024). Toxic, non-toxic, and essential elements in drinking water: sources and associated health issues in rural Asia. In Water Resources Management for Rural Development (pp. 171-190). Elsevier.

[2] Cogato, A., Marinello, F., & Pezzuolo, A. (2023). Soil Footprint and Land-Use Change to Clean Energy Production: Implications for Solar and Wind Power Plants. Land, 12(10), 1822.

[3] O'Sullivan, J. N. (2023). Demographic Delusions: World Population Growth Is Exceeding Most Projections and Jeopardising Scenarios for Sustainable Futures. World, 4(3), 545-568.

[4] Li, M. (2017). World energy 2017–2050: annual report. Department of Economics, University of Utah.

[5] Zhukovskiy, Y. L., Batueva, D. E., Buldysko, A. D., Gil, B., & Starshaia, V. V. (2021). Fossil energy in the framework of sustainable development: analysis of prospects and development of forecast scenarios. Energies, 14(17), 5268.

[6] Stevovic, I., Mirjanic, D., & Petrovic, N. (2021). Integration of solar energy by nature-inspired optimization in the context of circular economy. Energy, 235, 121297.

[7] Stevović, I., Mirjanić, D., & Stevović, S. (2019). Possibilities for wider investment in solar energy implementation. Energy, 180, 495-510.

[8] Stamopoulos, D., Dimas, P., Siokas, G., & Siokas, E. (2024). Getting smart or going green? Quantifying the Smart City Industry's economic impact and potential for sustainable growth. Cities, 144, 104612.

[9] Sovacool, B. K., Griffiths, S., Kim, J., & Bazilian, M. (2021). Climate change and industrial F-gases: A critical and systematic review of developments, sociotechnical systems and policy options for reducing synthetic greenhouse gas emissions. Renewable and Sustainable Energy Reviews, 141, 110759.

[10] Hassan, Q., Khadom, A. A., Algburi, S., Al-Jiboory, A. K., Sameen, A. Z., Alkhafaji, M. A., ... & Jaszczur, M. (2024). Implications of a smart grid-integrated renewable distributed generation capacity expansion strategy: The case of Iraq. Renewable Energy, 221, 119753.

[11] Tan, V., Deng, R., & Egan, R. (2024). Solar photovoltaic waste and resource potential projections in Australia, 2022–2050. Resources, Conservation and Recycling, 202, 107316.

[12] Mousavian, H. M., Shakouri, G. H., Mashayekhi, A. N., & Kazemi, A. (2020). Does the short-term boost of renewable energies guarantee their stable long-term growth? Assessment of the dynamics of feed-in tariff policy. Renewable energy, 159, 1252-1268.

[13] Khan, I., Liu, W., Zada, A., Raziq, F., Ali, S., Shah, M. I. A., ... & Yang, L. (2024). Recent progress in emerging materials and hybrid nanocomposites for peroxymonosulfate and peroxydisulfate activation towards solar light-driven photocatalytic degradation of emerging pollutants. Coordination Chemistry Reviews, 499, 215466.

[14] Sharma, A., Mahajan, P., & Garg, R. (2024). End-of-life solar photovoltaic panel waste management in India: forecasting and environmental impact assessment. International Journal of Environmental Science and Technology, 21(2), 1961-1980.

[15] Sun, Y., Li, Z., Wang, Q., Zhang, J., & Kong, H. (2023). Low carbon pathway and life cycle assessment of ammonia co-firing in coal power plants under the context of carbon neutrality. Energy Conversion and Management, 296, 117648.
[16] Nikolić, V., Ivaniš, M., & Stevović, I. (2014). INNOVATION OF ORGANIZATION MODEL FOR INTEGRAL RURAL DEVELOPMENT SERBIA CASE STUDY. Економика пољопривреде, 61(3), 695-706.
[17] Beer, M., Rybár, R., & Gabániová, Ľ. (2023). Visual impact of renewable energy infrastructure: Implications for deployment and public perception. Processes, 11(8), 2252.
[18] Mourato, A., Faria, J., & Ventura, R. (2024). Automatic sunspot detection through semantic and instance segmentation approaches. Engineering Applications of Artificial Intelligence, 129, 107636.
[19] Jarčuška, B., Gálffyová, M., Schnürmacher, R., Baláž, M., Mišík, M., Repel, M., ... & Krištín, A. (2024). Solar parks can enhance bird diversity in agricultural landscape. Journal of Environmental Management, 351, 119902.
[20] Usman, O., Iorember, P. T., Ozkan, O., & Alola, A. A. (2024). Dampening energy security-related uncertainties in the United States: The role of green energy-technology investment and operation of transnational corporations. Energy, 289, 130006.
[21] Song, C., Guo, Z., Liu, Z., Hongyun, Z., Liu, R., & Zhang, H. (2024). Application of photovoltaics on different types of land in China: Opportunities, status and challenges. Renewable and Sustainable Energy Reviews, 191, 114146.

STRUCTURE OF THE ALLFALFA YIELD DEPENDING ON PRE-SOWING TREATMENT OF SEEDS WITH GRIVLAG GROWTH SUBSTANCE (GVG)

СТРУКТУРА УРОЖАЯ ЛЮЦЕРНЫ В ЗАВИСИМОСТИ ОТ ПРЕДПОСЕВНОЙ ОБРАБОТКИ СЕМЯН РОСТОВЫМ ВЕЩЕСТВОМ ГРИВЛАГ (GVG)

Skamarokhova Alexandra Sergeevna, graduate student, researcher [1]
Agarkova Natalya Vasilievna, graduate student, research fellow [1]
Nemanja Stepanov, graduate student, research fellow [2]

Abstract: *This study reflects the change in the dynamics of the yield structure of the blue-hybrid alfalfa variety Bazhena (Medicago varia Martin) in the first year of life when seeds are treated with the organic growth substance Grivlag in the conditions of the Central Chernozem Zone of the Krasnodar Territory. According to the studies, alfalfa plants turned out to be the most leafy, the seeds and shoots of which were treated with a growth substance (22.92 g), which on average over three cuttings was 5.02% more than the mass of leaves in the control (21.65 g). The results obtained indicate a positive effect on the overall growth of the above-ground parts of those plants that were treated with the growth substance Grivlag during sowing. This had a particularly strong effect on the acceleration of the onset of the flowering phase of alfalfa, as evidenced by the percentage increase in inflorescences in the experiment compared to the control.*

Key words: *blue-hybrid alfalfa, crop structure, organic growth matter, leached chernozem*

Абстрактный: *Данное исследование отображает изменение динамики структуры урожая люцерны синегибридной сорта Бажена (Medicago varia Martin) первого года жизни при обработке семян органическим ростовым веществом Гривлаг в условиях Центральной черноземной зоны Краснодарского края. Согласно проведенным исследованиям, наиболее облиственными оказались растения люцерны, семена и всходы которых были обработаны ростовым веществом (22,92 г), что в среднем по трём укосам на 5, 02 % больше, чем масса листьев в контроле (21,65 г). Полученные результаты говорят о положительном влиянии на общий рост надземной части тех растений, которые были при посеве обработаны ростовым веществом Гривлаг. Особенно сильно это отразилось на ускорении наступления фазы цветения люцерны, о чем говорит процент увеличения соцветий в опыте по сравнению с контролем.*

Ключевые слова: *Люцерна синегибридная, структура урожая, органическое ростовое вещество, чернозём выщелоченный*

1. INTRODUCTION

Currently, throughout the world, crop production is presented with a wide range of growth substances and biostimulants, ranging from low-hazard and safe for products and the environment,

[1] FGBNU, Krasnodarskiy scientific center for animal husbandry and veterinary science, Krasnodar, Russia, e-mail: rskamarokhov@mail.ru
[2] Faculty of World Economy and International Politics, Moscow (Russia),
e-mail: nemanjastepanov@gmail.com

to completely natural, so-called biostimulants. The goal of creating all these biological products is pursued by one thing - to obtain products with higher yields and increase quality indicators, without harming the environment and at the same time obtaining economic efficiency. Scientists have invented, tested and studied a large number of growth substances and biostimulants in order to identify the most effective and suitable for production. One study tested several biostimulants: humic acids, macro- and microalgae extracts, alfalfa protein hydrolysate, amino acids alone or in combination with zinc, B vitamins, chitosan, and a commercial product containing silicon. For example, the macroalgae extract was effective in stimulating tree growth potential in both years, as evidenced by significantly greater leaf area (> 20% compared to control), as well as higher chlorophyll content and leaf photosynthetic rate. Treatment with macroseaweed extract, B vitamins and alfalfa protein hydrolysate significantly improved the intensity and duration of the red color of apples at harvest. Accordly, the content of anthocyanins in the peel of apples treated with the same biostimulants was significantly higher than in the control, which emphasizes the potential influence of these substances on the synthesis of secondary metabolites in apples [1].

Live bacteria that release useful substances also can be considered as a growth stimulants. Thus, cytokinin is required for the initiation of nitrogen-fixing nodules in alfalfa caused by rhizobia, and for the retardation of leaf senescence induced by drought stress, some free-living rhizobia have been found to produce cytokinin. The study combined two strains of Sinorhizobium that overproduce cytokinin. As a result, after severe drought stress, most alfalfa plants inoculated with these strains survived, and nitrogenase activity in their root nodules did not undergo obvious changes [2]. The so-called nanohumus obtained from lignite can also serve as a soil improver and growth regulator. To study the effect, alfalfa (Medicago sativa L.) was used. The positive effect of the humic product on soil properties and alfalfa growth in field conditions was evident after 2 years of use. A single application at the beginning of each growing season gave better results than divided into two applications. A single application of nanohumus significantly increased the available phosphorus in the soil by 63% and potassium by 96% compared to the control; it significantly increased total alfalfa biomass by 749%. These results provide important practical conclusions for the further use of humic material as a soil improver and growth regulator [3].

For alfalfa breeders, an important factor is the timing of flowering. Early-flowering alfalfa genotype 80 and late-flowering alfalfa genotype 195 were characterized by flowering phenotype. The analysis showed that the lower content of jasmonate, a hormone that regulates plant growth and development, in new leaves and the suppression of its biosynthesis genes may play a significant role in the early flowering phenotype. Comprehensive phenotypic, physiological, and transcriptomic analyzes indicate that hormone biosynthesis and signaling pathways, pathogenesis-related genes, signaling receptor kinase family genes, secondary metabolism genes, and proteasome degradation pathway genes are responsible for the early flowering phenotype in alfalfa. This will provide new insights into future research on flowering time in alfalfa and inform genetic improvement strategies to optimize this important trait [4].

2. MATERIALS AND METHODS OF RESEARCH

The studies were done according to standard methods [5, 6]. The aim of the study was to investigate the effect of growth substances (Grivlag) on alfalfa (Bazhena) yield changes. The experiments are set up on a trial estate of the Federal State Budgetary Institution "Krasnodar Scientific Center for Animal Science and Veterinary Medicine" (on April 20, 2022). The size of the experimental plot was 100 m2 (50 m2 experimental plot, 50 m2 control plot). Blue-hybrid alfalfa variety Bazhena was sown, treated with a solution of growth substance from a spray bottle, solution concentration (Medicago varia Martin) (patent holder and originator of the P.P. Lukyanenko Research Center, included in the register of breeding achievements of the Russian Federation since 2019).

The growth substance Grivlag (GVG) is a complex energized fertilizer with a complex chemical composition, up to 40% of which is occupied by sodium salts of petroleum acids, which are cyclic monobasic acids [7].

3. RESULTS AND DISCUSSION

Summary data on the yield structure of three alfalfa harvests in the first year of life are presented in Table 1.[8].
The highest total weight (66.6 g), weight of leaves (26.75 g), stems (33.35 g) and inflorescences (6.50 g) was in the second harvest of the first year of plant life. The smallest weight according to all indicators was noted in the first harvest: total weight 49.15 g, weight of leaves 18.90 g, stems 29.65 g and inflorescences 0.60 g).

Table 1. Structure of the Bazhen alfalfa yield in the first year of life without pre-sowing seed treatment

Parameters №	Total weight (g)	Leaf weight (g)	Stem weight (g)	Inflorescence weight (g)	Leaf weight vs total (%)	Stem weight vs total (%)	Inflorescences weight vs total (%)
1	49,15	18,90	29,65	0,60	38,45	60,33	1,22
2	66,6	26,75	33,35	6,50	40,17	50,08	9,76
3	54,25	19,30	30,45	4,50	35,58	56,13	8,29

The highest percentage of leaves from the total plant mass was also in the second harvest (40.17%), the highest percentage of stem mass from the total was observed in the first harvest (60.33%). The structure of the alfalfa yield from the experimental plot is presented in Table 2.

Table 2. Structure of the yield of Bazhen alfalfa in the first year of life treated with the growth substance Grivlag.

Option	Total weight, g.	Leaf mass, g.	Weight of stems, g.	Weight of inflorescences, g.
Control (without processing)	56,67±5,18	21,65±2,55	31,15±1,12	3,87±1,73
Experience (with pre-sowing seed treatment with Grivlag)	63,48±7,67	22,92±2,07	35,55±2,78	5,02±2,85

In the experimental treatment and control as well, the total weight was highest in the second harvest (78.65 g). The weight of leaves (26.95 g), stems (41.10 g) and inflorescences (10.60 g) significantly exceeded the weight of these plant parts in the second harvest compared to the first and third.

Table 3 shows the values of the measured parameters of the yield structure alfalfa (variety Bazhena) in all tree harvests in the first growing season (one year).

Table 3. Comparison of average values of the yield structure for three cuttings in the first year of alfalfa life, depending on the treatment of seeds with the growth substance Grivlag.

Option	Total weight, g.	Leaf mass, g.	Weight of stems, g.	Weight of inflorescences, g.
Control (without processing)	56,67±5,18	21,65±2,55	31,15±1,12	3,87±1,73
Experience (with pre-sowing seed treatment with Grivlag)	63,48±7,67	22,92±2,07	35,55±2,78	5,02±2,85

Note: ** $p<0,01$ *** $p<0,001$

When statistically processing data on the structure of the crop obtained from three harvests, unreliable results were obtained, however, alfalfa is a perennial forage crop, the structure of which must be studied for three years. According to preliminary data, it can be noted that the increase in the total weight of the different parts of alfalfa plants increased across all cuttings in the experimental treatment - 63.48 g, which is 12% more than in the control (56.67%). At each measurement, the same trend was observed. The weight of leaves in the experimental treatment (22.92 g) was 5.87% greater than in the control variant (21.65 g). The weight of the stems in the experiment (35.55 g) exceeded the weight in the control (31.15 g) by 14.12%.

An increase in the weight of stems in feed production is a negative factor, since the stem is an indigestible fiber - lignin, the content of which in the feed leads to a deterioration in the quality of the main feed (hay or haylage). However, with an increase in the total weight of the plant, a proportional increase in the weight of stems is a natural phenomenon, given that the weight of the leaves also increased.

It was noticed that plants from seeds treated with Grivlag began to bloom earlier than the control. Therefore, we can conclude that the treatment contributed to the acceleration of the reproductive phase of development of alfalfa plants. The weight of inflorescences in the experiment was 5.02 g, which is 22.90% more than the weight of inflorescences in the control (3.87 g).

4. CONCLUSIONS

The growth substance Grivlag had a positive effect on the yield structure of the blue-hybrid alfalfa variety Bazhena in the first year of sowing. In total, for three cuttings, the average total weight of experimental plants exceeded the weight of control plants by 12.0%. Also, in the experimental treatment, the average weight of leaves (by 5.02%), stems (14.12%) and inflorescences (by 22.9%) exceeded the control. The rate of flowering of alfalfa inflorescences has increased, which is also an important aspect in the further study of this growth substance.

REFERENCES

[1] Gorkovenko L.G., Bedilo N.A., Ossetsky S.I., (2016), Productivity and nutritional value of new varieties of alfalfa Rieger, Collection of scientific papers of the North Caucasus Research Institute of Animal Husbandry, T. 5. № 1. p. 110-114.

[2] Bedilo N. A., (2016), Productivity, feed value and symbiotic activity of leguminous grass species and their grass mixtures on leached chernozem of Western Ciscaucasia, abstract of thesis. ... candidate of agricultural sciences / Kuban. state agrarian univ. Krasnodar,

[3] Soppelsa S. (2018), Use of Biostimulants for Organic Apple Production: Effects on Tree Growth, Yield, and Fruit Quality at Harvest and During Storage / S. Soppelsa, M. Kelderer, C. Casera, M. Bassi // Front Plant Sci. 2018 Sep 20;9:1342. doi: 10.3389/fpls.2018.01342

[4] Xu J. et al. (2012), Effects of engineered Sinorhizobium meliloti on cytokinin synthesis and tolerance of alfalfa to extreme drought stress / J Xu, X.-L. Li, L. Luo // Appl Environ Microbiol. Nov; 78(22): 8056-61. doi: 10.1128/AEM.01276-12

[5] Zhao Y. (2022), Application timing optimization of lignite-derived humic substances for three agricultural plant species and soil fertility / Y. Zhao, M. A. Naeth // J Environ Qual. 2022 Sep;51(5):1035-1043. doi: 10.1002/jeq2.20393

[6] Ma D. et al. (2021), Identification and characterization of regulatory pathways involved in early flowering in the new leaves of alfalfa (Medicago sativa L.) by transcriptome analysis / D. Ma, B. Liu, L. Ge, Y. Weng // BMC Plant Biol. 2021 Jan 6;21(1):8. doi: 10.1186/s12870-020-02775-9.

[7] Williams, V. R., (1987), Guidelines for conducting field experiments with forage crops of the All-Russian Research Institute of Feeds, p. 17

[8] Dospehov, B.A. (2014), Methodology of field experience (with the basics of statistical processing of research results): a textbook for higher agricultural educational institutions / B. A. Dospehov. – M.: Alliance, p. 351

ORGANIC AGRICULTURE PERSPECTIVES AND CERTIFICATION IN WESTERN BALKANS

PERSPEKTIVE I SERTIFIKACIJA ORGANSKE POLJOPRIVREDE ZAPADNOG BALKANA

Aleksandra Stojkov Pavlović, PhD student[1]
Larisa Jovanović, Emeritus prof. dr [2]

Abstract: *Bioeconomy and ecology are indivisible, but investors are not always interested in the humane aspects of the economy, i.e. organic agriculture, however organic agriculture in Western Balkans is growing. This case study presents the results for selected countries: Serbia, Bulgaria (EU), Croatia (EU) and Montenegro. The goal of this work is to investigate perspectives of organic agriculture development and certification. In first section, is analyzed the present time situation in organic production and certification. In section two are presented results on growing of organic agriculture land and organic shares.*

Key words: *Organic Production, Ecology, Green Economy, Comparative Analysis, Western Balkans*

Apstrakt: *Bioekonomija i ekologija su nedeljive, ali investiture ne zanimaju uvek humani aspekti privrede, odnosno organska poljoprivreda, međutim organska poljoprivreda na Zapadnom Balkanu raste. Ova studija slučaja predstavlja rezultate za odabrane zemlje: Srbiju, Bugarsku (EU), Hrvatsku (EU) i Crnu Goru. Cilj ovog rada je da se istraže perspektive razvoja organske poljoprivrede i sertifikacija. U prvom delu, analizirana je trenutna situacija u organskoj proizvodnji i sertifikacija. U drugom delu su predstavljeni rezultati rasta organskog zemljišta i udeo organske proizvodnje.*

Ključne reči: *Organska proizvodnja, ekologija, zelena ekonomija, komparativna analiza, Zapadni Balkan*

1. INTRODUCTION

Organic agriculture contributes preservation of natural resources, primarily water and soil. It represents a system of sustainable agriculture which maintains ecological balance and minimizes the negative impact of agriculture on the environment. Also, it implies production in accordance with standards and certification. In current conditions of man-made transformation of nature, the principle adequacy of the materials and technologies used to productivity and resources of the biosphere is of cardinal importance [1]. In organic agriculture development, one of the main factors is the soil condition. Organic production is a very specific type of agriculture, basically the opposite of conventional agriculture, strongly ecologically oriented, expresses concern for the preservation of the environment, natural resources and biological diversity, emphasizes the use of natural materials and respect for the biological processes of plant growth and development and animals raised as part of agricultural activity [2]. Challenges facing agriculture and food production look huge [3]. It is generally known that producers that use modern strategies can play an important role in solving environmental problems [4]. Contemporary aspirations in agriculture inevitably imply the development of an ever-increasing share of organic agriculture in total agricultural production. management in a way that will ensure precaution and responsibility in order to protect the health

[1] Alfa BK University, Beograd, e-mail: aleksandra.stojkov.pavlovic@alfa.edu.rs
[2] Alfa BK University, Beograd, e-mail: larisa.jovanovic@alfa.edu.rs

and well-being of current and future generations and the environment [5]. As a developing country Serbia could spot an opportunity for agricultural development. The production of food products exclusively from ingredients that are not harmful to the health of consumers is the surest guarantee of food health safety [6]. Bulgaria and Croatia, as EU members, have implemented and use EU regulations, while Serbia and Montenegro, which are candidates for membership in terms of certification, have their own regulations.

2. MATERIALS AND METHODS

In this paper were used descriptive methods and comparative analyses through indicators of FiBL & IFOAM – Organics International (2023): The World of Organic Agriculture [5]. Product, incentives and certification research is proprietary research. Appreciation of current status in organic production for selected countries conducted by using official and statistical data for soil and land availability for countries of Western Balkans: Republic of Serbia, Bulgaria, Croatia and Montenegro.

3. RESULTS AND DISCUSSION

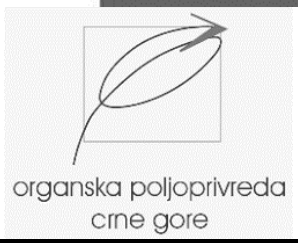
Bulgaria and Croatia, in addition to national certification, fully implement mandatory EU regulations – European Union of Regulation 848/2018, Serbia and Montenegro have implemented domestic regulations (Table 1).

Table 1. System of legal frameworks in organic production

Country	***Domestic policy***	***Relevant authority***	***In use***
Serbia	Law on organic production	Ministry agriculture, forestry and water management	Domestic
Bulgaria	National Plan for Delopment of Organic Farming in Bulgaria 2007-2013 (former)	Bulgarian Ministry of Agriculture, Food and Forestry	EU
Croatia	Law on organic production and labeling of organic products (former)	Republic of Croatia Ministry of Agriculture	EU
Montenegro	Law on Organic Production	Ministry agriculture, forestry and water management	Domestic

Source: Author‘s systematization

Table 2. Official organic product marks

Country	*Official mark*
Serbia	
Bulgaria	
Croatia	 
Montenegro	

Source: Author‘s systematization

Table 3. Control bodies and control authorities in the organic sector

Country	*Number of bodies and authorities*	*Relevant authority*
Serbia	6	Accreditation Body of Serbia
Bulgaria	17	European Commision
Croatia	11	European Commision
Montenegro	1	Accreditation body of Montenegro

Source: Author‘s research

By product types (table 3), Serbia mainly has the production of fruits with 458 producers of which 149 are processors. Producers are focused on: raspberries (from Arilje region), strawberries and berry fruits. Producers also export vegetables, grain, legumes and oilseeds. The production of organic meat and diaries is also under development. Cases of group organization of production have been noticed. The top 3 producers of 2022 in cooperative production shows table 4.

Table 4. Producers in cooperative organic production with number of cooperants

Producer	***Number of cooperants***
Zadrugar doo	763
Fortis doo	742
Frikos doo	577

Source: Author‘s research

Bulgarian production is based on honey: Acacia, Wildflower, Lavender, Black Forest and Linden, but Bulgarian rose products are also represented and other aromatic plants. Organic seeds and cereals are produced in Bulgaria. In Croatia, there are farms of grains and vegetables, but the main product is organic olive oil, for which the coast of the Adriatic Sea (example Terra Rossa from Sveta Katarina) is known, as well islands. “Šoltansko super organic” olive oil was awarded in Tokyo, New York and Dubai. Olive oil under a unique name is produced by small local producers from the island Šolta. Organic production in Montenegro is scattered and diverse that mostly cover local requirements, with no practice of the association. Vegetables, fruits and forest fruits, then figs and pomegranates (local potential), honey, cereals and lambs and sheep are grown. Vegetable grows 424 producers (371 fruit, 63 agricultural crops and medicinal plants, 10 vegetable crops, a 3 producers collect forest fruits and medicinal herbs). Livestock production has 64 producers (56 beehives), 27 deals with the processing, from which stand out: IN-SPE (wild plants and organic tea) and the largest farm is HM Durmitor [7].

Table 5. Comparative analysis of organic producers and products

Country	***Producer***	***Products***
Serbia	Minex Kruševac Master food Užice Medino Krnjevo Yugotrejd Arilje	Frozen fruit and forest products Strawberry and other berries Honey and bee products Raspberry, blackberry, strawberry, plum and cherry
Bulgaria	Adan Village Damovitsa Mountin Rose Sofia Amerov Honey Ignatievo Bilbo Varna	Seeds and grains Rose and aromatic plants Honey
Croatia	Terra Rossa Sv. Katarina Zrno Eko Imanje Dubrava Šolta group of producers	Olive oil Vegetable, arable and spicy crops olive oil

Montenegro	Pavlićević Zoran Žabljak Macanović Željko Pljevlja Mugoša Igor Podgorica IN-SPE HM Durmitor	Potatoes, Cabbage, Beetroot, Carrot, Onion, Barley, Buckwheat, Rye and flour Wild pomegranate, Fig Plum, Apple Honey Aromatic Herbs Lambs, sheeps

Source: Author's research

Serbia established a digital register of agriculture holdings through the eAgrar platform. All incentives can be realized by registration and request on the eAgrar platform. Incentives for organic crops amount to 63,000 dinars per hectare (maximum of 20 ha). Maximum total amount 1,260,000 dinars. Exceptionally in 2023, incentives for organic plant production are in the corresponding percentage amount in relation to amount for financial contribution for basic incentives in plant production and recourse for fuel [8]. Incentives for organic livestock for 2023 the maximum total amount of incentive is 55,000,000 dinars. Incentives for certification the maximum amount per user is 1,000,000 dinars [8].

Bulgaria and Croatia are a part of the Common agricultural policy (CAP) [9]. Bulgaria's CAP Strategic Plan has been submitted in 2021, for period 2023-2027 includes two eco-schemes for organic maintenance payments in the first pillar: crops and animals. There are payment for crops, grazing animals, pigs and bee's families. The payment rate for plants is divided into 3 parts: basic payment, supplement for proven production of at least 70% of the national average, supplement for the use of organic seeds and planting material. Another new feature is the introduction of a regressive rate for each of the crop groups, with 100% paid up to 50 ha; 50% from 50 to 65 ha and 10% over 65 ha.

Croatia consisted in the increase of organic pastures, grassland, and orchards, and the organic vegetable production has not grown that much in the previous years. This is due to CAP payment model based on hectares. The budget set for organic farming under the first pillar is EUR 1,750,000 million for the whole CAP period (2023-2027). Most of the eco-schemes will be available to conventional farmers only. [10].

Montenegro incentives [11]: support per ha, conditional head of livestock, poultry and number of bee colonies. Producers who for the first time sign an Agreement undertake to remain in organic production at least 3 years, otherwise they will be obliged to return the received support. The amount of support per request cannot exceed €20,000. There are funds for the purchase of wax for organic production. Payment in organic production for producers who perform the certification process for the first time in the is more stimulating and higher. Payment in plant production for: €300-450 per ha. Payment in livestock €120; poultry - €2.5; bee colony - €40.

Beside incentives for the development of organic production, there are projects such as the Organic Bridge INTERREG - IPA in cooperation with the EU implemented in Serbia and Croatia [12].

In Serbia, the organic sector has been developing in recent years, with its expansive growth, organic production will have its more intensive application only in the coming period [13]. The production of healthy food can be a postulate of satisfying existential needs, but also a factor of revitalization [14], thus natural assets continue to provide environmental resources and services [15]. In 2020 the number of producers was 439 and the latest data shows 651 producers in 2022 [16]. For Bulgaria,

this sector is national priority [17]. In Croatia the number of organic producers is growing. Montenegro shows no progress. (Table 6).

Table 6. Number of producers and other operator types by country 2021

Country	***Producers***	***Producers (2019-2020)***	***Trend in number of producers***
Serbia	458	439	+19
Bulgaria	5942	5942	0
Croatia	6024	5153	+871
Montenegro	422	423	-1

Source: Author‘s systematization

Table 7. Organic farming indicators data in Serbia, Bulgaria, Croatia, Montenegro (2020)

Indicator ***Country***	***Organic agricultural land (including in-conversion areas) in ha***	***Organic shares of total agricultural land in %***	***Organic Agricultural land development – 10-years growth in %***
Serbia	19317	0,6	209,7
Bulgaria	116253	2,3	364,6
Croatia	108610	7,2	239,0
Montenegro	4823	1,9	57,2

Source: Author‘s systematization

Organic shares of total agricultural land data shows big efforts of Croatia (7.2) as 27th world country, Bulgaria (2.3) takes 52nd place, and Serbia with less than 1 (0.6) takes 92nd place in the world scale, but the 10-years data of development is encouraging in each of selected countries, in Bulgaria 10-years growth of organic agricultural land is 346.4%, in Croatia 239% and in Serbia 209.7%. Serbia‘s notably weaker results. Otherwise Montenegro 1.9%, and 10-years growth of 57,2%.

It is also necessary to consider the characteristics of the soil. Based on researches [18, 19, 17, 20] Serbia has diverse resources and soil of different taxonomies, which is why is close to Bulgaria, unlike Croatia, which has less soil of that quality Montenegro has areas such as Serbia. Significant amounts of land in Croatia and Serbia are not suitable for organic production because of lignite and other phytotoxic elements. Damage of land in Bulgaria is the result of coal mining [21] and use of lignite. In Montenegro certain types of soil near polymetallic mines and lignite fields and other industrial facilities can become phytotoxic and unsuitable [22]. Organic production in Croatia is

considerably lower than in other EU countries [23], thus this research confirms the differences between Croatia and Bulgaria. However, it must be considered organic share in total agricultural land with 7.2 in Croatia [18] and 2.3 in Bulgaria. Montenegro has negative trend in number of producers compared to the previous period, share of 1.9 of total agricultural land is higher than in Serbia (0.6). Serbia has sufficient natural resources for the development of organic agriculture, but has not finance support for acceptable technologies and means of production [24]. In general, when it comes to the number of producers, the trend is positive in Serbia (+19) and Croatia (+871), there are no changes in Bulgaria, while the trend is negative in Montenegro.

4. CONCLUSIONS

The development of organic agriculture in the Western Balkans is close with the processes in the EU. Organic agriculture makes its contribution to the development of the green economy, thus perhaps we can place it even more closely as a bio-economic activity, given that it fully corresponds to its goals. Industrial processes that affect the soil also affect organic production. Without investments and the support of the government, it is not possible to achieve the development of organic agriculture. The increase in the area of arable land under organic production and the number of the organic producers testify in favor of the fact that the concept of organic production is outlook and long-term profitable activity. Success of organic farming depends on soil quality. The transition from fossil sources to renewable energetic sources is obligatory for organic agriculture development. The advantage of Montenegro is almost 30,000 ha of Terra Rossa land of typical quality, but it is necessary to invest additionally to regulatives. Bulgaria and Croatia are committed to the Action plan for organic production in the European Union 2021 – 2027 and CAP policy through their Eco-Schemes. Serbia and Montenegro to harmonize future the regulations with EU.

REFERENCES

[1] Ermakov V, Jovanović L (2023) The importance of biogeochemistry in environmental protection and green growth. In Jovanović L, Ermakov V, Ostroumov S (ed) The role of green economy transition in green growth and environmental protection. Ecologica, Belgrade DOI: https://10.18485/tgesd.2023.2.ch1

[2] Ristić L, Despotović D, Veselinović P (2022) Organic agriculture as a factor in the development of green economy. Ecologica https://doi.org/10.18485/ecologica.2023.30.112

[3] Janković M, Bogdanović Jović A, Ivannikov N, Kijački, D (2023) Organic production as a concept of preserving the ecological specificities of rural areas. Ecologica DOI: https://10.18485/ecologica.2023.30.110.8

[4] Čajka Z , Jovanović L (2014) Sustainable marketing management. Ecologica, Belgrade

[5] Willer H, Schlatter B, Trávníček J (2023) The World of Organic Agriculture, Statistics and Emerging Trends 2023. FiBL, Frick & IFOAM-Organics International, Bonn

[6] Jovanović L, Mikulec Pešić I, Pavlović I (2007) Application of HACCP in food production and distribution. Ecologica, Belgrade

[7] ECOCONCECT (2022) Izjveštaj o organskoj poljoprivredi

[8] http://www.minpolj.gov.rs/organska/?script=lat

[9] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Eco-schemes

[10] IFOAM (2023) Evaluation of support for organic farming in draft CAP Strategic Plans (2023-2027)

[11] https://www.gov.me/clanak/javni-poziv-za-dodjelu-podrske-organskoj-proizvodnji-za-2023-godinu

[12] Interreg – IPA CBC (2021) Evaluation (Impact assessment) of Interreg IPA Cross-border cooperation Programme Croatia-Serbia 2014-2020

[13] Tripković A, Arsić Lj, Dobričanin S (2023) Small and medium-sized enterprises as the backbone of the development of organic production in the Republic of Serbia. Ecologica.

https://doi.org/10.18485/ecologica.2022.30.111.2
[14] Bojičić R, Tripković A (2023) The influence of organic production on the business of agricultural farms. Ecologica DOI: https://doi.org/10.18485/ecologica.2023.30.111.5
[15] Pavićević N (2023) Creating a model of the process of improving the development of the green economy concept: IDEF methodology application. Ecologica. https://doi.org/10.18485/ecologica.2022.30.111.9
[16] MAFWM (2023): List of producers involved in organic production in 2022
[17] Shishkov T, Kolev N (2014) The Soils of Bulgaria. Springer, Dordrecht
[18] Bašić F (2013) The Soils of Croatia. Springer, Dordrecht
[19] Pavlović P, Kostić N, Karadžić B, Mitrović M (2017) The Soils of Serbia. Springer, Dordrecht
[20] Protić N, Marinović Lj, Milicic B, Stevanović D, Mojašević M (2005) The Status of Soil Surveys in Serbia and Montenegro. European Soil Bureau
[21] Kirilov I, Banov M (2016) Reclamation of lands disturbed by minig activities in Bulgaria. Agricultural Science and Technology. DOI:10.15547/ast.2016.04.066
[22] Vidojević D, Zdruli P, Čivčić H, Marković M, Milić S, Mukaetov D, Knežević M, Sharku A (2022) State of the art of soil management in Western Balkans 2021. Standing working group for regional rural development (SWG)
[23] Gajdić D, Petljak K, Mesić Ž (2018) An exploration of distribution channels: Challenges and opportunities for organic food producers in Croatia. Economics of agriculture DOI:10.5937/ekoPolj1804461G
[24] Jovanović L, Stojkov Pavlović A (2023) Perspectives of organic agriculture in Serbia. Scientific Council of the Russian Academy of Sciences for Soil Science UDC: 631.95:574.22

EFFECT OF FERTILIZERS ON HEAVY METAL RESIDUES IN AGRICULTURAL SOILS

UTICAJ ĐUBRIVA NA SADRŽAJ TEŠKIH METALA U POLJOPRIVREDNOM ZEMLJIŠTU

Elahmar M.A., researcher[1]
Ana Anđelković, research associate[2]
Nenad Trkulja, senior research associate[2]
Sanja Đurović, research associate[2]
Snežana Janković, principal research fellow[3]
Slađana Savić, research associate[2]
Danijela Šikuljak, principal research fellow[2]

Abstract: *The use of fertilizers is an integral part of agricultural production nowadays, as it has beneficial effects on the yield of agricultural products and the functioning of the agricultural sector. Nevertheless, their unregulated use can lead to serious harmful effects on the environment and human health. The aim of this research is to measure the residual amounts of selected elements in agricultural soils, aggregated due to the use of fertilizers during the vegetation season and to predict the potential for contamination of agricultural soils. The applied dose of fertilizers has resulted in the accumulation of heavy metals in the soil, but their quantities were within the allowed threshold values.*

Key words: *fertilizers, heavy metals, residues, contamination, soil*

Apstrakt: *Primena đubriva je u današnje vreme sastavni deo proizvodnje jer unapređuje poljoprivredni sektor i prinos gajenih biljaka. Međutim, njihova nekontrolisana primena može dovesti do ozbiljnih štetnih efekata na životnu sredinu i zdravlje ljudi. Cilj ovog istraživanja je bio da se izmere zaostale količine pojedinih elemenata u zemljištu usled primene đubriva tokom vegetacije useva i da se na osnovu toga predvidi mogućnost zagađenja poljoprivrednog zemljišta. Primenjena doza đubriva je uticala na akumulaciju metala u zemljištu i njihov sadržaj je bio u graničnim vrednostima.*

Ključne reči: *đubriva, teški metali, ostaci, kontaminacija, zemljište*

1. INTRODUCTION

Good agricultural practices nowadays imply an integral approach to growing crops, an increased use of nonchemical measures and the production of healthy and safe food, with no harmful effects on human and animal health and the environment. The main goal of every agricultural production is to ensure the highest yields and economic benefits. Benefits and downsides of conventional agricultural production have been analyzed for a decade now, leading agricultural production towards a more organic approach to food production. Nevertheless, organic production is not always

[1] Biotechnology Research Center, Tripoli, Libya,
[2] Institute for Plant Protection and Environment, Belgrade, Serbia, e-mail: ana.andjelkovic21@gmail.com; trkulja_nenad@yahoo.com; stojakovicsm@yahoo.com; bonita.sladja@gmail.com; dulekaca@yahoo.com
[3] Institute for Science Application in Agriculture, Belgrade, Serbia, e-mail: sjankovic@ipn.bg.ac.rs

a source of the best quality food. The fact is that food produced in this way is safer, as it contains less nitrates and pesticides. On the other hand, organically produced food also contains lower amounts of proteins, and its higher amount of minerals and vitamins does not give it an advantage over conventionally produced food [1-2]. An advantage of these organically produced products is certainly a higher content of secondary metabolites forming part of the defense mechanisms of plants, animals, and humans [2]. Due to the conflicting facts, practical results, and analysis, in this case it is often debatable whether the goal justifies the cause?

One of the aspects of successful production is also the application of fertilizers. Although their application strengthens the agricultural sector, their effects should not be seen only through the prism of increased crop yields, as their effects on the environment and human health should also be considered. In the times of climate change, analyses have shown that commercial fertilizers increase CO_2 emissions, global warming, soil contamination, and the contamination and eutrophication of surface and groundwaters [3-4]. Also, a study [5] has shown that a reduced use of fertilizers would lower the emission of harmful gases by 20%. In general, an inadequate application of fertilizers affects the agricultural soils directly, and climate change, human, livestock, and game health indirectly. Furthermore, research has shown that plants absorb only about 50% from nitrogen-based fertilizers, while the remaining amount goes into groundwaters or the atmosphere in the form of N_2O gas [6-7]. An uncontrolled use of nitrogen and phosphorus-based fertilizers is especially harmful, as it leads to anion build up in the soil [8]. Also, high concentrations of nitrates in tap water can lead to cancer development, while resulting in lower concentrations of oxygen in the rivers and increased concentrations of salt in the ground, thus increasing alkalization of agricultural soils. Nevertheless, despite all of the above, agricultural production is unimaginable without fertilizers. [9] have done research in Germany which has shown that a reduced application of nitrogen fertilizers reduces wheat yields by up to 50%, the producers' revenues by up to 40%, while the wheat price increased (up to 5%), as did the investments in the production (by about 12%). Fertilizers contain macro and micro elements essential for the crop. However, their on presence content in the environment and food, due to their uncontrolled application, can reach toxic levels. Each state has defined limits on the maximum allowable concentrations of these elements in food, water, soil, and air.

The aim of this research was to measure the amounts of nickel, zinc, and manganese that remain in the soils after the application of fertilizers during the vegetation season, and to predict the potential for contamination of agricultural soils based on this.

2. MATERIAL AND METHODS

Trials were conducted in 2021 in laboratory conditions. Residues of chemical elements in the soil were tested after the application of synthetic fertilizers. Fertilizers were applied at quantities of 1.5 ml/100 ml of water (with 3 l/ha as the recommended dose) 25 days after plant emergence. Seeds were planted in 1 L volume pots in the following treatment combinations: monocultures - *Avena fatua* (AV), *Abutilon teophrasti* (AB), wheat (PŠ) and corn (KK) and their combinations KK *vs.* AB, KK *vs.* AV, AB *vs.* AV, PŠ *vs.* AV, PŠ *vs.* AB. Plants (pots) were watered when needed and kept in controlled conditions: light/dark 12/12 h, T = 25/22 ºC. Analysis of heavy metal contents were done 20 days after removing the plants, following the Meeting the Challenges of Soil Analysis with the Avio 200 ICP-OES methodology (Author: Nick Spivey PerkinElmer, Inc. Shelton, CT). From each pot (treatment) 1 g of finely ground soil was extracted (in three replicates). Soil degradation was done using 20 ml of concentrated nitric acid for 1 hour at 80°C, after which 5 ml of hydrogen-peroxide were added and the sample was heated for 30 min at 60-70°C, resoaked in 5 ml of hydrochloric acid and heated for 1 h. After cooling, distilled water was added up to 100 ml of volume and the filtered content was used in the analysis of heavy metal contents. The calibration curve was obtained from the mixture of heavy metals and microelements. Adequately diluted working solutions were on prepared (in the range of 0.05 mg/kg to 2 mg/kg) based on which the calibration curves were produced. The content of heavy

metals and microelements in the soil samples are given in mg/kg of the soil. All the results were compared by analysis of variance (LSD test) and t-test of independent samples.

3. RESULTS AND DISCUSSION

The presence of metals in the soil in quantities higher than the allowed represents a potential environmental risk, with possible harmful effects on human and animal health. Heavy metals can reach the soil, and consequently the food chain, through the application of different fertilizers, industry, traffic, and pesticide use. Microelements from fertilizers are often a source of heavy metals and their uncontrolled use or facilitates their deposition. In the instances when their concentration is high, plants can absorb large amounts of these compounds, which reach human and animal organisms through the food chain. [10] state that accumulated quantities of these metals are often not toxic for plants, even though they can be for people and animals (e.g. cadmium). This study has shown that applied fertilizers have resulted in higher quantities of copper, zinc, nickel, and molybdenum in the soil (with the exception of nickel after the application of F3 fertilizers). Average values of heavy metal and microelement content in soil samples following the application of fertilizers are shown in Table 1, with results of statistical analysis given in Table 3.
Based on the analysis of average content of tested elements the following was shown: 1) when grown in monoculture, zinc was present in all samples following the application of both tested fertilizers, copper was also present in all samples (except for KK) after the application of both fertilizers, while manganese was detected only in PŠ after the application of F2 fertilizer and 2) when grown in combination treatments: zinc was detected in all samples, except in the KK *vs* AB combination after the application of F3 fertilizer, copper was present in KK *vs* AV and PŠ *vs* AV combinations after the application of F3 fertilizer, nickel in KK *vs* AV and PŠ *vs* AV combinations after the application of F2 fertilizer and in KK *vs* AB, AV *vs* AB, and AV *vs* PŠ combinations after the application of F3 fertilizer, while manganese was registered in AB *vs* AV and PŠ *vs* AV combinations after the application of F3 fertilizer (Table 1). No consistency in the deposition of certain metals in the soil was observed depending on the plant species, which leads us to conclude that the tested fertilizers (Table 2) are the source of the detected elements.

Table 1. Average values of heavy metal and microelement content (mg/kg soil) in soil samples

plants	fertilizer	Nickel	Copper	Zinc	Manganese
soil	control	0.099	17.498	9.843	59.356
KK	F2	≤	≤	10.835	≤
KK	F3	48.530	≤	20.628	≤
PŠ	F2	≤	23.228	28.212	62.406
PŠ	F3	0.993	24.133	29.695	≤
AV	F2	≤	19.796	20.596	≤
AV	F3	2.495	22.359	25.354	≤
AB	F2	1.832	18.635	24.052	≤
AB	F3	3.283	27.159	29.745	≤
KK vs AV	F2	3.479	24.749	38.962	≤
KK vs AV	F3	≤	≤	13.300	≤
KK vs AB	F2	≤	≤	12.987	≤
KK vs AB	F3	2.098	≤	≤	≤
AB vs AV	F2	≤	≤	19.503	≤
AB vs AV	F3	6.640	21.705	28.543	64.717
PŠ vs AV	F2	9.728	20.846	26.405	≤
PŠ vs AV	F3	12.896	25.692	29.791	62.881

KK-corn, AV-*Avena fatua*, AB-*Abutilon teophrasti*, PŠ-wheat, ≤ - lower of equal to the amount in the control (with no plants or fertilizers applied) soil sample.

All the detected quantities were below the threshold of the maximum allowable concentrations (MAC). From the aspect of safe food production these tests have shown that the application of fertilizers in recommended doses is safe, although a potential environmental risk is always present.

Table 2. Macro and micro elements in the tested fertilizers (based on the product declaration)

	F2	F3
Polyphenolic (hydroxy) acids	-	-
Nitrogen	0,2%	16-24 %
Phosphorus	0,4%	12 %
Potassium	0,02%	36 %
Iron	220 mg/l	0,01-0,04 %
Magnesium	550 mg/l	1,9 %
Zinc	49 mg/l	0,01-0,02 %
Copper	35 mg/l	0,009-0,01 %
Boron, Calcium, Molybdenum, Cobalt, Nickel	10 mg/l	-
Boron	-	0,02 %
Calcium	-	14 %
Molybdenum	-	0,001-0,002 %
Manganese	54 mg/l	0,009-0,03 %

Statistical data analysis has shown that the differences between treatments were statistically significant for: the zinc content in all the samples compared to the control (except for KK *vs* AB), copper content in all the samples from the monoculture treatments after the application of both fertilizers and after the application of the F2 fertilizer in KK *vs* AV and PŠ *vs* AV combinations and the F3 fertilizer in AB *vs* AV and PŠ *vs* AV combination treatments, nickel content in KK *vs* AV and PŠ *vs* AV combination treatments after the application of the F2 fertilizer and in KK *vs* AB and AB *vs* AV combinations after the application of the F3 fertilizer, and manganese content only after the application of the F3 fertilizer in AV *vs* PŠ and AV *vs* AB combination treatments (Table 3).

Table 3. Statistical analysis of the heavy metal contents (mg/kg soil) and microelements in the samples of soil treated by fertilizers compared to the control (LSD test)

K *vs* sample	fertilizer	Ni	Cu	Zn	Mn
KK	F2	-	-	**	-
KK	F3	**	-	**	-
PŠ	F2	-	**	**	**
PŠ	F3	**	**	**	-
AV	F2	-	**	**	-
AV	F3	**	**	**	-
AB	F2	**	**	**	-
AB	F3	**	**	**	
KK vs AV	F2	**	**	**	-
KK vs AV	F3	-	-	**	-
KK vs AB	F2	-	-	**	-
KK vs AB	F3	**	-	-	-
AB vs AV	F2	-	-	**	-
AB vs AV	F3	**	**	**	**
PŠ vs AV	F2	**	**	**	-
PŠ vs AV	F3	-	**	**	**

K - control, p<0,01**, KK - corn, PŠ - wheat, AB - *Abutilon theophrasti*, AV - *Avena fatua*, Zn - zinc, Ni - nickel, Mn - manganese, Cu - copper

It is well known that some weed species can accumulate certain chemical elements and serve as bioaccumulators to improve the environment. [11] analyzed plant material of the weed species *Abutilon theophrasti* grown on contaminated soils (lead 1004.3 mg/kg, copper 711.5 mg/kg and zinc 1234.2 mg/kg) and detected the following amounts of lead 38.7 mg/kg, copper 32.5 mg/kg and zinc

56.1 mg/kg. [12] determined hyperaccumulation of lead by the weed species *Avena fatua*. Hyperaccumulation as a phytoremediation method can be very useful, but when this accumulation happens in plants intended for dietary consumption, it can present a significant health risk. The trials have shown that wheat plants are capable of easily absorbing zinc, nickel, and copper, while the absorption of lead and chromium is more difficult [13]. The rhizosphere of corn was also detected to contain numerous macro and micro elements: copper 16.34 mg/kg soil, 6.997 mg/kg lead, 0.19 mg/kg cadmium, and 69.77 mg/kg zinc, while at the end of the vegetation season corn seeds contain 0.341 mg/kg mass of lead and 0.342 mg/kg mass of zinc. Similar was detected by [14]. These studies indicate a risk for human health [15]. Consequently, it is very important to create a balance when applying fertilizers on the fields in order to maintain a healthy and clean environment. This confirms the fact that the application of fertilizers must be done only after conducting an analysis of the soil quality.

4. CONCLUSION

The applied dose of fertilizers has resulted in the accumulation of heavy metals in the soil and their contents were within the acceptable limits. In order to avoid the harmful effects of fertilizers and their pollutants, it is necessary to select for hybrids/varieties which are characterized by a highly efficient use of the available nutrients. Also, studies should focus on the development of fertilizers containing minimal amounts of contaminants, highlighting the need for the application of organic fertilizers and optimizing fertilizer doses for specific crops, ensuring minimal losses. Contamination of soils and water by fertilizers can also be reduced to a minimum by applying different control measures, such as phytoremediation, wastewater treatment, raising awareness, and developing appropriate national legislation.

5. ACKNOWLEDGMENT

The authors express their appreciation to the Ministry of Science, Technological Development and Inovation of the Republic of Serbia for providing the financial support (Grants No. 451-03-47/2023-01/200010 and No. 451-03-47/2023-01/200045).

REFERENCES

[1] Brandt, K., Molgaard, J. P. (2001). Organic agriculture: does it enhance or reduce the nutritional value of plant foods? Journal of the Science of Food and Agriculture, 81(9), 924-931.
[2] Winter, C. K., Davis, S. F. (2006). Organic Foods. Journal of Food Science, 71(9), 117-124.
[3] Khan, M. N., Mobin, M., Abbas, Z. K., Alamri, S. A. (2018). Fertilizers and Their Contaminants in Soils, Surface and Groundwater. In: Dominick A. DellaSala, and Michael I. Goldstein (eds.) The Encyclopedia of the Anthropocene, 5, 225-240. Oxford: Elsevier.
[4] Sedlacek, C. J., Giguere, A. T., Pjevac, P. (2020). Is Too Much Fertilizer a Problem?. Front. Young Minds, 8:63. doi: 10.3389/frym.2020.00063
[5] Scialabba, N. E. H., Müller-Lindenlauf, M. (2010). Organic agriculture and climate change. Renew. Agric. Food Syst., 25, 158–169.
[6] Hirel, B., Tétu, T., Lea, P. J., Dubois, F. (2011). Improving nitrogen use efficiency in crops for sustainable agriculture. Sustainability, 3, 1452–1485.
[7] Erisman, J. W., Galloway, J. N., Dice, N. B., Sutton, M. A., Bleeker, A., Grizzetti, B., Leach, A. M., de Vries, W. (2015). Nitrogen: Too Much of a Vital Resource. Science Brief. Zeist: WWF Netherlands.
[8] Kovačević, D., Oljaca, S., Dolijanovic, Z., Simic, M. (2010). Sustainable Agriculture: Importance of Cultural Practices Adaptation in Winter Wheat Technology. Növényterméls Suppl., 59, 1-4.

[9] Schmitz, P. M., Hartmann, M. (1994). The economic implications of chemical use restrictions in agriculture. 62nd IFA Annual Conference, Istanbul, Turkey.
[10] Dudka, S., Piotrowska, M., Chlopecka, A. (1994). Effect of elevated concentrations of Cd and Zn in soil on spring wheat yield and the metal contents of the plants. Water Air Soil Pollut., 76, 333-341.
[11] Cui, S., Zhou, Q., Chao, L. (2007). Potential hyperaccumulation of Pb, Zn, Cu and Cd in endurant plants distributed in an old smeltery, northeast China. Environ Geol., 51, 1043-1048.
[12] Esfandiar, J., Mohammad, J., Babak, M., Ali, T., Nosratallah, Z. (2017). Evaluating Tolerance Of Plants Species To Heavy Metals In Oil Polluted Region (Case Study: Pazanan Gachsaran). Rangeland Winter, 10 (4), 409-424.
[13] Lubenn, S., Sauerbeck, D. (1991). The uptake and distribution of heavy metals by spring wheat. Water, air and soil pollution, 57, 239-247.
[14] Benavides, L. C. L., Pinilla, C. A. L., Serrezuela, R. R., Serrezuela, W. F. R. (2018). Extraction in Laboratory of Heavy Metals Throught Rhizofiltration using the Plant *Zea mays* (maize). International Journal of Applied Environmental Sciences, 13 (1), 9-26.
[15] Hou, S., Zheng, N., Tang, L., Ji, X., Li, Y. (2019). Effect of soil pH and organic matter content on heavy metals availability in maize (*Zea mays* L.) rhizospheric soil on non-ferrous metals smelting area. Environ Monit Assess, 191, 634.D. C., 51.

ANTICANCER POTENTIAL OF SHORT-CHAIN SATURATED FATTY ACIDS IN MILK AND DAIRY PRODUCTS

ANTIKANCERNI POTENCIJAL KRATKOLANČANIH ZASIĆENIH MASNIH KISELINA U MLIJEKU I MLIJEČNIM PROIZVODIMA

Vesna Gantner, Full professor [1]
Milivoje Ćosić, Associate professor [2]
Krešimir Kuterovac, mag.ing. [3]
Vera Popović, Full professor [4]
Ranko Gantner, Full professor [5]

Abstract: *Cancer has become one of the most frequent health problems in the human population worldwide. On the other hand, most of the cancer cases could be prevented. Prevention implies an adequate lifestyle and nutrition rich with nutrients and anticancer components. Butyric acid, a short-chain fatty acid present in various amounts in milk and dairy products has proved to have anti-inflammatory and anticancer effects. Therefore, milk and dairy products, especially butter supposed to be a substantial part of the healthful, balanced and sustainable human diet.*

Key words: *anticancer potential, short-chain fatty acids, milk, dairy products*

Apstrakt: *Rak je postao jedan od najčešćih zdravstvenih problema u ljudskoj populaciji diljem svijeta. S druge strane, većina slučajeva raka mogla bi se spriječiti. Prevencija podrazumijeva adekvatan način života i prehranu bogatu nutrijentima i antikancerogenim komponentama. Maslačna kiselina, kratkolančana masna kiselina prisutna u različitim udjelima u mlijeku i mliječnim proizvodima, dokazano ima protuupalno i antikancerogeno djelovanje. Stoga bi mlijeko i mliječni proizvodi, posebice maslac, trebali biti značajan dio zdrave, uravnotežene i održive ljudske prehrane.*

Ključne reči: *antikancerogeni potencijal, kratkolančane zasićene masne kiseline, mlijeko, mliječni proizvodi*

1. INTRODUCTION

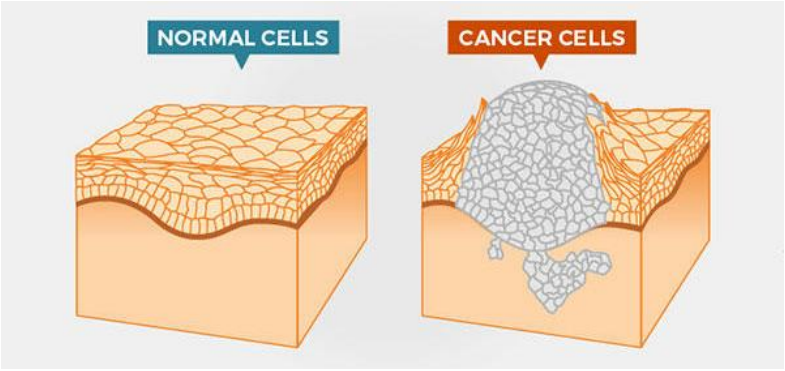
Cancer represents a leading cause of death worldwide, with nearly 10 million deaths in the year 2020. The most common cancer types in 2020 were: breast (2.26 million cases); lung (2.21 million cases); colon and rectum (1.93 million cases); prostate (1.41 million cases); skin (non-melanoma) (1.20 million cases); and stomach (1.09 million cases). Furthermore, the most common causes of

[1] J.J. Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, Osijek, Croatia, e-mail: vgantner@fazos.hr
[2] Bijeljina University, Faculty of Agriculture, Pavlovića put bb, Bijeljina, Bosnia and Hercegovina, e-mail: mickocosic@gmail.com
[3] Institute of Field and Vegetable Crops, Maksima Gorkog 30, Novi Sad, Republic of Serbia, e-mail: vera.popovic@ifvcns.ns.ac.rs
[4] Agroporc, Petrinja, 40250, Croatia, e-mail: kresimir.kuterovac@gmail.com
[5] J.J. Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, Osijek, Croatia, e-mail: rgantner@fazos.hr

cancer death in the year 2020 were: lung (1.80 million deaths); colon and rectum (916,000 deaths); liver (830,000 deaths); stomach (769,000 deaths); and breast (685,000 deaths). Each year, approximately 400,000 children develop cancer. The cancer prevalence of cancer is affected by factors such as tobacco use, high body mass index, alcohol consumption, low fruit and vegetable intake, lack of physical activity, and infections like HPV and hepatitis (about 30% of cancer cases in low- and lower-middle-income countries). Prevalence prevention is an essential way to reduce cancer cases and deaths. Furthermore, 30–50% of all cancer cases could be prevented by the application of strategies like reducing tobacco and alcohol use, promoting healthy diets, physical activity, and vaccination against cancer-causing infections. Since cancer has become one of the most frequent health problems in the human population, this review aimed to analyze the causes, diagnosis, treatment and prevention of cancer as well as the anticancer potential of short-fatty acids in milk and dairy products of various species of domestic animals.

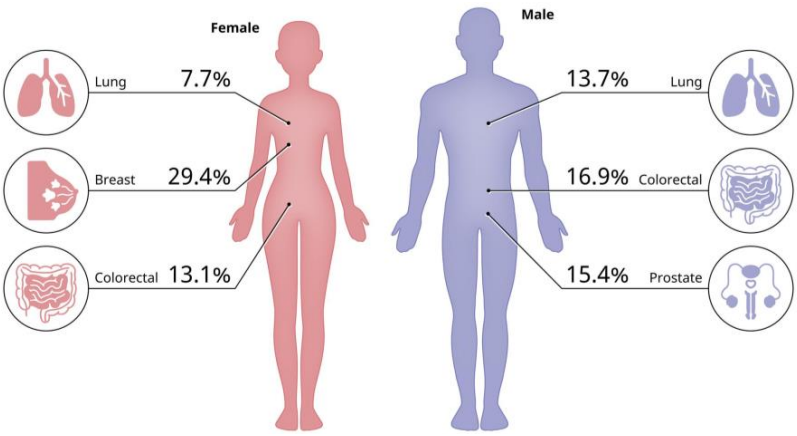
2. CANCER

Cancer, a pervasive disease, is characterized by uncontrolled growth and spreading of cells throughout the body [1, 2]. This condition may originate anywhere in the human body, which is composed of countless cells. Normally, human cells undergo division and multiplication to generate new cells as required by the body. Upon reaching the end of their life cycle or becoming damaged, these cells die, and new ones take their place. However, at times, this well-ordered process breaks down, leading to the growth and multiplication of abnormal or damaged cells beyond the required levels. Such cells tend to form lumps of tissue, referred to as tumors. These tumors may either be benign (non-cancerous) or malignant (cancerous), with the latter being particularly harmful. Malignant tumors have the capability of invading neighboring tissues and can metastasize to other parts of the body, forming new tumors. Cancer cells differ from normal cells in several ways. They grow without signals instructing them to grow, disregard signals telling them to stop dividing or to die, and deceive the immune system into aiding them in surviving and expanding.



Picture 1: Comparison of normal and cancer cell [1]

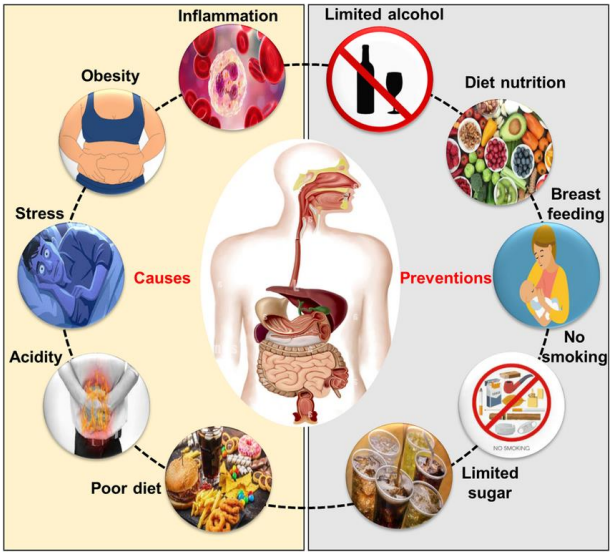
Furthermore, cancer is a complex and diverse disease that can affect any part of the body. It is classified by the type of cell that is initially affected. Cancer can affect any part of the body, such as the colon, liver, lung, breast, skin, and others, and is caused by a variety of complex factors, including genetic mutations, environmental influences, and lifestyle choices [1, 3]. Therefore, there are many types of cancer, and each type has its unique characteristics, symptoms, and treatment options (Picture 2).



Picture 2: Prevalence of some cancers in human population in Singapore [4]

Accordingly, to NCI [1], Bladder Cancer is a type of cancer that affects the bladder, which is a hollow organ in the lower abdomen that stores urine. The most common symptoms of this type of cancer include blood in urine, frequent urination, and pain during urination. Breast Cancer is a type of cancer that begins in the breast tissue, commonly in the lining of the milk ducts or lobules that supply the ducts with milk. This type of cancer is more common in women, but it can also affect men. Some of the common symptoms of breast cancer include a lump or thickening in the breast, changes in breast size or shape, and nipple discharge. Colon and Rectal Cancer, also known as Colorectal Cancer, is a type of cancer that starts in the colon or rectum, which are parts of the digestive system. This type of cancer is often asymptomatic in its early stages, but as it progresses, symptoms such as abdominal pain, rectal bleeding, and changes in bowel habits may occur. Endometrial Cancer is a type of cancer that originates in the lining of the uterus, which is the organ where a fetus grows during pregnancy. The most common symptom of endometrial cancer is abnormal vaginal bleeding, especially after menopause. Kidney Cancer, also known as Renal Cell Cancer, is a type of cancer that starts in the kidneys, which are responsible for filtering blood and producing urine. Symptoms of this type of cancer include blood in urine, back pain, and weight loss. Leukemia is a type of cancer that affects the blood and bone marrow, characterized by the overproduction of abnormal white blood cells. Symptoms of leukemia include fatigue, weakness, fever, and frequent infections. Liver Cancer is a type of cancer that begins in the liver, an organ that performs vital metabolic and detoxifying functions. Symptoms of this type of cancer include abdominal pain, unexplained weight loss, and yellowing of the skin and eyes. Lung Cancer is a type of cancer that starts in the lungs and is often associated with smoking. Symptoms of this type of cancer include coughing, chest pain, shortness of breath, and hoarseness. Melanoma is a type of skin cancer that begins in the cells that produce the pigment melanin. Symptoms of melanoma include changes in the appearance of moles or pigmented areas, such as asymmetry, irregular borders, and changes in color or diameter. Non-Hodgkin Lymphoma is a type of cancer that affects the lymphatic system, which is part of the immune system. Symptoms of this type of cancer include enlarged lymph nodes, fever, night sweats, and weight loss. Pancreatic Cancer is a type of cancer that begins in the pancreas, an organ that secretes enzymes and hormones like insulin. Symptoms of this type of cancer include abdominal pain, unexplained weight loss, and jaundice. Prostate Cancer is a type of cancer that starts in the prostate gland in men. Symptoms of this type of cancer include difficulty urinating, weak urine flow, and blood in semen. Thyroid Cancer is a type of cancer that begins in the thyroid gland, which regulates metabolism, heart rate, and more. Symptoms of this type of cancer include a lump or swelling in the neck, difficulty swallowing, and hoarseness. It is essential to note that cancers can also be grouped by the body location or system they affect. Additionally, there are specific cancers that are more prevalent in children or adolescents.

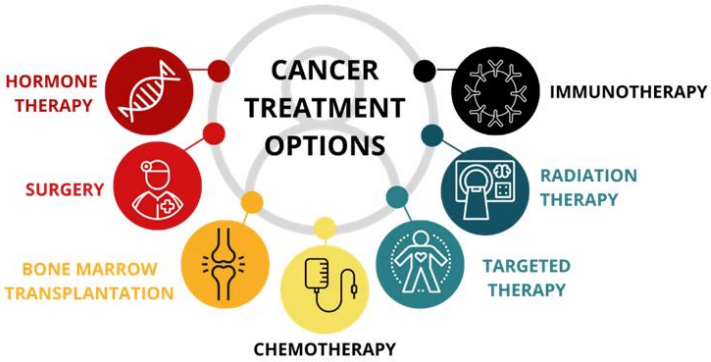
Cancer represents a multifaceted disease that may result from various factors, with the most significant being mutations that occur within the DNA of cells. These mutations can either be inherited or acquired due to exposure to environmental factors. There are a number of causes of gene mutations that can lead to cancer [1, 5]. Lifestyle choices are a significant contributor to the development of cancer. Activities such as tobacco use, excessive alcohol consumption, unhealthy diet, and physical inactivity can all increase the risk of gene mutations that lead to cancer. Environmental exposure is another significant factor that can contribute to the development of cancer. Exposure to physical carcinogens such as radiation and ultraviolet (UV) light, chemical carcinogens such as cigarette smoke, asbestos, alcohol, air pollution, and contaminated food and drinking water can all cause mutations that can lead to cancer. Biological factors such as viruses, bacteria, and parasites can also contribute to the development of cancer. For instance, some viruses such as H. pylori, human papillomavirus (HPV), hepatitis B, hepatitis C, HIV, and the Epstein-Barr virus have been linked to cancer. Age is another factor that can increase the risk of developing cancer. The risk of developing cancer generally increases with age due to a buildup of risk factors and less effective cell repair mechanisms. It is important to note that not all cancers are caused by external factors; some cancers are genetic and are not preventable. However, by being aware of the various factors that can contribute to the development of cancer, individuals can take steps to reduce their risk and seek appropriate medical care when necessary.



Picture 3: Cancer: causes and prevention [6].

The process of diagnosing cancer involves a series of tests and procedures to confirm the presence of cancer and determine its stage [1,7]. The diagnostic process commences with a comprehensive physical examination whereby the healthcare practitioner searches for lumps or anomalies in the body that may be indicative of cancer. Subsequently, laboratory tests are conducted to identify abnormal levels of certain substances in the blood, urine, or other body fluids that may suggest the presence of cancer. Imaging tests, including CT scans, MRIs, PET scans, ultrasounds, and X-rays, are employed to identify any irregularities within the body that may be suggestive of cancer. These tests generate detailed images of internal structures, enabling medical professionals to detect the location and size of any tumors. Following suspicion of cancer, a biopsy is usually performed. This technique involves the surgical removal of a small sample of tissue from the affected area of the body, which is then examined under a microscope to detect the presence of cancer cells. Biopsies

are typically performed using a needle or during surgery. Once a cancer diagnosis is confirmed, healthcare professionals determine the stage of cancer using staging tests. Cancer staging refers to the extent to which the cancer has spread from its original site and is classified using a range from 0 to 4, with higher numbers indicating more advanced cancer. Knowledge of the cancer stage is crucial because it assists medical practitioners in estimating the likelihood of recovery and determining the most appropriate course of treatment.



Picture 4: Cancer treatment options [8]

In the fight against cancer, treatment plans are carefully crafted to address each individual's unique type and stage of the disease [1, 8]. There are a variety of treatments available, each with a specific role in combating cancer. Some of the most common cancer treatments are surgery (a procedure to remove cancer from the body); chemotherapy (a drug-based approach to eliminating cancer cells; radiation therapy (high doses of radiation used to kill cancer cells and reduce tumor size); immunotherapy (a treatment that boosts the immune system's ability to fight cancer cells); hormone therapy (a method to slow or halt the growth of hormone-dependent cancers such as breast and prostate cancer); targeted therapy (a treatment focused on genes or proteins that contribute to cancer growth and survival); stem cell transplant (a procedure to restore blood-forming stem cells in patients whose cells have been destroyed by chemotherapy or radiation); hyperthermia (a therapy that heats body tissue to damage and kill cancer cells while minimizing harm to normal tissue), and photodynamic therapy (a treatment that uses light-activated drugs to destroy cancer cells). Treatment options are chosen based on several factors, including cancer type and stage, potential side effects, and the patient's overall health and preferences. A thorough evaluation of these factors helps determine the most effective treatment plan for each patient.

Taking proactive steps to prevent cancer is crucial for maintaining good health. The latest research suggests that there are several key strategies that can significantly reduce the risk of developing cancer [1]. One of the most important steps is to avoid tobacco, as both smoking and exposure to secondhand smoke have been linked to an increased risk of various cancers, including lung, mouth, throat, pancreas, bladder, cervix, and kidney. In addition to avoiding tobacco, adopting a healthy diet can also help reduce the risk of cancer. A diet rich in fruits, vegetables, whole grains, and beans can provide the body with essential nutrients and antioxidants that can help prevent the development of cancer cells. Limiting alcohol, processed meats, refined sugars, and fats from animal sources is also recommended. Maintaining a healthy weight and engaging in regular physical activity can also help lower the risk of cancer. Being at a healthy weight can help prevent the development of breast, prostate, lung, colon, and kidney cancers. Regular exercise can also help boost the immune system, which can help prevent cancer. Early detection is also critical for cancer prevention. Regular screenings can help detect cancers at an early stage when they are more treatable. Certain vaccines, such as the HPV vaccine, can also help prevent cancers linked to viral infections. Additionally, using sunscreen and avoiding excessive sun exposure can prevent skin cancer. Finally, reducing exposure to environmental pollutants and occupational carcinogens can also decrease cancer risk.

By taking these proactive steps, individuals can significantly reduce their risk of developing cancer and maintain good health.

3. ANTICANCER DIET

An anticancer diet is a diet that aims to reduce the risk of cancer by including foods that are known to have cancer-fighting properties [9]. Based on the latest research, the key components of an anticancer diet include consuming a variety of fruits and vegetables (Picture 5). These plant-based foods are rich in antioxidants and phytochemicals that help protect the body against cancer. Another important component is whole grains, which are a great source of fiber, vitamins, and minerals that can contribute to cancer prevention. Lean proteins such as fish, poultry, and plant-based proteins are preferred over red and processed meats, as they are less likely to contribute to cancer development. Healthy fats, found in nuts, seeds, and olive oil, are also central to an anticancer diet. These fats are important for maintaining good health, and they have been shown to have anticancer properties. To reduce the risk of cancer, it is also recommended to limit intake of processed foods, sugar-sweetened drinks, and excessive alcohol. Following dietary patterns such as the Mediterranean diet, which emphasizes natural and plant-based foods, can be beneficial in preventing cancer. It is important to note that while no single food can prevent cancer, a balanced diet combined with a healthy lifestyle can play a significant role in lowering your risk of developing cancer.

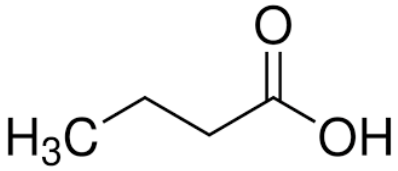
Picture 5: Anticancer food [10].

Numerous studies have been conducted to investigate the potential link between milk consumption and cancer prevention. These studies [11, 12, 13, 14] have found that milk and other dairy products are an excellent source of essential nutrients such as calcium, vitamin D, proteins, and milk fat, which are vital for maintaining overall health and well-being. However, it is essential to note that the relationship between milk consumption and cancer risk is intricate and can vary depending on the type of cancer. Some studies suggest that certain milk components, such as calcium and vitamin D, may have protective effects against colorectal cancer. Furthermore, the anticancer potential of short-chain saturated fatty acids in milk have being investigated in several scientific papers (table 1). Fatty acids are carboxylic acids that make up a significant part of lipids. They play important roles in cellular processes and are fundamental structural components of cells. They can be classified based on length, saturation, and carbon content. Saturated fatty acids that are less than six carbon atoms long are collectively known as short-chain fatty acids. These are produced when gut bacteria ferment fiber. Polyunsaturated fatty acids (PUFAs) can inhibit tumor development due to their anti-inflammatory properties. Short-chain fatty acids (SCFAs) produced by the gut microbiota have the potential to enhance immunotherapy by regulating the function of immune cells and modulating the immunogenicity of tumor cells [15].

Table 1. Anticancer effect of short-chain fatty acids (SCFAs)

Saturated fatty acid	Effect	Cancer type
4:0 Butyric	inhibiting glucose transport and glycolysis	colorectal cancer [16]
		human breast cancer, leukemia
$CH_3(CH_2)_2COOH$	histone deacetylase inhibitor	[17]
5:0 Valeric		breast cancer [18]
	histone deacetylase inhibitor	liver cancer [19]
$CH_3(CH_2)_3COOH$		prostate cancer [20]

Butyric acid, also known as butanoic acid, a short-chain fatty acid is a naturally occurring substance that is produced in the gut by bacteria when dietary fiber is fermented. It is also present in animal fats and vegetable oils. The health benefits of butyric acid have been extensively studied, and it has been found to have several potential advantages. One of its key roles is in promoting gut health. Butyric acid serves as a vital energy source for the cells lining the colon and helps to maintain the overall health of the gastrointestinal tract. Moreover, butyric acid exhibits anti-inflammatory properties that can be beneficial for individuals struggling with irritable bowel syndrome (IBS) and Crohn's disease. Additionally, butyric acid has been shown to inhibit the growth of cancer cells and promote cell death, which suggests that it may be helpful in preventing colon cancer. Specifically, butyric acid has been shown to suppress glucose metabolism in colorectal cancer cells by inhibiting glucose transport and glycolysis by reducing the abundance of membrane glucose transporter 1 (GLUT1) and cytoplasmic glucose-6-phosphate dehydrogenase (G6PD2 [16]. This effect is regulated by the GPR109a-AKT signaling pathway. In addition, butyric acid has been found to significantly enhance the chemotherapeutic efficacy of 5-fluorouracil (5-FU) on colon cancer cells. There is evidence to suggest that sodium butyrate can block the growth of colorectal cancer cells and increase the rate of cell death. One study, in particular, found that sodium butyrate exerted this effect on the cancer cells. These findings suggest that butyric acid and its derivatives may hold promise as an adjunct therapy for colorectal cancer. Furthermore, butyric acid has anticancer effect on human breast cancer and leukemia acting as histone deacetylase inhibitor [17].



Valeric acid, also known as pentanoic acid, is a significant active chemical constituent of valerian plant (perennial flowering plant *Valeriana officinalis*) and has been demonstrated to possess anti-cancer properties. The broad spectrum of anti-cancer activity of valeric acid has human body. Among these fatty acids, saturated fatty acids (SFA) are the most abundant, comprising approximately 70% of the total fat content in milk. The remaining fat is made up of mono-unsaturated fatty acids (MUFA) and poly-unsaturated fatty acids (PUFA). If we look closely at the saturated fatty acids in milk fat, we can identify two main types: short- and medium-chain saturated fatty acids (10-13%) and long-chain saturated fatty acids (50-55%). Some of the most common long-chain saturated fatty acids in milk include palmitic acid (27%), myristic acid (10-12%), and stearic acid (9%).

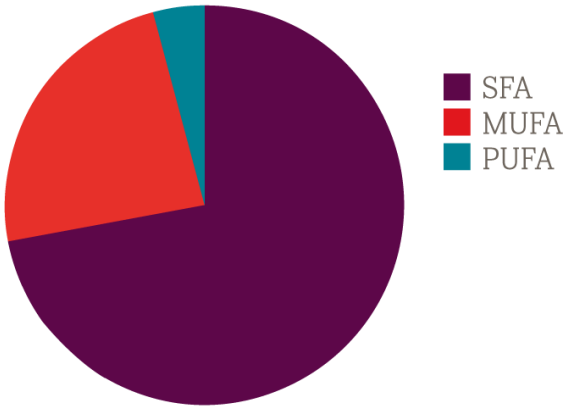


Figure 1: Typical fatty acid profile of cows' milk [23]

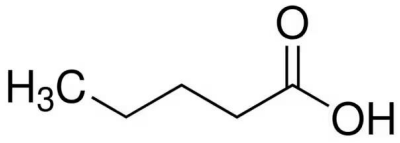
Milks composition and properties vary significantly across different species [24]. Cows are the largest milk producers, accounting for 85% of global milk production, followed by buffaloes, goats, ewes, mares, and donkeys. While there are notable differences in energy content, fat, lactose, protein, and ash among different types of milk, there are also some similarities between milk from ruminants and non-ruminants. Interestingly, the structures of fat globule membranes are similar in non-ruminants and human milk, while the milk fat globule structure in ruminants is quite different. The size of fat globules varies significantly between species and is highly correlated with milk fat content. Milk from ruminants and women contains notably higher amounts of triacylglycerols, while the amount of free fatty acids and phospholipids is lower compared to milk from mares and donkeys. The triacylglycerol structure in women and non-ruminants is similar. Milk from non-ruminants has lower levels of saturated and monounsaturated fatty acids but higher levels of unsaturated fatty acids, particularly C-18:2 and C-18:3. Cholesterol content is similar in women and ruminants' milk but lower in non-ruminants' milk.

The level of butyric acid in milk can differ significantly depending on the type of milk [25]. Goat milk, for example, has a notably higher concentration of butyric acid than cow milk, which contributes to its distinct flavor and potential health benefits. However, cow milk also contains butyric acid, albeit in lower amounts. Furthermore, the precise amount of butyric acid can fluctuate depending on factors such as the breed and diet of the animal. Valeric acid is a type of fatty acid that occurs naturally in the milk of various animal species. While limited information exists about the content of valeric acid in goat milk, it is known that goat milk is a rich source of various fatty acids [25]. In contrast, research on cow milk has shown that valeric acid is an isoacid that can impact rumen fermentation and metabolism and has been approved as a feed additive for lactating dairy cattle [26]. Interestingly, the level of valeric acid in milk can differ depending on several factors, such as the animal's breed and diet. For instance, studies have shown that a diet high in concentrate increases the amount of valeric acid in cow milk, while a diet high in forage decreases it. Similarly, the level of valeric acid in goat milk can vary based on factors such as the animal's breed, age, and lactation stage.

Mare's milk is a highly nutritious drink that contains short-chain saturated fatty acids (SCFA), which are known for their beneficial health effects [27]. In particular, one of the most important SCFAs found in mare's milk is butyric acid (C4:0), which plays a crucial role in maintaining gut health and preventing various diseases. Butyric acid is produced during the fermentation of dietary fibers by gut bacteria and has been found to help prevent inflammation in the intestines, which can lead to various gastrointestinal disorders. Moreover, the fatty acid profile of mare's milk can vary depending on the lactation stage, age, and breed of the mare. For instance, milk from the 15th week of lactation has been found to have a more beneficial fatty acid composition, with low values of the

atherogenic index (AI) and thrombogenic index (TI). These indices are important for the prevention of atherosclerosis and thrombosis, which are major risk factors for heart disease and stroke. Additionally, mare's milk has been shown to contain high levels of important nutrients such as calcium, phosphorus, and vitamins A and D, which are essential for maintaining strong bones and teeth, as well as supporting immune function. Overall, mare's milk is a highly nutritious and beneficial drink that can provide numerous health benefits when consumed regularly.

been observed, especially its high cytotoxicity towards liver cancer cells [19]. The compound has been found to influence several cancer-related pathways, which may trigger apoptosis. It operates as a potential novel histone deacetylase (HDAC) inhibitor and suppresses liver cancer development. In addition, valeric acid has been linked to decreased breast cancer cell proliferation, migration, colony formation, and 3D formation in vitro, in a dose- and time-dependent manner [18]. The compound is responsible for reducing HDAC activity and inducing global DNA hypomethylation, which may reduce breast cancer cell proliferation.



4. MILK AND DAIRY PRODUCTS

Dairy products are a wide-ranging group of food articles that are produced from the milk of various mammals, including cows, goats, sheep, and buffalo [21]. These products are a significant source of essential nutrients such as calcium and protein for human population around the world. Each dairy product has its unique taste, texture, and nutritional value, and they are used in different ways in various cuisines. Milk is a white liquid that is commonly used as a beverage or a base for other dairy products. It is rich in vitamins and minerals that contribute to good health. Cheese is a fermented milk product that comes in various forms, including soft and hard, and mild and pungent flavors. It is a popular ingredient in many dishes, and it is also consumed on its own as a snack or an appetizer. Yoghurt is another cultured milk product that has a creamy texture and a tangy flavor. It is often consumed as a healthy snack, and it is also used as an ingredient in various recipes. It contains live probiotics that are beneficial for gut health. Butter is a high-fat spread that is made from the butterfat layer of milk. It is commonly used in cooking and also as a condiment. Cream is another dairy product that is made from the butterfat layer of milk. It is used in cooking, baking, and as a topping for desserts. Ghee is a form of clarified butter that is commonly used in South Asian cuisine. It has a nutty flavor and is often used for cooking. Kefir is a probiotic fermented milk that has a slightly effervescent and tangy taste. It is considered a healthy food item due to its high nutritional value. Cottage cheese is a high-protein curd cheese with a mild flavor. It is often used in salads and as a healthy snack. Sour cream is another fermented cream that has a tangy taste. It is used as a topping or an ingredient in various dishes. Whey protein is a concentrated dairy protein that is often used in supplements and health foods. It is a popular source of protein for athletes and bodybuilders. Dairy products represent an important part of many diets and are enjoyed by millions of people.

Milk is a highly nutritious fluid that contains an abundance of essential nutrients, making it an important part of a healthy and balanced diet [22]. Some of the key nutrients found in milk include protein, calcium, vitamin D, potassium, B12, riboflavin (B2), and phosphorus. These nutrients are essential for maintaining overall health, and they all play unique roles in the body. One of the most well-known benefits of milk is its ability to promote bone health. The high levels of calcium and vitamin D in milk are crucial for maintaining strong and healthy bones, which can help prevent conditions such as osteoporosis and fractures. In addition to promoting bone health, milk is also an excellent source of high-quality protein. Protein is vital for muscle growth and repair, and milk is

particularly rich in casein and whey proteins, which are two of the most important types of protein for building and maintaining muscle mass. Milk also contains several nutrients that are beneficial for heart health. Some studies suggest that milk may help reduce blood pressure and the risk of heart disease, thanks to its potassium and omega-3 fatty acid content. These nutrients help to regulate blood pressure, reduce inflammation, and support overall cardiovascular health. Finally, milk may also aid in weight management when consumed as part of a balanced diet. The protein in milk can help to promote feelings of fullness and satiety, making it easier to maintain a healthy weight. Additionally, milk is a low-calorie beverage that can help to replace higher-calorie drinks. Furthermore, milk contains various types of fatty acids, each of which plays a unique role in the

Product	C 4:0	Product	C 4:0	Product	C 4:0
Butter oil	3.23 g	Tilsit cheese	0.88 g	Sweetened condensed milk	0.28 g
Cotija Cheese	1.58 g	Roquefort cheese	0.88 g	Ricotta cheese	0.25 g
Goat cheese	1.50 g	Dry milk	0.87 g	Sheep milk	0.20 g
Romano cheese	1.36 g	Asadero cheese	0.86 g	Goat milk	0.13 g
Parmesan cheese	1.30 g	Limburger cheese	0.80 g	Whole milk (3.7% fat)	0.12 g
Gruyere cheese	1.05 g	Feta	0.78 g	Milk (2% fat)	0.08 g
Muenster cheese	1.04 g	Cream cheese	0.72 g	Buttermilk	0.08 g
Colby cheese	1.04 g	Fontina cheese	0.72 g	Yogurt	0.06 g
Port De Salut cheese	1.03 g	Swiss cheese	0.68 g	Philadelphia cream cheese	0.06 g
Edam cheese	1.00 g	Blue cheese	0.66 g	Cottage cheese	0.04 g
Gouda cheese	1.00 g	Cheddar cheese	0.63 g	Kefir	0.03 g
Monterey cheese	0.98 g	Neufchatel cheese	0.61 g	Milk whey liquid	0.00 g
Provolone cheese	0.98 g	Brie cheese	0.56 g	Human milk	n/d
Cheshire cheese	0.97 g	Camembert cheese	0.49 g	Milk based protein powder	n/d
Gjetost cheese	0.96 g	Queso Fresco cheese	0.49 g	Fat-free sour cream	n/d
Anejo cheese	0.91 g	Mozzarella cheese	0.39 g		
Queso Chihuahua cheese	0.90 g	Sour cream	0.34 g		

Table 2. Content of butyric acid (4:0) in milk and dairy products [28].

Butyric acid, as fatty acid with anti-inflammatory and anticancer effects, also could be found in dairy products, particularly in butter and ghee [28]. Butyric acid is produced during the fermentation process of milk and contributes to the flavor of these products. The content of butyric acid (4:0) in milk and dairy products is presented in Table 2. The highest content of butyric acid is reported in butter oil (3.23 g), while the lowest was in milk whey liquid (0.00 g).

5. CONCLUSION

Cancer has become one of the most prevalent health problems in the human population but most of the cases could be prevented. Prevention implies an adequate lifestyle and nutrition rich with

nutrients and anticancer ingredients. Butyric acid, a short-chain fatty acid present in various amounts in milk and dairy products has anti-inflammatory and anticancer effects. Therefore, milk and dairy products, especially butter supposed to be a significant part of the healthy, balanced and sustainable human diet.

6. ACKNOWLEDGEMENTS

Acknowledgements: Research and dissemination were supported by the Fund for Bilateral Relations within the Financial Mechanism of the European Economic Area and Norwegian Financial Mechanism for the period 2014-2021 (Grant number: 04-UBS-U-0031/23-14).

REFERENCE

[1] National Cancer Institute, NCI (2023) What Is Cancer? Cancer Types, How Cancer Is Diagnosed, Types of Cancer Treatment, Causes and Prevention, U.S. Department of Health and Human Services, National Institutes of Health
[2] Desai, N., Katare, P., Makwana, V., Salave, S., Vora, L. K., Giri, J. (2023) Tumor-derived systems as novel biomedical tools-turning the enemy into an ally. Biomaterials research, 27(1), 113. https://doi.org/10.1186/s40824-023-00445-z
[3] Liu, X., Yang, J., Li, H., Wang, Q., Yu, Y., Sun, X., Si, S., Hou, L., Liu, L., Yang, F., Yan, R., Yu, Y., Fu, Z., Lu, Z., Li, D., Xue, H., Guo, X., Xue, F., Ji, X. (2022) Quantifying substantial carcinogenesis of genetic and environmental factors from measurement error in the number of stem cell divisions. BMC cancer, 22(1), 1194. https://doi.org/10.1186/s12885-022-10219-w
[4] Gleneagles Hospital, GH (2023) Cancer Care, Gleneagles, Conditions treatments, https://www.gleneagles.com.sg/conditions-treatments/cancer-care
[5] Meijers, W. C., de Boer, R. A. (2019) Common risk factors for heart failure and cancer. Cardiovascular research, 115(5), 844–853. https://doi.org/10.1093/cvr/cvz035
[6] Xiaogang, H., Sharma, M., Saif, I., Ali, G., Li, X., Salama, E-S. (2022) The role of nutrition in harnessing the immune system: a potential approach to prevent cancer. Medical Oncology. 39. 10.1007/s12032-022-01850-5
[7] Nooreldeen, R., Bach, H. (2021). Current and Future Development in Lung Cancer Diagnosis. International journal of molecular sciences, 22(16), 8661. https://doi.org/10.3390/ijms22168661
[8] EBIS Medical (2022) Cancer Treatments, https://ebismedical.com/cancer-treatments/
[9] American Institute for Cancer Research (2023) AICR's Foods that Fight Cancer, https://www.aicr.org/cancer-prevention/food-facts/
[10] Nutrition Daily, ND (2023) Top 10 anti-cancer foods https://nutritiondaily.in/blogs/news/top-10-anti-cancer-foods
[11] Badawy, A. A., El-Magd, M. A., Al Sadrah, S. A. (2018) Therapeutic Effect of Camel Milk and Its Exosomes on MCF7 Cells In Vitro and In Vivo. Integrative cancer therapies, 17(4), 1235–1246. https://doi.org/10.1177/1534735418786000
[12] El-Gawad, A. M. A., El-Hassan, D. G. A., Aboul-Enein, A. M., Abdelgayed, S. S., Aly, S. A., Esmat, G., Mostafa, A. A., Bakr, M. H., Ali, R. A., Ayoub, M. A. (2021) Anticancer activity of milk fat rich in conjugated linoleic acid against Ehrlich ascites carcinoma cells in female Swiss albino mice. Veterinary world, 14(3), 696–708. https://doi.org/10.14202/vetworld.2021.696-708
[13] El-Maksoud, A. A. A., Makhlouf, A. I. A., Altemimi, A. B., El-Ghany, I. H. A., Nassrallah, A., Cacciola, F., & Abedelmaksoud, T. G. (2021) Nano Milk Protein-Mucilage Complexes: Characterization and Anticancer Effect. Molecules (Basel, Switzerland), 26(21), 6372. https://doi.org/10.3390/molecules26216372

[14] Mahmoudi, M., Khomeiri, M., Saeidi, M., Davoodi, H., Memarian, A. (2023) Anticancer potential of fermented milk with autochthonous lactic acid bacteria. Journal of applied microbiology, 134(3), lxad041. https://doi.org/10.1093/jambio/lxad041
[15] Westheim, A.J.F., Stoffels, L.M., Dubois, L.J., van Bergenhenegouwen, J., van Helvoort, A., Langen, R.C.J., Shiri-Sverdlov, R., Theys, J., (2022) Fatty Acids as a Tool to Boost Cancer Immunotherapy Efficacy. Frontiers in Nutrition, 9:868436. doi: 10.3389/fnut.2022.868436
[16] Geng, H.W., Yin, F.Y., Zhang, Z.F., Gong, X., Yang, Y. (2021) Butyrate Suppresses Glucose Metabolism of Colorectal Cancer Cells via GPR109a-AKT Signaling Pathway and Enhances Chemotherapy. Frontiers in Molecular Biosciences, 8:634874. doi: 10.3389/fmolb.2021.634874
[17] Foglietta, F., Serpe, L., Canaparo, R., Vivenza, N., Riccio, G., Imbalzano, E., Gasco, P., Zara, G.P. (2014) Modulation of butyrate anticancer activity by solid lipid nanoparticle delivery: an in vitro investigation on human breast cancer and leukemia cell lines. Journal of pharmacy & pharmaceutical sciences: a publication of the Canadian Society for Pharmaceutical Sciences, Societe canadienne des sciences pharmaceutiques, 17(2), 231–247. https://doi.org/10.18433/j3xp4r
[18] Shi, F., Li, Y., Han, R., Fu, A., Wang, R., Nusbaum, O., Qin, Q., Chen, X., Hou, L., Zhu, Y. (2021) Valerian and valeric acid inhibit growth of breast cancer cells possibly by mediating epigenetic modifications. Scientific Reports, 11, 2519, https://doi.org/10.1038/s41598-021-81620-x
[19] Han, R., Nusbaum, O., Chen, X., Zhu, Y. (2020) Valeric Acid Suppresses Liver Cancer Development by Acting as a Novel HDAC Inhibitor. Molecular therapy oncolytics, 19, 8–18. https://doi.org/10.1016/j.omto.2020.08.017
[20] Rui, H., Hongxing, Y., Ya, L., Changquan, L., Lingeng, L. (2022) Valeric acid acts as a novel HDAC3 inhibitor against prostate cancer. Medical Oncology, 39:213 https://doi.org/10.1007/s12032-022-01814-9
[21] Joseph, M. (2023) 22 Dairy Products: An A to Z Guide, Nutrition advance, https://www.nutritionadvance.com/dairy-products/
[22] Kubala, J. (2023) 5 Ways That Drinking Milk Can Improve Your Health, Healthline, Nutrition, https://www.healthline.com/nutrition/milk-benefits
[23] Megalac (2024) Saturated and unsaturated fatty acids in milk, https://www.megalac.com/resources-advice/fats-advice/108-saturated-and-unsaturated-fatty-acids-in-milk
[24] Gantner, V., Mijić, P., Baban, M., Škrtić, Z., Turalija, A. (2015) The overall and fat composition of milk of various species, Mljekarstvo 65 (4), 223-231 (2015)
[25] Kompan, D., Komprej, A. (2012) The Effect of Fatty Acids in Goat Milk on Health. Milk Production - An Up-to-Date Overview of Animal Nutrition, Management and Health. InTech. http://dx.doi.org/10.5772/50769.
[26] Muller, L.D. (1987) Branched Chain Fatty Acids (Isoacids) and Valeric Acid for Ruminants. The Professional Animal Scientist, 3(1), 9-12. https://doi.org/10.15232/S1080-7446(15)32370-6
[27] Czyżak-Runowska, G., Wójtowski, J.A., Danków, R., Stanisławski, D. (2021) Mare's Milk from a Small Polish Specialized Farm—Basic Chemical Composition, Fatty Acid Profile, and Healthy Lipid Indices. Animals, 11, 1590. https://doi.org/10.3390/ani11061590
[28] FitAudit (2024) Butyric acid (4:0) in Milk and Dairy Products, https://fitaudit.com/categories/mlk/butyric

INVESTMENT IN THE DEVELOPMENT OF AGRO-TOURISM AND THE PRODUCTION OF ETHNO FOOD AND DRINKS - GREAT CHANCE FOR THE ECONOMIC RECOVERY OF THE REPUBLIC OF SERBIA

ULAGANJE U RAZVOJ AGROTURIZMA I PROIZVODNJU ETNO HRANE I PIĆA – VELIKA ŠANSA ZA PRIVREDNI OPORAVAK REPUBLIKE SRBIJE

Dragan Bataveljić, full professor[1]
Anka Vojvodić, professor of vocational studies[2]
Marko Vojvodić, professor of vocational studies[3]

Abstract: *In the paper, the authors point out that, both in our country and in the surrounding countries, the popularity and demand for this type of vacation is growing more and more. This type of tourism represents a special form of tourist offer and there is an increasing market demand for it. It is often identified with rural, i.e. rural tourism, but tourism workers point to the fact that there is a difference between them, although these carriers of the tourist offer, owners of facilities that provide services, and even tourists themselves, interpret this form of tourism differently. However, what is indisputable is that agritourism means a return to nature and that the hosts on their own agricultural land and the facilities built on it, allow their visitors to directly (immediately) participate in all the work related to the maintenance and normal functioning of their farms. Here we mean, first of all, the care of the animals and plants that are there, planting fruit, harvesting grapes, harvesting wheat and other grains, removing the harvest and all other agricultural products that are characteristic of those areas, such as, for example: corn, olives, strawberries, raspberries and other types of fruits and vegetables. This type of tourism allows tourists to stay in a natural environment, in the fresh air, in a rural environment and appeared at the end of the 20th century as a reaction to the systematic endangerment of the environment that surrounds modern man.*

Key words: *agritourism, rural tourism, ecology, agriculture, ethnic food and drink*

Apstrakt: *Autori u radu ukazuju da, kako u našoj zemlji, tako i u zemljama okruženja, sve više raste popularnost i potražnja za ovakvom vrstom odmora. Ova vrsta turizma predstavlja jedan poseban oblik turističke ponude i za njim postoji sve veća potražnja tržišta. Često puta dolazi do identifikovanja sa seoskim, tj. ruralnim turizmom, ali turistički delatnici ukazuju na činjenicu da između njih postoji razlika, mada ovi nosioci turističke ponude, vlasnici objekata koji pružaju usluge, pa čak i sami turisti, različito tumače ovaj oblik turizma. Međutim, ono što je nesporno, jeste da agroturizam znači povratak prirodi i da domaćini na svom sopstvenom poljoprivrednom zemljištu i objektima podignutim na njemu, omogućavaju svojim posetiocima da direktno (neposredno) učestvuju u svim poslovima koji se tiču održavanja i normalnog funkcionisanja njihovih farmi. Tu mislimo, pre svega, na brigu o životinjama i biljkama koje se tu nalaze, sadnji voća, berbi grožđa, žetvi pšenice i drugih žitarica, skidanju letine i svih drugih poljoprivrednih proizvoda koji su karakteristični za ta područja, kao što su, na primer: kukuruz, masline, jagode, maline i druge vrste voća i povrća. Ova vrsta turizma omogućava turistima boravak u prirodnom okruženju, na svežem*

[1] Faculty of Law, University of Kragujevac, High School of Health and Sanitary "VISAN", Belgrade,
e-mail: bataveljic@jura.kg.ac.rs
[2] High school of health and sanitation "VISAN", Belgrade e-mail: anka.vojvodic@vzsvisan.com
[3] High school of health and sanitation "VISAN", Belgrade, e-mail: marko.vojvodic@vzsvisan.com

vazduhu, u seoskoj sredini i javlja se krajem XX veka kao reakcija na sistematsko ugrožavanje okoline koja okružuje savremenog čoveka.

Ključne reči: *agroturizam, seoski turizam, ekologija, poljoprivreda, etno hrana i piće*

1. INTRODUCTION

It is the constitutional right of every human being to live in a healthy environment, in order to ensure respect for his other basic natural and inviolable right to preserve his own health and the health of his descendants. These rights are, therefore, found in the largest number of modern democratic constitutions, and so it is with the valid highest general legal act of the Republic of Serbia from 2006. Namely, Article 74 of this act stipulates that "everyone has the right to a healthy environment and to timely and complete information about its condition. Everyone, especially the Republic of Serbia and its autonomous provinces, is responsible for the protection of the environment. It is everyone's duty to protect and improves the environment", while the Criminal Code of the Republic of Serbia, Chapter Twenty-four, deals with 15 criminal acts against the environment. Due to the importance of protecting the environment, this Criminal Code devotes a significant part of its text to the aforementioned acts, with a tendency to show the penal policy of the Republic of Serbia in the case of endangering the environment that surrounds us and specifying the sanctions for various instances of its endangerment. This means that these positive legal regulations cover numerous criminal acts that endanger the environment. However, it can be stated that, nevertheless, the penal policy in this area is a treasure and enables the perpetrators of these illegal actions to behave in an ecologically irresponsible manner. In addition, there is also the fact that a large number of perpetrators of such crimes remain undetected and, therefore, are not properly sanctioned.

It is undeniable that the number of inhabitants on our planet is constantly increasing. Thus, according to official statistics, at the beginning of the 19th century, there were one billion inhabitants in the world, at the beginning of the 20th century, 1.6 billion, and at the beginning of the 21st century, about 6 billion, and today, at the end of 2023, about 8 billion. According to demographers' forecasts, in the middle of this century, in 2050, 9 billion people will live on planet Earth. This means that such a sudden increase in population requires ever greater food production, which, however, is threatened by the construction of numerous industrial complexes, precisely on the most fertile agricultural land, then by erosion and degradation of agricultural land, uncontrolled use of artificial fertilizers and the like. In the modern man's race for ever-increasing profits, there have been huge problems in the preservation of the environment, fertile land, clean water and unpolluted air, and thus also in the provision of healthy and correct food. All this led to the degradation of available agricultural resources, although today the necessity of developing organic production is constantly emphasized, which enables the protection of the environment, existing resources and, above all, the production of healthy food, which can be used for human and animal nutrition. This production is based on the use of environmentally acceptable materials, which are biodegradable, because it uses renewable energy sources and emphasizes the protection of existing biodiversity. It should be emphasized here that this production excludes any use of genetically modified food, which can end up in the final food chain and lead to catastrophic consequences for the health of both humans and animals. Therefore, in our country, as well as in neighboring countries, there is a growing need and interest in the production of ethnic food and drinks, the consumption of which leads to the development of different types of tourism. Namely, tourism itself represents an extremely important economic city, which directly or indirectly contributes to the production of organic food and, hence, today we have an increasing demand from the population for the development of rural and ethnic tourism [1].

2. OPPORTUNITIES OF THE REPUBLIC OF SERBIA FOR THE DEVELOPMENT OF RURAL AND ETHNO TOURISM

It is unnecessary to talk about how generous God was when he created Serbia and gifted natural beauty, because both local and foreign experts agree. Thus, after the end of the Second World War, the appropriate expert representatives of the international community, for the reconstruction of the devastated and impoverished country, advised that the then Socialist Republic of Serbia, as a member of the Second Yugoslav State, should emphasize three key things, which will always be current and without for which life is almost impossible, and the demand for them is increasing - production of healthy food, tourism and spa (climatic) treatment. However, the government at that time believed that we should develop, first, heavy and then light industry and, in this way, enter into a race with far more developed and technologically more advanced countries in Europe and the world. All of this led to the neglect of the capacities we had at that moment and we did not understand their importance, destroying agricultural and other capacities through uncontrolled deforestation, excessive use of herbicides and pesticides, polluting watercourses, neglecting development and investment in those economic branches that could do a lot lead to the economic recovery of the country and increase the living standard of the population faster.

Rural, health, eco and ethnic tourism represent a great chance for the Republic of Serbia for its economic recovery, because our country has huge capacities for the further development of these types of tourism, provided that further devastation of everything that constitutes sustainable development and the possibility of ethnic production is not allowed. food and drink. Our country still has exceptional conditions for this production, because it has huge areas of land in rural areas that are not polluted by conventional production and industrial waste. Here we mean, first of all, small agricultural farms, which produce organic food and can offer it in their tourist facilities or offer it to tourists in their immediate surroundings. In this way, they save both time and money, because they can market their products "at their doorstep", avoiding going to markets in cities.

Precisely because of this, the Republic of Serbia recognized (admittedly, with a delay, but we hope that it is never too late) the importance of the development of these types of tourism and the production of ethnic food and beverages, so that it adopted the appropriate legal regulations, which enable the achievement of the goals foreseen in the Tourism Development Strategy of the Republic of Serbia for the period from 2016 to 2025. This Strategy was prepared in accordance with the provisions of the Law on Tourism from 2009 and 2019, primarily in accordance with Article 7 of this Law, which indicates that this Strategy establishes the long-term goals of tourism planning and development, especially in accordance with the overall economic, social , ecological and cultural-historical development. It includes, first of all, an analysis of the current state of tourism development and a comparative analysis of competing countries, as well as advantages, disadvantages and a vision of tourism development in our country.

The main goals of this Strategy are to enable the sustainable economic and ecological development of tourism in our country and to increase the share of tourism in the gross domestic product (therefore, to increase the total number of employees in this important branch of the economy), to strengthen the competitiveness of the tourism industry, both domestically and internationally. international market. It is indisputable that special attention will be paid to the development of tourism in the economic, ecological and social sense, as well as to the development of organic production, which will certainly ensure a significantly better image of the Republic of Serbia on the European and world tourism market. "The Republic of Serbia has five national parks, ten nature parks, fourteen landscapes of exceptional shapes, seventy-two nature reserves and special nature reserves, two hundred and eighty-seven natural monuments and about seven hundred registered farms engaged in rural, ethnic and ecotourism" [4]. Of course, this is not the end of the available capacities, because in our country, according to some estimates, there are still as many (700) unregistered farms, one of whose main activities is dealing with the mentioned types of tourism.

Ethno, eco and rural tourism in its beginning had enough labor and was based on what was provided by individual households, but with the rapid development of these types of tourism and the increasing demand of users of these tourist services, along with the development of organic production, the need arose for employment of numerous tourist workers, who are engaged in various activities. This means the employment of those citizens whose main activity is the production of healthy organic food, the preparation of gastronomic specialties from safe and correct raw materials, the transportation of interested tourists to regions that are rich in gastronomic resources and organize fairs and festivals of ethnic food and drinks (of course, with mandatory tasting), as well as the direct provision of services by catering workers in an increasing number of facilities that offer such specialties. The fact is that our country did not recognize the importance of all of the above in time, so that for decades after the Second World War, the village was neglected and neglected, put on the margins of events and politicians were the ones who took care of it (especially in the last couple of decades since the introduction of multi-partyism, i.e. party pluralism) "sanctified" and "visited" only before the elections, making huge and unrealistic promises. In addition, the media was not focused enough on the village, rural households and the invaluable capacities of rural (unpolluted) areas, so that both domestic and foreign tourists were not sufficiently informed about the advantages of eco and ethnic tourism, which these areas provide. Certainly, gastronomic, health, religious and other types of tourism, as their subsystems, find their significant place there and provide the users of these tourist services with numerous pleasures and complete the exceptional tourist offer.

Due to the above-mentioned omissions and the non-domestic attitude towards the village and the rural population (in the valid Constitution of the Republic of Serbia from 2008, there is no category of village and it is not mentioned in a single word), the consequences are far-reaching. Over 1,000 villages in the Republic of Serbia (about ¼ of the total number of villages) are almost completely empty, which represents a very gloomy statistic. Today, there are numerous studies in this regard, but for the purposes of this work, we could cite the results of research reached by Branislav Gulan, which he published in his monograph "Rural Environments in Serbia - Saving the Village and the State" in 2019. Namely, according to his research, there are 4,709 villages in Serbia, of which 1,200 are in the process of disappearing, in 1,034 settlements live less than 100 inhabitants, in 550 less than 50 inhabitants, about 100 villages are completely empty, and in as many villages live ten inhabitants, whose average age is about 70 years [5]. This is why the attitude towards the countryside has changed in the last few years, so that the highest political institutions of our country have made it possible to obtain numerous subsidies for registered agricultural households, the purchase of agricultural machinery and other necessary equipment, for the provision of seed material, the purchase of abandoned houses (according to some estimates there are about 50,000 such houses in Serbia) and the like. Also, the National Team for the Revival of Serbian Villages was formed, and within the Serbian Academy of Sciences and Arts there is an Academic Committee for the Village, as well as a Committee for the Study of the Population.

How important the village is, as well as life in a healthy environment, in an open space, without restrictions, was seen in the difficult moments we experienced during the pandemic caused by the COVID-19 virus in the period 2020-2022. years. Here we are referring, first of all, to unconstitutional measures restricting the right to freedom of movement, which were introduced due to the so-called "lockdown". These measures were particularly difficult for citizens who lived in apartments and who could not go out to meet basic life needs, such as purchasing necessary food, food products, medicines, going to the doctor, receiving appropriate therapy, and the like. Due to the neglect of villages, especially in rural areas, for decades, young people have been moving out and going to cities in search of a better existence, where they often do not always find it. The result

is the devastation of rural areas and the sale of agricultural land and dilapidated rural houses for low sums of money[4].
However, during the pandemic, the demand for staying in rural households, which provided the opportunity for families with children to be in such healthy environments, rose sharply, especially since it was not known what measures would be taken to prevent the spread of the pandemic, their extent and how long will they last. That is why the prices of such facilities have increased many times and this trend continues until today, especially since the habits of tourists have changed, so the state also realized what a chance there is to develop tourism in rural areas and that, therefore, it needs much more attention and funds. to invest in this economic branch.

It is undeniable that political, economic, health and other crises can negatively affect the development of tourism in general, including rural tourism. Namely, political instability, which can be a consequence of war conflicts, coups, demonstrations, strikes and the like, economic crisis and decline in living standards, significantly reduce the desire and ability of users of tourist services to travel and change their place of residence. The same could be said for health crises, such as H_1N_1 epidemics, SARS, the Ebola virus and others, because then freedom of movement is restricted and, in this way, the spread of infection is prevented. This is how the recently survived global pandemic of COVID-19 led to the so-called "lockdown" and locking people in their houses and apartments, because it was the biggest pandemic in world history. This undoubtedly had enormous consequences for the tourism industry, as it limited the ability to travel from one country to another, from one place to another within a country, and even to leave one's own apartments and yards. That is why, as we have already stated, in our country (and according to information from other countries) and in other parts of the world, rural tourism and rural wide areas, where people could spend their time much more safely, gained importance. together with his family, using all the benefits of nature, clean air and healthy water, with the use of ethnic food and drinks.

3. TRADITIONAL SERBIAN FOOD AND DRINK - ORGANIZING ETHNO FAIRS

From the above, it can be concluded that the demand (and, therefore, the consumption) for ethnic food and drink in the world is increasing, so that the tradition is experiencing its renaissance in every respect. The current process of globalization in the world, which was initiated by the great powers, tends to the unification and loss of the identity of small countries, so that, precisely, the awakening of national pride, the desire to preserve traditions and customs, to return to one's roots, to prepare old dishes and drinks (especially from organic products), preservation of old crafts and the like, leads to protection from losing one's identity. This is also recognized in the Republic of Serbia, so today we have more and more organizations that deal with pointing out the competitive advantages of traditional Serbian drinks and food products. Unfortunately, our traditional cuisine still hasn't taken the place it deserves in the world[5], so we can read much more and easily get acquainted with already tried and globally known cuisines, such as: Italian, Mexican, Spanish, Greek , Chinese, French and others.

In addition to the increasing demand of foreign tourists for our traditional food and domestic natural drinks, their interest in spa and rural tourism is also growing. Hence, a significantly larger

[4] There were situations when in numerous villages (especially in Vojvodina) a rural household with a house and all the accompanying facilities could be bought for only a few thousand euros.

[5] Certainly, we ourselves are, to a large extent, to blame for such a situation (especially our media), because we have not sufficiently promoted the beauty, quality and advantages of our old traditional dishes and drinks in the past decades. Also, when foreign guests come to us, our restaurateurs and tourist workers are very often ready to offer them specialties from some other regions or surrounding countries (various types of fish and seafood, artificial drinks, etc.), instead of offering what is autochthonous and that users of tourist services cannot find in their communities where they live.

marketing strategy of our country is needed, so that the advantages and qualities of providing services from these activities are recognized in the world, better positioned and take their rightful place. Of course, a special responsibility and role lies in the much greater involvement of individual ministries of the Republic of Serbia, producers of traditional types of food and drinks and their distributors, numerous tourist organizations, travel agencies, educational, health and other institutions. [6]. The main goal of such activities should be to create an appropriate culture of using healthy food and quality (alcoholic and non-alcoholic) drinks, produced in a traditional way, as it was done centuries ago. The result, for sure, will be getting that position (place) on the non-hierarchical ladder of Serbian cuisine, which really belongs to it, so that, due to the growing demand for ethnic food and drink, there will be a significantly higher consumption and an increase in the quality and quantity of these services [7]. Due to insufficient marketing activities in the world, little is still known about the advantages of our traditional cuisine, by which we mean both different dishes and different types of drinks. Almost everyone in the world knows about whiskey, metaxa, tequila, vodka and other alcoholic beverages, but few people are familiar with the quality of our homemade brandy, which is much better and healthier (when it is made in a natural, traditional way and without unnecessary additives). and which, as such, "opens all doors", because real lovers and connoisseurs of alcoholic beverages recognize its value very easily and quickly.[6]

Bearing in mind the above, numerous authors in their works talk about the extremely large impact of tourism in general, and rural tourism in particular, on the development and economic recovery of each country. Combined with agriculture and the production of healthy food, this impact is much greater [8], so that, in order to connect them even more, it is necessary to further invest and invest in technological achievements, increase the offer, build new hotels, restaurants of traditional cuisine and adapt to the requirements and the needs of users of tourist services. In these activities, the role of marketing, all types of media, social networks, promotion of local types of food and drinks, provision of adequate transport and every other type of infrastructure, strengthening of trust, communication and exchange of information between producers, suppliers and carriers of the tourism industry is particularly important. The connection and joint action on the market of organizations that are engaged in the production, distribution, sale and offer of ethnic food and drinks will certainly contribute to the increase in the quality and quantity of the tourist offer and the expansion of the tourist market, the increase in the living standard of the population, and therefore a significant impact on the economy of our country [9].

In order to achieve all this, it is necessary to engage young, educated, capable and determined people, who are ready to take on all these challenges, to educate consumers and create a culture of consuming, first of all, ethnic food and drinks. Undeniably, this very important role is played by appropriate trade fairs, which, thank God, are increasing all over our beautiful country of Serbia. There, a special place is occupied by the traditional fair in Belgrade, which last year, in 2023, was held (for the 17th time) in the period from November 30 to December 3, and where lovers of good food and drinks had the opportunity to enjoy a unique combination of tradition and authenticity. At this fair, sponsored by the Ministry of Agriculture, Forestry and Water Management, in addition to the city of Belgrade, more than 300 producers presented themselves, and the goal of organizing such an event is[7], in the first place, establishing a brand of ethnic products. This Fair, like most others, is designed so that in one, relatively small space, producers of healthy food and drinks, culinary masters and true lovers of traditional cuisine meet, promote their local culinary heritage, hold lectures on the importance of preserving and further developing organic production. The fact that during those few days a huge number of mutual communications, exchange of information and

[6] The author of this work himself was a witness to this, who during his frequent trips to Europe, always takes the permitted amount of this drink, which in German-speaking countries, most often humorously, is called "Heiliges Wasser" (holy water).

[7] Many participants from Bosnia and Herzegovina (primarily from Republika Srpska), Montenegro, Macedonia, Romania, Greece and other surrounding countries give this fair an international character.

establishing contacts about further cooperation is achieved is especially significant, because both the exhibitors themselves and thousands of visitors from all over Serbia and other countries can directly familiarize themselves with the quality and quantity of everything of what is offered to them on that occasion. This is the only way to revive the flavors of old recipes and the beauty of traditional food preparation techniques in an exceptional atmosphere, which insists on the diversity and authenticity of the gastronomic heritage of all regions of the Republic of Serbia.

Also, these and similar manifestations help manufacturers to bring their high-quality products to the market, to promote and turn them into brands, to carry out the promotion, above all, of organic food and drinks[8], to preserve and protect forgotten recipes and contribute to the protection of geographical origin (up to now more than 50 requests for obtaining a product geographical origin label are supported). The organizers of last year's Belgrade Ethnic Food and Beverage Fair have repeatedly emphasized that this traditional manifestation played a very significant role in the so-called to the "branding" and promotion of many products from different areas of our country, such as: Leskovac ajvar, Kačar and Homolj honey, tobacco crackers, Futo cabbage, Pirot iron sausages, jams, pickled winter meats, various sweets, cured meat specialties, lukewarm products, cheeses, tea mixes, dried fruits, bakery products, wines, brandies, juices and the like. Therefore, we can freely say that each subsequent fair (in general, and especially in Belgrade) represents a real "treasure" of taste and tradition, gathering an increasing number of exhibitors, both from our country and from numerous countries in Southeast Europe, thus celebrating the wealth of diverse gastronomic heritage and promoting national specialties and products that are deeply rooted in the culture and tradition of these areas. In this way, many things were "pulled out" from oblivion and preserved for generations to come, so that such events represent a real "epicenter" of the taste and smell of tradition. Certainly, numerous workshops, lectures and various cultural events further enrich such manifestations, giving visitors the opportunity to talk with passionate producers of such high-quality products and culinary masters, to get to know the beauty and rich taste of authentic products from our country and representatives of other countries.

4. RURAL TOURISM IN SERBIA AND LEGAL ASPECTS OF ITS DEVELOPMENT

When we talk about the importance of the production and use of ethnic food and drinks, as a great chance for the economic recovery of our country, we must point out the fact that further investment in the development of rural tourism is necessary, as well as the way to regulate this type of tourism economy. Here we mean, first of all, the Law on Tourism, the Law on Hospitality and the Law on Consumer Protection, as well as numerous other by-laws, which in this case, we would not list and analyze in more detail. It should be borne in mind that both the law and the by-laws change during their validity, in whole or in part, adapting to the current situation, changes in the supply and demand market, the economic, political and health situation in the country and the world, as well as the state at the global tourist level. Tourist services in rural households can be provided by natural persons, entrepreneurs, companies and other legal entities, and the most attractive tourist destinations are those that have protected nature, a preserved environment and tourist motives that attract guests. Therefore, the most important prerequisite and basis for the development of this type of tourism is the change in economic activities in the countryside and the reaffirmation of traditional cultural values. It is a fact that in recent years the interest of tourists has been growing for ecologically clean nature, for consumption of domestic (autochthonous) agricultural products, as well as for learning about culture, religion, customs and living conditions in the place and surroundings where they stay during their vacation. Users of tourist services in such environments have additional needs (in addition to accommodation and food), which arise from the desire to fulfill their free time with quality, with certain excursions, cultural events, education, and even work

[8] Today in Serbia, according to the words of the current Minister of Agriculture at the opening of the Fair, around 7.000 agricultural households are engaged in organic production.

on the farm.[9] This is necessary in order to escape from work, worries and efforts in search of an exciting experience and some new activities that trigger emotions and provide a break from everyday worries, stresses and the like. Today, tourists travel more and more to these areas to change the environment, stay in nature and in cleaner air and get everything they don't have at home. Of course, their desire to gain new knowledge, to study the culture of other peoples and try local specialties, to examine the beliefs of that region, to see, touch and feel something unknown or to relive some memories of the former way of life also plays an important role.

In order to achieve all this, it is necessary to legally regulate tourism activities in the countryside, so that the latest Law on Tourism from 2019 regulates the conditions and method of planning and developing tourism, as the principles on which the regulation of relations in the field of tourism is based. Here we mean, above all, the integral development of tourism and its sustainable development, which is based on the preservation of natural and cultural assets, the preservation and development of the local community, the increase of efficiency and responsibility in the area of use of tourist space, the provision of unique standards for the provision of tourist services, protection national economy, provision of unique and public electronic records, planning of rural and ethnic tourism development policy in accordance with the Tourism Development Strategy of the Republic of Serbia. In addition to this planning document, there are certainly others, such as: Strategic master plan, Strategic marketing plan, tourism development program, tourist products, promotional activities, and all of them must be harmonized with the aforementioned Tourism Development Strategy of the Republic of Serbia.

Also, a very important general act is the 2019 Act on Catering, which regulates the conditions and manner of performing catering activities. According to this Law, a rural tourist household is an object or a group of objects in which the services of accommodation, preparation and serving of ethnic food and drinks (as well as other types of these products) are provided, all in a rural (village) environment, with elements of local characteristics and heritage. . A caterer, before starting to perform activities in a catering establishment of domestic craftsmanship and a rural tourist household, obtains a decision by which that establishment is categorized, and it is especially insisted that health conditions are met and regular health inspections of such catering establishments are carried out, all in accordance with the Law on health care.

As the third significant act related to the legal aspect of the development of rural tourism in our country, we cite the Law on Consumer Protection of the Republic of Serbia from 2021, which was adopted with the aim of protecting the position of consumers, informing them and improving their knowledge of their rights and obligations, ways protection of the rights and obligations of the association, whose field of activity is the achievement of consumer protection goals. The rights established by this Law are binding in nature and the consumer cannot waive them, and the legal provisions are applied to the relationship between consumers (in our case, users of tourist services) and service providers in rural tourism. The obligation to inform the users of tourist services (as well as their education) in an unambiguous, legible and easily perceptible manner is particularly emphasized. This means, first of all, informing about all the elements of the contract before its conclusion about all the elements of the sale of ethnic food and drinks, the provision of accommodation services or any other tourist service.

5. CONCLUSION

From the above, we can conclude that investing in the development of agritourism and the production of ethnic food and beverages is a great chance for economic recovery and the economic revival of our country. The Republic of Serbia has extremely large opportunities for the

[9] It should be emphasized that today's quality does not mean any kind of luxury, but a good product and timely service.

development of rural tourism, and therefore the Tourism Development Strategy of the Republic of Serbia for the period 2016-2025 was adopted, which was prepared in accordance with the provisions of the Law on Tourism. The aforementioned Strategy has numerous goals, the most important of which is enabling sustainable economic development in our country and increasing the total number of employees in this extremely important economic branch. This will undoubtedly contribute to increasing the share of tourism in the gross domestic product and ensure a much better image of the Republic of Serbia on the tourist market, not only in Europe, but also in the whole world. Numerous fairs and festivals of ethnic food and drinks play a huge role in all of this. In our country, decades ago, the village was neglected and was on the margins of the interest of those who "lead" the country and decide on the way to ensure the existence and raise the standard of living of its population. We hope that, finally, after the recognition of rural tourism and villages in general as a great chance for the Republic of Serbia and its exit from the multi-decade economic crisis, there will be the application of valid legal regulations and their implementation, because until now they were just "an empty letter on paper ", and the peasant was in the center of attention only during the elections, when big promises were made, which were soon forgotten. Our current Constitution of the Republic of Serbia from 2006 did not dedicate a single word to the village, nor did it mention it in its provisions - of course, it didn't have to, but it could!?

REFERENCES

[1] Beslać, M., Ćorić, G. (2017), Financial and production aspects of genetically modified organisms, Economics of Agriculture, vol. 64, no. 4, pp. 1583-1595.
[2] The strategy was prepared in accordance with the provisions of the Law on Tourism from 2009 and 2019, "Official Gazette of RS", no. 98/2016.
[3] Law on Tourism from 2019, "Official Gazette of RS", no. 17/2019.
[4] Beslać, M., Cogoljević, V., Vujović, S. (2023), Financing organic production and its impact on the development of rural, ethnic and ecotourism in Serbia, ECOLOGICA, vol. 30, no. 111, pp. 427-434.
[5] Gulan, B. (2019), Rural areas in Serbia - saving the village and the country, Prometej Publishing House, Belgrade.
[6] Rakić, M., Rakić, B. (2010), Positioning and differentiation of traditional Serbian food, Ekonomske teme, vol. XLVIII, no. 2, pp. 253-263.
[7] Papadopoulos, H. (1997), Trendy tastes, Restaurants USA, vol. 17, no. 2, pp. 41-44..
[8] Meler, M., Cerović, Z. (2003), Food marketing in the function of tourist product development, *British Food Journal*, vol. 105, no. 3, pp. 175-192.
[9] Saračević, M., Međedović, E., Mašović, S., Selimović, F., Novalić, F. (2011), Improvement of education, information and communication of employees in the agribusiness sector and the way of realization by applying LCMS, Scientific conference - AGROBIZNIS2011, Novi Pazar..
[10] Law on catering, "Official Gazette of RS", no. 17/2019.
[11] Law on Consumer Protection, "Official Gazette of RS", no. 88/2021.
[12] Law on health care, "Official Gazette of RS", no. 25/2019 and 92/2023

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

COLOSTRUM, THE IMPORTANCE OF COLOSTRUM IN FEEDING CALVES

KOLOSTRUM, ZNAČAJ KOLOSTRUMA U HRANIDBI TELADI

Zvonimir Steiner, Full professor [1]
Ivan Babić, Ph.D.[2]
Ranko Gantner, Full professor [3]
Vesna Gantner, Full professor [4]

Abstrakt: *Hranidba kolostrumom neophodna je za prijenos pasivnog imuniteta i zdravlje novorođene teladi. Unutar prva dva do najkasnije četiri sata života tele treba popiti ili posisati kolostrum. Sadržaj hranjivih tvari (masti, ugljikohidrata, proteina, minerala, vitamina) višestruko je veći u kolostrumu u usporedbi s mlijekom. Pasivni imunitet stječe se uzimanjem kolostruma i imunoglobulina koji se u njemu nalaze. Intenzivna apsorpcija imunoglobulina događa se tijekom prvih 12 do 24 sata života. Najbolji je način čuvanja kolostruma duboko zamrzavanje i čuvanje na – 20°C. Tako zamrznuti kolostrum najbolje je iskoristiti u razdoblju do godinu dana. Odmrznuti kolostrum telad izuzetno dobro prima i iskorištava.*

Ključne reči: *kolostrum, telad, hranjive tvari, pasivn imunitet, čuvanje kolostruma*

Abstract: *Colostrum feeding is necessary for the transfer of passive immunity and the health of new-born calves. Within the first two to four hours of life, the calf should drink or suck colostrum. The content of nutrients (fats, carbohydrates, proteins, minerals, vitamins) is many times higher in colostrum compared to milk. Passive immunity is acquired by taking colostrum and the immunoglobulins contained in it. Intensive absorption of immunoglobulin occurs during the first 12 to 24 hours of life. The best way to store colostrum is deep freezing and storage at -20°C. Colostrum frozen in this way is best used within a period of up to one year. Calves receive and use thawed colostrum extremely well.*

Key words: *colostrum, calves, nutrients, passive immunity, colostrum storage*

1. INTRODUCTION

Colostrum is a product of the mammary gland of mammals, and it is secreted during five to seven days after birth. Colostrum, which we also call colostrum or curd, is the "first milk" that is rich in antibodies. The life and health of the calf and its further breeding depend on whether it has sucked the appropriate amount of colostrum in time. The costs of breeding heifers increase if there is a higher mortality of calves or if diseases that could have been prevented by taking colostrum need to be treated. Cow colostrum differs from normal milk in color, taste and chemical composition. Colostrum is a sticky yellowish secretion, with a specific smell, slightly salty taste and thick consistency [1]. Compared to milk, colostrum has a higher acidity. Due to the higher content of simple proteins, colostrum coagulates (coagulates) when cooked. The most important difference

[1,3,4] J.J. Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, Osijek, Croatia; e-mail: zsteiner@fazos.hr

[2] Belje Plus Ltd, 31327, Bilje, Croatia,

between colostrum and normal milk is the protein composition. Colostrum is primarily rich in globulins and immunoglobulins. The protein concentration in colostrum is up to 14%. In the first 24 hours, the composition of colostrum changes, and the protein content approaches that of milk [2]. Considering the exceptional importance of colostrum for the further development and productivity of the young, this review paper aimed to analyze the characteristics and significance of the use of colostrum.

2. TAKING COLOSTRUM

Within the first two to four hours of life, the calf should drink or suck colostrum. This is necessary for the following reasons: the calf is born without antibodies and is instructed to receive them through the mother's colostrum in order to be protected from pathogens that are normally present in the herd environment. The concentration of antibodies in colostrum decreases rapidly after birth, and the ability to adopt antibodies in the small intestine of the calf is possible only during the first 12-16 hours after birth [1, 2, 3, 4].

The amount of first colostrum that the calf needs to drink or suck is 1.5 to 2 liters, and it is determined by the capacity of the rennet, which is also 1.5 to 2 liters. The next feeding should follow no later than 12 hours after birth, with the same amount of colostrum. There is a strong positive correlation between the amount of colostrum consumed in the first hours of life and the level of immunity. Thus, in the test [5], it was determined that less than two liters of colostrum sucked in the first two feedings during the 12 hours of life did not provide adequate immunity, so such calves had a lower growth rate until the third month of life. The best results with regard to calf growth were obtained from a daily amount of colostrum of 2.5 to 3.5 liters. A larger amount of colostrum than stated did not result in better growth results.

In herds where machine milking is used, it is recommended to feed calves with colostrum from the first day from a teat container. In this way, control and quality of colostrum is possible. The practice that is present on some farms, according to which the calf stays with its mother for the first seven days and is often suckled, is not recommended because first-time heifers need a longer period of adaptation to machine milking. Sucking calves is not justified even in herds with manual milking of cows.

3. CHEMICAL COMPOSITION OF COLOSTRUM

The chemical composition of cow colostrum during parturition and during the next two days of lactation, as well as a comparison with normal milk 48 and 72 hours after calving, are shown in Table 1. The content of nutrients (fats, carbohydrates, proteins, minerals, vitamins) is many times higher in colostrum in compared to milk. All the mentioned nutrients are most abundant in colostrum after parturition, and then gradually decrease during the first and second day after the cow gives birth.

Compared to milk, colostrum is more acidic, and the content of dry matter and protein is significantly higher. Colostrum contains significantly more micro and macro elements and vitamins A, D and E compared to milk. Colostrum has an increased content of catalase enzymes and purgatives that help expel meconium from the digestive system. It was also found that cows with a lower level of colostrum have more protective bodies at the first milking than cows that produce more colostrum. In general, older cows have better quality colostrum compared to younger cows. The quality of colostrum also depends on the structure of the sphincter of the teat canal. Cows prone to mastitis, as well as cows with a short dry period, produce colostrum of poorer quality [6,7].

Table 1. Changes in the composition of colostrum and milk after calving [8,6,9]

A nutrient	Colostral milk			Normal milk	
	Delivery	13 hours after calving	24 hours after calving	48 hours after calving	72 hours after calving
Dry matter, %	33,6	20,9	15,6	14,0	12,8
Fats, %	6,5	2,5	3,6	3,7	3,7
Proteins, %	23,1	13,7	7,1	4,9	3,5
Casein, %	5,6	4,5	4,2	3,6	2,8
Albumin and globulin %	16,9	9.0	2,6	1,1	0,7
ß-lactoglobulin, %	-	0,8	0,8	0,3	0,3
α- lactoglobulin, %	0,2	0,1	-	0,1	0,04
Serum albumin, %	0,1	-	-	-	0,09
Imunoglobulin, %	6,8	5,1	3,2	0,8	0,09
Lactose, %	2,1	3,5	4,2	4,4	4,8
Ash, %	1,4	1,1	1,0	0,9	0,8
Calcium, %	1,5	1,5	1,3	1,2	1,3
Phosphorus, %	0,3	-	-	-	0,1
Magnesium %	0,04	-	-	-	0,01
Sodium, %	0,07	-	-	-	0,06
Potassium, %	0,12	-	-	-	0,10
Iron, % (mg/100g)	0,20	-	-	-	0,05
Copper (mg/100g)	0,06	-	-	-	0,02
Carotenoids (µg/g fat)	35	-	-	-	8
Vitamin D (ng/g fat)	30	-	-	-	15
Vitamin E (µg/g fat)	125	-	-	-	20
Thiamine (µg/100g)	60	-	-	-	40
Riboflavin (µg/100g)	500	-	-	-	150
Niacin (µg/100g)	100	-	-	-	80

4. PHYSIOLOGICAL CHARACTERISTICS OF COLOSTRUM

The importance of colostrum in feeding calves is extremely important because it is the only complete food. In addition to the increased content of nutrients (Table 5), recent research [10] indicates that colostrum is rich in numerous growth factors and hormones, and colostrum feeding has a beneficial effect on milk yield after growing up, which is associated with the presence of IGF-I, IGF-II, somatotropin , insulin, prolactin and leptin [11]. Through the lactocrine mechanism, hormones participate in the development of the digestive system, the development of digestive enzymes and the improvement of the absorption of nutrients from the digestive system. [12] investigated the occurrence of disease and death in calves and found that the mentioned phenomena increase if adequate amounts of immunoglobulin are not absorbed, and the most common cause of calf death is poor colostrum quality and late feeding after parturition.

If the colostrum is of poorer quality [13], they suggest adding various commercial supplements to the colostrum. Supplements prepared in this way may contain bovine immunoglobulins, and they are prepared from whey, colostrum of immunized cows or obtained by monoclonal antibody technology. The preparations produced in this way can increase the content of antibodies (IGg) in low-quality colostrum and increase the low titer of antibodies in calves.

5. ABSORPTION OF NUTRIENT AND PROTECTIVE SUBSTANCES

Tele se rađa s nerazvijenim želudcima i bez aktivnog imuniteta. Pasivni imunitet stječe se uzimanjem kolostruma i imunoglobulina koji se u njemu nalaze. Intenzivna apsorpcija imunoglobulina događa se tijekom prvih 12 do 24 sata života. Poslije ovog kratkog razdoblja sposobnost crijeva za apsorpciju imunoglobulina značajno se smanjuje. Zbog toga telad treba što prije uzeti majčin kolostrum. Idealno je da telad uzme kolostrum 30 minuta nakon rođenja, a najkasnije četiri sata nakon rođenja. Napajanje teladi kolostrumom u količini 4% do 5% od tjelesne mase potrebno je zbog toga što novorođena telad ne sadrže antitijela te kolostrum trebaju dobiti kako bi se zaštitila od bolesti. Sposobnost teladi za apsorpciju (upijanje) imunoglobulina znatno je smanjena 24 do 36 sati nakon rođenja. Neposredno poslije teljenja telad mogu biti inficirana patogenim mikroorganizmima. Kolostrum je koncentrirani izvor lako dostupnih visokoprobavljivih hranjivih tvari i energije [14].

6. THE IMPORTANCE OF COLOSTRUM

As a rule, the recommendation is that the calf should receive its first colostrum as soon as possible, based on the fact that its composition changes rapidly. [6,9,15] state that the antibody concentration 12 hours after calving decreases by half of the initial level.

At birth, the calf has a poorly developed immune system because the placenta does not allow the transfer of antibodies from the mother to the fetus during pregnancy. It is important to point out that globulins contain antibodies that the cow produces to protect itself from the microorganisms it is exposed to in the environment. The calf is protected from diseases through colostrum in the earliest period of its life, until its own immune system develops and activates. Antibodies are proteins that recognize and destroy pathogens or pathogens in the calf's body [16, 17]. There are three main types of immunoglobulins, namely G, M, A, which are represented in colostrum in the following proportions: from 85 to 90%; 5 to 10% and 5 to 10%. These three types of Ig have specific tasks in the immune system. Ig-G are able to recognize and destroy invading pathogens outside the bloodstream in any body organ. The main role of Ig-M is the destruction of bacteria that have entered the blood. Ig-A binds to the cell membranes of organs and thus prevents pathogens from doing so before them and causing disease.
The success of colostrum feeding is based on four factors: the timeliness with which the calf takes colostrum after calving, the amount of colostrum the calf drinks, the quality and concentration of immunoglobulins in colostrum and the purity of pathogens in colostrum [18].

The principle of timeliness of taking colostrum is manifested in the fact that colostrum globulins can reach the blood during the first 24 hours, but it should be emphasized that already at the end of 24 hours after birth, the globulins can almost no longer pass into the bloodstream. The content of immunoglobulin in the first nine hours after the birth of the calf is almost the same. It is important to give the calf two liters of colostrum in the first 12 hours of life. If the calf has not drunk any colostrum within 12 hours after birth, it will certainly not be able to acquire adequate immunity. If possible, the calf should be given colostrum one hour after birth. American farmers who keep their cows on pasture reward the staff in charge of caring for the calves per reared calf. Calves are fed within two hours or helped to stand up and suck colostrum. Special attention is paid to the female calf. Every reared female calf is capital for the future, whether it is used for its own overhaul or sold for breeding. It is stated that colostrum has a very high nutritional value, and in addition to its nutritional value, its laxative role has also been proven.

Considering the quantity, it is ideal for the calf to be fed with two liters of high-quality colostrum within an hour after birth. The second time, the calf should be watered with two to three liters of colostrum no later than eight hours. It is recommended that the cow and calf be together, if not

longer, then at least for the first twelve hours after calving. If the calf did not stand up and drink the colostrum on its own within three hours after birth, it needs to be helped to drink it. In the USA, they do this using an esophageal feeding tube [19].

In terms of quality, the protein content of first milk is 5 to 6%, but it can vary from 2 to 15%. The antibody concentration decreases with each subsequent milking. Already at the second milking, the antibody level decreases to 65%, and at the third milking, this proportion is 40% compared to the first milking [2, 20].
Nutrients such as fat and protein, which are important for the growth of the calf, are represented in a higher proportion than in ordinary milk. The percentage of fat is about 6.7%, and protein is about 14%. The lactose content is lower than in regular milk, so it reduces the risks of diarrhea in the newborn calf (Vega et al., 2011). In dairy breeds, the concentration of Ig in colostrum is lower than in fattening breeds. Of the milk-producing breeds, HF has the least IG- in colostrum. First heifers usually have less IG, and cows in the third lactation have the most immunoglobulins [17].

The biggest challenge when feeding colostrum is how to keep it clean, free of pathogens, and this is achieved by hygiene of udders, milking machines and calf feeding equipment. [2, 19] state the positive features of colostrum that classify it as an indispensable food in the first days of life, namely digestibility, purgative properties, provision of passive immunity to the calf, provision of vital nutrients (proteins, carbohydrates, fats, minerals, vitamins). Despite the fact that passive protection decreases, colostrum enables the transition to the establishment of active immunity, which the calf acquires at four weeks of age.

In herds with high milk production, a certain amount of unused colostrum remains. In the case of first-calf heifers, about 35 kg of excess may remain, and in the case of older cows, the excess of colostrum varies from 50 to 70 kg. Excess colostrum can be used fresh, fermented or preserved [19]. Fresh colostrum can be used to feed older calves that are on a milk diet by diluting it with warm water at a ratio of 2:1 or it can be added to an already prepared milk replacer before feeding.

The best way to preserve colostrum is deep freezing and storage at -20o C. Colostrum frozen in this way is best used within a period of up to one year. Calves receive and use thawed colostrum extremely well. Frozen colostrum is gradually thawed at a temperature of up to 50 oC. It is recommended not to thaw colostrum at room temperature because the number of microorganisms doubles every 20 to 30 minutes [21, 22].
Antov, [19] suggests that colostrum is frozen in three consecutive milkings from old cows that have calved in autumn and have been on the farm for a long time and have not suffered from mastitis. If the cow ate green fodder during the summer, and hay and silage in the winter, the colostrum is rich in carotene and vitamin E. Excess colostrum is filled into buckets with a volume of 0.5 to 1 liter, which we mark with stickers and keep in freezers. Despite the fact that about 10% of the value of fresh colostrum is lost by freezing, it allows raising calves without the risk of disease and losses. If necessary, it is thawed and prepared for feeding calves by submerging buckets with frozen colostrum in larger containers with water temperature no higher than 40 oC. Higher temperatures damage immunoglobulins, thus losing the protective role of colostrum.

Lack of colostrum can occur in first-time heifers, and one of the causes is the stress that occurs during calving. There is also a possibility that the cow may die during difficult calving. Then it is recommended that the calf be fed with colostrum from a calving cow at approximately the same time. If the calf were to drink the milk of previously calved cows, it could end fatally for the calf. In such cases, it is best to use frozen colostrum.

7. CONCLUSION

Colostrum is primarily rich in globulins and immunoglobulins, with the help of which the calf gains passive immunity. It is necessary to give it to the calf in the first two to four hours due to absorption by globulins and immunoglobulins. In addition to the increased content of nutrients, colostrum is rich in numerous growth factors and hormones, and colostrum feeding has a beneficial effect on milk yield after growing up, which is associated with the presence of IGF-I, IGF-II, somatotropin, insulin, prolactin and leptin. Colostrum enables the transition to the establishment of active immunity, which the calf gets at four weeks of age.

8. ACKNOWLEDGEMENTs

Research and dissemination were supported by the Fund for Bilateral Relations within the Financial Mechanism of the European Economic Area and Norwegian Financial Mechanism for the period 2014-2021 (Grant number: 04-UBS-U-0031/23-14).

REFERENCE

[1] Berge A. C. B. , Besser T.E., Moore D,A., Sischo W.M. (2009): Evaluation of the effects of oral colostrum supplementation during the first fourteen days on the health and performance of preweaned calves. J Dairy Sci. 2009 Jan;92(1):286-95. doi: 10.3168/jds.2008-1433.
[2] Pantelić, Branislava (2015), Significance of colostrum in calves first days of life. Zbornik radova Pravilnom ishranom, negom i zaštitom do zdravlja 4, 18-21.
[3] Davis, C. J., Drackley, J. K. (1998), The development, nutrition, and management of the young calf. Iowa State University Press, Ames, Iowa,
[4] Godden, S. M., Fetrow, J. P., Feirtag, J. M., Green, L. R., Wells, S. J. (2005), Economic analysis of feeding pasteurized nonsaleable milk versus conventional milk replacer to dairy calves. Journal of the American Veterinary Medical Association 226, 1547-1554.
[5] Losada H, Vieyra J, Rivera J, Martinez H, Pealing R, Cortes J and Arias L 1997 Cattle behaviour as an indicator of animal welfare in the sustainable dairy systems of Iztapalapa in the east of Mexico City. Livestock Research for Rural Development. Vol 9, No 4. http://www.cipav.org.co/lrrd/lrrd9/4/mex941.htm,
[6] Caput, P. (1996), Cattle farming. Celeber, Zagreb,
[7] Uremović, Z. (2004), Cattle farming.Croatian Dairy Association, Zagreb,
[8] Božanić Rajka, Jeličić Irena, Bilušić Tea (2012.): Analysis of milk and milk products. Plejada d.o.o., Zagreb,
[9] Džomba, E. (2015), Cattle feeding (in Domaćinović et al.: Special feeding of domestic animals) Josip Juraj Strossmayer University, Faculty of Agriculture Osijek,
[10] Bach, A. (2012), Ruminant nutrition symposium: Optimizing performance oh the offspring nourishing and managinig the dam and postnatal calf for optimal lactation, reproduction, and immunity. Journal of Dairy Science, 90, 1835-1845.
[11] Garnsworthy, P. C., Fouladi-Nashta, A. A., Man, G. F., Sinclair, K. A., Weth, R. (2009), Effect of dietary-induced changes in plasma insulin concentrations during the early post partum period on pregnancy rate in dairy cows. Reproduction, 137, (4), 759-768,
[12] Henniger P., Henniger T., Seehuse F., Distl O., Ganter M. (2014), Causes of death in calves with experimentally induced bovine neonatal pancytopenia (BNP). Berl Munch Tierarztl Wochenschr. 2014 Jan-Feb;127(1-2):61-9. PMID: 24490345.
[13] Jovanović, R., Dujić, D., Glamočić, D. (2000), Nutrition of domestic animals. Stylos-publishing house, Novi Sad,
[14] C.C. Stanley, C.C. Williams, B.F. Jenny, J.M. Fernandez, H.G. Bateman II, W.A. Nipper, J.C. Lovejoy, D.T. Gnatt, G.E. Goodlier (2002):Effects of feeding milk replacer once

versus twice daily on glucose metabolism in Holstein and Jersey calves. J. Dairy Sci., 85 (2002), pp. 2335-2343,
[15] Skřivánek, M. (2011.): Kritické kontrolní body v odchovu telat do 100. dne věku. Náš chov 8, 76,
[16] Gorgulu, M., Siuta, A., Ongel, E., Yurtsevan, S., Rustu Kutlu, H. (2003), Effect of Probiotic on Growing Performance and Health of Calves. Pakistan Journal of Biological Sciences, 6,7, 651-654,
[17] Kuroki, M., Ohta, M., Ikemori, Y., Icatlo Jr., F. C., Kobayashi, C., Yokoyama, H., Kodama, Y. (1997), Field evaluation of chicken egg yolk immunoglobulins specific for bovine rotavirus in neonatal calves. Archives of Virology, 142, 843-851,
[18] Ahmed, M.A., Younis, E.E.A., Osman, S.A., Ishida, Y., El-Khodery, S.A., Shimamoto, T. (2009.): Genetic analysis of antimicrobial resistance in Escherichia coli isolated from diarrheic neonatal calves. Veterinary Microbiology, 136, 3–4, 397-402,
[19] Antov, G. (1992), Colostrum. Significance and use. National agricultural calendar, Novi Sad,
[20] Hofírek, B., Dvořák, R., Němeček, L., Doležel, R., Pospíšil, Z. (2009), Nemoci skotu. Česká buiatrická společnost, Brno, 845- 1001.
[21] Frydrych, Z. (2004), Mléčné krmné směsi a startery ve výživě odchovaných telat. Náš chov 12, 42 – 43,
[22] Motejlek, M. (2015), Základní aspekty výživy a zdraví telat Bakalářská práce, Zemědělská fakulta Jihočeská Univerzita v Českých Budějovicích, 1-50.

PRODUCTION OF FOOD IN ACCORDANCE WITH NATURE

PROIZVODNJA HRANE U SKLADU SA PRIRODOM

Biljana Matejić,[1]
Saša Stepanov, Prof. dr [2]
Stanko Simović, esearch associate[3]

Abstract: *The tasks that are set before all of us participants in the food production process are that the agricultural production practice must be sustainable from the economic, social and ecological aspects. Maintaining active biodiversity in the soil and improving diversity in agro-eco systems are prerequisites for sustainable agriculture and the application of positive practices. Today, organic agriculture represents a significant part of the global food production system, and its principles are increasingly receiving recognition and support for their contribution to sustainable development and environmental preservation.*
The demand for healthy food is constantly increasing as a reaction to knowledge about the negative effects of established production methods. It is the ultimate choice of every nation that cares about its health, the planet and the well-being of current and future generations.
The health of the soil, plants, animals, people and the planet as a whole is a big challenge for us at this time.

Key words: *agricultural production, healthy life, MINERAL forte PLUS, healthy planet*

Apstrakt: *Zadaci koji se postavljaju pred sve nas učesnike u procesu proizvodnje hrane su da poljoprivredna proizvodna praksa mora biti održiva sa ekonomskog, socijalnog i ekološkog aspekta. Održavanje aktivnog biodiverziteta u zemljištu i unapređenje diverziteta u agro-eko sistemima su preduslovi za održivu poljoprivredu i primenu pozitivnih praksi. Organska poljoprivreda danas predstavlja značajan deo globalnog sistema proizvodnje hrane, a njeni principi sve više dobijaju priznanje i podršku za svoj doprinos održivom razvoju i očuvanju životne sredine.*
Potražnja za zdravom hranom je u stalnom porastu kao reakcija na saznanja o negativnim efektima ustaljenih metoda proizvodnje. To je krajnji izbor svakog naroda koji brine o svom zdravlju, planeti i blagostanju sadašnjih i budućih generacija.
Zdravlje zemljišta, biljaka, životinja, ljudi i planete u celini predstavlja veliki izazov za nas u ovom trenutku.

Ključne reči: *poljoprivredna proizvodnja, zdrav život, MINERAL forte PLUS, zdrava planeta*

1. INTRODUCTION

When man began to lead a sedentary lifestyle and engage in agriculture, he began to exert a direct influence on the environment and to change it in accordance with his needs. Today, when there are almost 8 billion people on the planet, the impact of agriculture and food production on the environment is enormous. The main problem is the industrial model of food production, which mercilessly depletes natural resources and pollutes the environment through the use of chemical preparations, affecting healthy nutrition, diseases and the survival of the human population.

[1] Director of the company "AZARREDE" Novi Sad,, e-mail: biljanamatejicns@gmail.com
[2] Center for Research, Science, Education and Mediation "Cinep", Belgrade,
e-mail: sasa.stepanov@gmail.com
[3] Advisory agency "Agronom SOS", Belgrade,

Corporations dictate the rules of the market game and use all possible ways to make even more profit, at the expense of the health of people (the little man) and nature.
They assured us, both producers and customers, that a different system was not possible. They convinced the producers that they had to spray against various diseases, that they should use mineral fertilizers (NPK) abundantly so that the fruit would be large, that they had to buy seeds from corporations because these domestic seeds would not bear fruit. They assured consumers that everything had to be so in order to provide enough food for the population, in order to provide the so-called food safety. The conventional model of food production is based on these assumptions. The producer depends on large corporations that control every segment of food production, from seeds to all preparations, primarily for their own interest, and not for food safety, as is often tried to justify in public. And most people accepted it. Why? Because it's easier for everyone. The average farmer goes to the agricultural pharmacy, buys everything he needs, does as he is told and does not think too much about what he is doing. The average customer goes to the store, buys what he needs and doesn't think too much about the origin of his food. Convenience and choice make our lives easier. However, everything has a price. Too much comfort leads to dullness. Too many choices lead to a kind of devaluation of basic life values.

Care about the modern world, which in the last few decades, and especially in the last few years, has entered a very difficult and complex situation. Namely, the development of science, technology and industry in the past centuries followed its own course, which could be followed to some extent, but the impact on nature, food and life got out of control. Modern science teaches us - that work is a specific activity of man, through which he developed to his present form. By developing and strengthening health through conscious activities, man improves his basic function in society, that is, he works and creates material and cultural goods. It is time for man to return to nature in order for it to return to man.

The tasks that are set before all of us participants in the food production process are that the agricultural production practice must be sustainable from the economic, social and ecological aspects. Maintaining active biodiversity in the soil and improving diversity in agro-eco systems are prerequisites for sustainable agriculture and the application of positive practices.

2. CHANGE OF CONSCIOUSNESS AND RESPONSIBILITY

As in any process, everything starts with a change in consciousness that leads to a different perception of the problem and finding solutions that are accessible and applicable to everyone. The awareness that all beings are interconnected and interdependent through the ecosystem is the starting point towards a food production system in harmony with nature. [1].

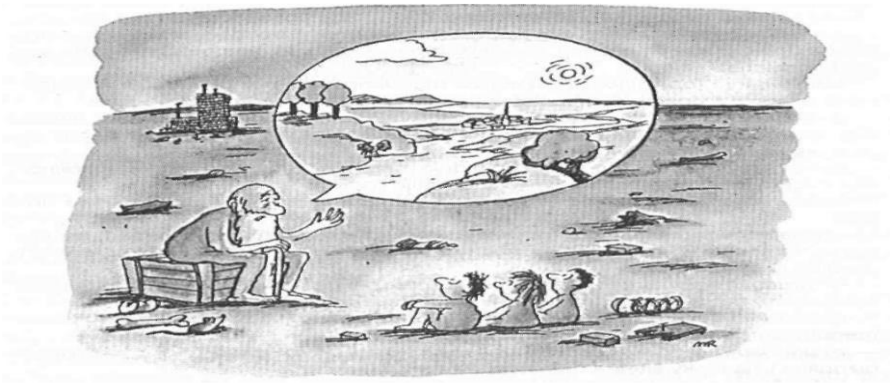


Figure 1. Will this caricature soon become our reality or will the concept of sustainable development come to life? Environmental damage knows no borders, EU leaflet, 1991.

Care about the modern world, which in the last few decades, and especially in the last few years, has entered a very difficult and complex situation. Namely, the development of science, technology and industry in the past centuries followed its own course, which could be followed to some extent, but the impact on nature, food and life got out of control. Modern science teaches us - that work is a specific activity of man, through which he developed to his present form. By developing and strengthening health through conscious activities, man improves his basic function in society, that is, he works and creates material and cultural goods. It is time for man to return to nature in order for it to return to man.

Man is dependent on nature in every sense, nature is our home, which feeds us and gives us what we need and that we should respect that. This sounds logical, but it is very far from our way of life. In order to respect and live with nature, we need radical changes in our way of life, and above all, a change in consciousness. The world is thinking about it, why shouldn't we.

The European strategies for food production are divided into several tracks and scheduled for implementation by 2030: [2]

1. Field-to-table strategy
2. Strategy for the return of progeny to our environment.
3. The green agenda, which includes the protection of land as a non-renewable resource.
4. The existing intensive agricultural production is unsustainable in many ways and requires new approaches and new solutions. [4]

- stimulate farmers to produce certified organic food,
- overcoming the consequences of climate change,
- reduce excessive energy costs in agriculture,
- renewable agriculture,
- the EU imperative is to reduce the use of pesticides by 50% by 2030,
- reduce the use of chemical nutrients/artificial fertilizers/ in agriculture,
- introduce cover crop technology for the benefit of the ecosystem,
- enable the availability of nitrogen to plant crops with an ecological approach and reduce the carbon footprint.

Our response to the set goals-tasks is reflected in the effort to offer MINERAL *forte* PLUS 100% natural on a larger scale as a tool that without false modesty solves many problems in agricultural production, which is confirmed by current practice. We realized that as a company we are on the right track.

We are followers of new technology, but processing with the help of knowledge and expertise what nature has in various forms, natural minerals. We grind three types of minerals with machines to a micronized form. Such a product supports the physiology of plants, we do not change the plants, we only follow their needs. They repay us with healthy fruits that, with proper processing, can be made into various forms. But it all has the expected smell and taste. We don't need chemical additives for flavor and color.

And that's where we come to the basic premise of this work, which is how to move towards the path of food production that is in harmony with nature and what is needed to achieve that goal, how to use the natural resources and elements that we have in nature and that are within our reach hands. The goal is to provide producers, and therefore future customers, with a healthy product, and this

[4] With the recent adoption of the EU strategy "From field to table", ecologically produced food is gaining more and more importance. It is a package of 27 legal proposals and policies that will change the ways in which food is produced and consumed in Europe in the next ten years. The strategy predicts that by 2030, the use of pesticides and antibiotics in agriculture will be reduced by 50%, and artificial fertilizers by 20%.

can be achieved by using the preparation MINERAL *forte* PLUS, which will still preserve the most valuable thing of all that we have, in addition to the environment, our health. We are aware of that, or at least we are becoming more and more aware, one cannot do without the other and that is why

WE DO NOT CHANGE THE LAWS OF NATURE BUT SUPPORT THE PROPER NUTRITION AND PHYSIOLOGY OF PLANTS

The connection of an unpolluted environment, unsprayed food and healthy animals with our health is inextricable. It is important that we always keep this in mind and that we choose the highest quality food of controlled production for ourselves and our family.

Organic agriculture, as defined by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization, is a production management system that promotes healthy ecosystems including natural diversity, biological cycles and emphasizes the use of methods that largely exclude the use of off-farm inputs [3] . Organic farming is often associated with the concept of sustainable agricultural development. According to Cvijanović [4], the central place in the concept of sustainable development belongs to natural resources and agriculture, considering that there is no sustainable development without rational use of resources in food production.

3. HOW DO WE BECOME HEALTHIER WITH ORGANIC FOOD?

Numerous scientific studies over the years have shown that organically grown food has great nutritional value. On average, the presence of minerals, iron is higher by 21%, magnesium by up to 29%. Vitamin C has more than 27%. This series does not end there. If you drink organic milk or eat organic cheese, you will get as much as 50% more omega 3 fatty acids than there are in industrially produced milk.

Organic food also does not contain genetically modified ingredients, which are produced in laboratory conditions, with the aim of increasing the resistance of plants.
There are 3 most important reasons why organic food is healthier:

1. Zero tolerance to pesticides.
2. Does not contain antibiotics and synthetic hormones.
3. More antioxidants in products that have not been treated.

Organic agriculture is growing more and more, while simultaneously meeting the demands of society, such as sustainable development, biodiversity, food quality, etc. [5]. Organic agriculture also has other functions such as ensuring food safety, protecting the environment, preserving non-renewable resources and harmonizing agricultural production with market demands [6]. The principles of organic agriculture are [7]:

- preservation of long-term soil fertility,
- nitrogen self-sufficiency through the use of legumes and biological fixation, as well as efficient recycling of organic materials,
- protection is largely based on crop rotation, natural predators, diversity, fertilization, resistant varieties and a limited level of thermal, biological and chemical interventions,
- extensive livestock management, behavior and animal welfare issues, with an emphasis on nutrition, housing, health, and care,
- paying attention to the impact of the agricultural production system on the environment and biodiversity protection.

If organic agriculture is viewed from the point of view of society, and not exclusively from the point of view of farmers, it is in any case economically justified. This is reflected in the fact that it can produce positive effects such as [5], [6];

- impact on the agroecosystem,

- impact on employment in rural areas,
-ecological practices can also affect land that is not used for agricultural purposes, such as that used for hunting or tourism.

Važno je napomenuti da uprkos prednostima organskih proizvoda, potrošači treba da imaju na umu da nisu svi organski proizvodi stvoreni jednaki i da različite zemlje imaju različite standarde za organsku proizvodnju.
Therefore, reading declarations, buying from verified producers and farmers and eating a varied and balanced diet are key aspects of maintaining a healthy diet.

Today it is clear that nutrition is one of the most important factors for human health. The fight for healthy food and healthy production has a wide social and environmental impact. Here are some key factors and challenges in that fight [8]:

1. Consumer Empowerment: Educating consumers about the benefits of healthy food and organic products is key to driving demand. Informed consumers often choose products that are produced using sustainable methods and without the use of synthetic chemicals. Educating consumers about the nutritional benefits of healthy foods can contribute to their health.
2. Availability of healthy options: One of the challenges is to ensure that healthy food and controlled products are available to more people. Sometimes these products are more expensive, which can make access difficult for certain sections of society.
3. Supporting local producers: Supporting local organic farmers can improve the availability of healthy food at the local level. Fostering local markets and communities that support farmers can help develop a sustainable supply chain.
4. Regulation and standards: In some cases, improving regulations and setting high standards for organic production can increase consumer confidence in such products. Clear regulations also contribute to ensuring the quality and integrity of organic food.
5. Education of producers: Farmers should be educated about the benefits of organic production and sustainable agricultural practices. Proper training can help farmers to switch to ecological methods and manage their farm effectively.
6. Sustainability and environmental awareness: Promoting sustainability and environmental awareness in agriculture is important for the long-term success of the fight for healthy food. Understanding the environmental impact of conventional farming practices can encourage a shift to more sustainable methods.
7. Encouraging political support: Politics plays a key role in supporting controlled production. It is necessary to encourage policy measures for sustainable agriculture, promote local markets and ensure the availability of healthy food.
8. Fight for food inequality: The fight for healthy food also includes the fight against social inequalities.

The joint efforts of consumers, producers, governments, non-governmental organizations and industry can contribute to achieving the goals of healthy food and organic production at the global level.

4. "LIVING AGRICULTURE" IN SERBIA

4.1. THE STATE OF AGRICULTURE IN SERBIA

The availability of agricultural land gives Serbia a comparative advantage for the development of agriculture in the direction of cleaner production of high-quality food. However, despite the strong natural potential, the development of controlled and organic agriculture in Serbia has been relatively slow until now.

All the resources that are included in the production system protect, above all, the land as one of the greatest assets, especially in Vojvodina. Organic methods of production with the use of compost and manure preserve the natural fertility of our arable land [9].

Measures to support agriculture can have a positive effect on the further growth and development of organic production, however, the incentives allocated within the measures for the implementation of agrarian policy vary greatly from year to year, which significantly discourages producers from turning more seriously to ecologically acceptable food production systems [9].

Figure 2. Soil pollution and overall degradation of its fertility is one of the most serious problems today [8].

Today, the profession of an agriculturist is completely devalued and is considered a lower type of knowledge. This attitude also reflects the situation in the agricultural sector in Serbia. The average age of farmers in Serbia is over 55, young farmers are a statistical error. The number of agricultural farms is decreasing dramatically from year to year. Less than 1% of the total agricultural land in Serbia is under organic production. The level of organic matter on most agricultural land is less than 3%, which means that the soil is almost dead. Most of the land is at risk of erosion, i.e. loss of the surface soil layer.

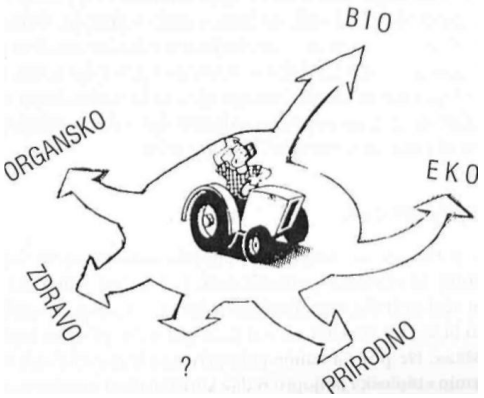


Figure 3. Confusion about the names *sc* denotes organic agriculture, for producers and consumers, is the first step of misunderstanding [8].

The term "organic agriculture" is sometimes used in combination with the term "biological agriculture", so we often come across the combined name "organic - biological agriculture". With this, they really want to emphasize as much as possible that agriculture is the one that respects

living beings and that is why in production it prefers to use living, organic rather than non-living, inorganic substances.
In short, by the name biological or organic agriculture we mean that "LIVING AGRICULTURE"

Organic agriculture in Serbia has seen a certain growth in recent years, with the increased interest of farmers and consumers in a sustainable and ecological approach to agriculture. Some of the key aspects of organic agriculture in Serbia include [10]:

1. Increase in the area under organic crops: The number of farms engaged in organic agriculture and the area under organic crops recorded a gradual increase.
2. Incentives and support: The Government of Serbia provides certain incentives and subsidies to farmers engaged in organic farming in order to support the sustainable development of this sector.
3. Certification: Organic products in Serbia often go through the certification process, which guarantees that the products are grown in accordance with the standards of organic agriculture.
4. Consumer interest: There is a growing consumer interest in organic products, which has contributed to an increase in the supply of organic products on the market.
5. Education and awareness: There are activities aimed at educating farmers about organic practices, as well as raising consumer awareness about the benefits of organic products.

Agroecology deals with these difficult and demanding issues. Various organizations and initiatives around the world are trying to put agroecology on the agenda of decision makers. FAO, the Food and Agriculture Organization of the United Nations, has recognized agroecology as a science-based system that has the potential to transform our food production systems to be far healthier and more sustainable than they are today.

4.2. HOW TO START THE TRANSITION FROM CONVENTIONAL TO AGRO-ECOLOGICAL PRODUCTION?

There is no one solution and one conclusion as to what should be done in order for agriculture and food production to be in accordance with the values and principles of agroecology because it is a multi-dimensional long-term process.

From the perspective of the small man, it starts from a change of consciousness and networking of small producers and consumers for the realization of common interests. This is something that has already taken root on the Small Food Producers in Serbia platform. Thousands of consumers and producers across Serbia, relatively speaking, united in the fight to preserve quality, traditional food from the countryside. The next step can be motivating producers to switch from conventional methods to agro-ecological production methods, and on the other hand, with an adequate connection with consumers who are ready to support and cooperate, through an agreement on the long-term purchase of their products. products. In this way, the producer secures the market, the customer knows from whom and what he buys. Such economic models in agroecological practices are called "community-supported agriculture", and they are primarily based on mutual trust. When such a model is formed and becomes functional in practice in some environment, the story can be further spread and such partnerships can be created in any local environment.

A conscious consumer should think about what he eats, how that food was produced and who are the people who produced his food. The producer should think about how to preserve and improve the health and quality of the ecosystem, by increasing the quality of the soil and the conditions in which the animals live, because healthy soil and animals imply healthy food and ultimately healthy people. The most important thing is understanding that we need each other, support and cooperation based on trust are the basic elements to change anything for the better. Through nature, we are all

connected and interdependent, and only together can we unlock and initiate processes that will preserve nature for us and future generations.

5. MORE THAN ORGANIC FARMING AND HEALTHY FOOD

Organic production is a system of sustainable agriculture based on high respect for ecological principles through rational use of natural resources, use of renewable energy sources, preservation of natural diversity and environmental protection. Organic production methods involve the use of natural processes and substances, and limit or completely eliminate the use of synthesized agents. [11].

Unlike conventional, organic production is based on the biological balance of the soil-plant-animal-human system. Therefore, the health of people and other living things, the agro-ecological system and natural cycles in nature are protected. Organic production is a system of sustainable agriculture based on high respect for ecological principles through rational use of natural resources, use of renewable energy sources, preservation of natural diversity and environmental protection. Organic production methods imply the application of natural processes and substances, and limit or completely eliminate the use of synthetic agents [12].

But it is a long way from recognition on paper to the implementation of our product in practice. Working in the field with farmers is a demanding process because it is difficult to discard acquired habits and knowledge in favor of something new.

5.1. PRODUCE "FOOD FOR THE SOUL" WITH ORGANIC PREPARATIONS

The " AZARTREDE " company and its employees are not only a "practical system of knowledge about food production in accordance with nature" but, above all, they are a value system that tries to create connections and relationships between producers and consumers, between producers and ecosystems and ecosystems and consumers, between institutions and civil society. It's all part of a puzzle where, if one piece is missing, the system is out of balance, doesn't work as it should, and threatens to slowly collapse. The main task is to try to look at the food production system from a holistic perspective. And the human spirit is also part of the puzzle, a spice that completes and makes the dish better. In addition to the environmental and climate crisis, we live in a time of spiritual crisis. Traditional values that held society and families are slowly being lost, new values are leading to individualism, in which the sense of community and collective good is slowly dissolving. And nature is a collective good that should serve all beings. All our products are made respecting all of the above in constant coordination with farmers, a direct and irreplaceable factor in our mission.

6. MINERAL *forte* PLUS

Human presence is necessary regardless of all the artificial intelligence that is offered, we must have young and educated people who will share the acquired experience in agricultural production with direct producers and control their work in the field. Our cooperation with such organized people is the right approach that leads to the goal, the production of healthy and controlled plant and animal food.

The **Mineral *forte* Plus** product is of natural origin. It is produced in the form of a powder and dissolves in water in a few seconds. It is soluble because it is composed of properly selected minerals, calcium Ca, magnesium Mg and boron B are declared. Fine grinding is achieved through a high-tech processing process. It is a means for supplementing plants and improving the soil - it regulates the acidity of the soil.

Mineral *forte* Plus applied foliarly or through the root system nourishes the plant and enables a wide range of positive effects. Intended for conventional and organic production, it meets the certification requirements for the production of organically healthy food**.**

Mineral *forte* Plus can be mixed with all protective agents. It is non-toxic to humans, animals and insects. The preparation changes the energy composition of the plant, accelerates the creation of organic matter, increases the natural resistance of plants.

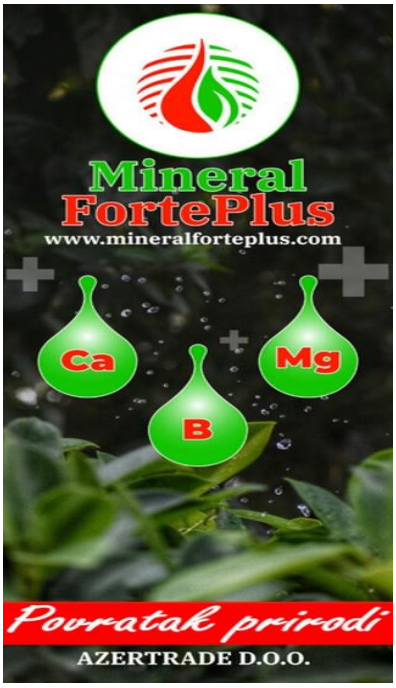


Figure 4. Mineral forte Plus, plant feed and soil improver [13].

Table 1. Name and content of the nutrient [14].

Nutrient matter	Content
Calcium oxide (CaO)	**50 %** / - 3%
Magnesium oxide (MgO)	**12 %** / - 3%
Bor	1%

Physical properties: powder, white-gray color, odorless
Granulometric composition: Particles of 1 mm min 98%, Particles of 0.25 mm min 80%
Recommended quantities: 3-4 kg/ha depending on the type of soil and culture, dissolved 0.2-0.5%
Storage method: Store in original packaging in dry storage rooms

In order to fully understand the role of this agent in agriculture and its effect on plants, we must refer to plant physiology. Green plants have the ability to, with the help of chlorophyll, synthesize organic matter from carbon dioxide, water, light and solar energy by assimilation. The word photosynthesis means combining by means of light. Life on Earth would be endangered without this process.

The most important process that occurs in the photosynthetic reaction (this is the second part of the process) does not require the presence of light and takes place in chloroplasts. We need to understand this cycle to understand the importance of adding calcium from our product. Here, one oxygen atom is removed from the carbon dioxide (CO_2) molecule, and then the carbon (C), hydrogen (H) and oxygen (O) atoms combine to form the organic molecule CH_2O. Carbohydrate molecules, monosaccharides, disaccharides or polysaccharides, are formed by linking several of these molecules together. The first carbohydrate formed is glyceraldehyde-3 phosphate, which contains 3 carbon atoms. This means that for the synthesis of one molecule of carbohydrates, the cycle must turn three times and fix three molecules of CO_2.

Glucose is therefore very rich in energy. Plants use it as fuel for their growth, but also for the production of starch (it is an energy store) and cellulose. Throughout the process, the importance of carbon dioxide is constantly emphasized. The reason for this is that increasing the concentration of carbon dioxide (up to the optimal limit) accelerates photosynthesis, and thus increases organic matter.
Carbon dioxide appears in the air in a concentration of (about) 0.03% (it usually varies because it is heavier than air), which is insufficient for normal photosynthesis and metabolism. We make up for it by foliar application of our preparation.
By applying the dissolved Mineral forte Plus powder to the leaves of the plant, we manage to increase the amount of CO2 and thereby have a positive effect on all the described processes [13].

The preparation dissolved in water creates a very fine film with extremely small particles on the surface of the leaf and begins to penetrate through the stomata into the interior of the leaf. Once inside the leaf, calcium carbonate is dislocated due to the large contact surface of the micronized calcite. This creates two decomposition products: carbon dioxide and calcium oxide. Because calcite dissociation is easy, carbon dioxide is constantly available to plants through the leaves.

This process is important during high heat, which saves water through reduced transpiration.
In these processes, free calcium is a good barrier for plant stress, whether it is pathogen attack or environmental conditions. The plant closes its openings because it has a sufficient amount of carbon dioxide necessary for photosynthesis.

The element BOR is part of the composition of organic compounds, it plays an important role in the process of pollen germination, biosynthesis of phosphorus compounds, sugar translocation from leaf to fruit.
Magnesium affects numerous processes, the intensity of photosynthesis and dry matter. Any deficit is solved by applying Mineral *forte* Plus.

Summarizing the effect of Mineral forte Plus, it can be concluded that it is applied to all plant species through the leaves in a concentration of 0.3-0.5%. It increases the organic matter and thus the yield, strengthens the immunity of plants, if necessary accelerates the vegetation of plants, reduces the need for water in the dry period, is completely non-toxic and suitable for the production of healthy food and ecologically preserves the environment..

The preparation represents a combination of high technology and nature, enabling plants to: [13].

1. Bioregulation
2. They feed the plant
3. They increase immunity
4. They improve the quality of cultivated plants

Benefits for users, producers of organic food are presented by: [13].

1. Increase in yield
2. Improvement of land

3. The possibility of reducing expensive means for feeding and protection, proper nutrition is half the protection!!!

Accordingly, the preparation will help plants to produce fruits of high nutritional and biological value without chemical treatments. Mineral *forte* Plus is the base product for several products in a series produced by the company AZERTRADE and present on our market. It is used outdoors and in closed systems.

The preparation is a natural biostimulator and is used under regular circumstances in all phenophases of plants.
It is especially recommended for SOS use - after mechanical damage to plants in the phase before flowering because it quickly restores the herbaceous stem and leaf mass.

Many years of experience show the exceptional resistance of the treated plants to temperature stress, the durability of the leaf mass in conventional chemical treatments.
The presence of micronized particles improves physiological effects: [14]

- Improved photosynthetic activity of the plant even in unfavorable circumstances.
- Accelerated metabolic activity reflected in increased protein synthesis.
- Increased amount of polyphenols

Effects and benefits after using Mineral Forte Plus:

- More intensive growth and development of plants.
- Resistance of plants to stress caused by lack of water.
- Increased fruit resistance during ripening,
- Increased yield of crops per unit area.
- The amount of FIRST class fruits increases considerably - /12-15%/
- The need to use protective equipment is reduced.
- The harmful effect of the used chemical preparations is neutralized, the withdrawal period in the fruit of the plants is shortened.
- Micronized calcium from the preparation also acts protectively on the fruit.
- Reduces soil acidity and creates an environment in which:
  *microorganisms cannot be active.
  *plants easily absorb microelements from the soil.

Special benefits are manifested in plants where an increased presence of BOR and MAGNESIUM is required - better flowering, greater presence of sugar in the tubers of sugar beet and potatoes because the use of useful energy by the plant during photosynthesis is reduced

- The presence of this preparation enables preservation of moisture near the root system.
- The presence enables better utilization of nitrogen, N which is already in the immediate vicinity of the root system and reduces the need for additional N (nitrogen).

The principle of fairness in the context of organic agriculture refers to the creation of honest and fair relations towards the wider social environment, nature and life as a whole. Mineral forte Plus is a preparation that tries to bring the context of fairness back into the framework of a healthy life. Analyzes performed in authorized laboratories gave a recommendation for permission to be included in the list of funds of the Ministry of Agriculture as a preparation/means allowed for organic production [15].

7. CONCLUSION

"Whoever is the father of a disease, improper diet is its mother"

Džordž Herbert

Believe it or not, this was said in the 16th century. We put our health at the service of corporate profits, the chemical industry in the broadest sense, the one that "supports" small and large food producers, processes their plant and animal products, adding a sea of additives, emulsifiers, artificial colors and now also the production of meat from plant proteins. we are already building a factory that will do it, but unfortunately it doesn't end there either, completely chemically produced meat, "printed meat" for 98% of the planet's inhabitants. Of course, we are all here, you who work in a chain of state institutions or you are a scientist and expert who will be very happy to participate in the quasi-success of high technology. How is it possible ?

Let's all ask ourselves if this is normal, ethical, healthy, deeply human, then who are we?
Let's start from thinking, are we interested in their profits or the crumbs of something that will fall from that table? Is it worth being in that company? Will you feed it to your children and grandchildren? We are only people who have our own life on this planet, we inherited it from our ancestors and we should leave it to our descendants. At this moment, let everyone think of someone they love who is five, ten years old...
What do we feel? Shame, anger, helplessness or are we resigned to reality?

We as a company and all our associates perceive the situation as the last alarm to start changing things. It's not impossible, just that each of us should think about what to do or not to do in the context of this story and we started an avalanche.
Let's remember our childhood, how much we had and what we ate, how we rejoiced when there was the smell of homemade bread at grandma's house, when vegetables were being picked and lunch was being prepared, we reached out and picked a fruit and ate it without washing it. She was not ideal, a little lumpy, but healthy. That happiness was real. Are we happier now when they sell us ideal fruits and vegetables, beautiful on the outside, but without taste or smell?

Let us, the consumers, be the ones who set the standards and requirements, impose our needs and desires on the producers. Let's not let them keep offering us their technological products. Let's get back to ourselves. Let's take action and produce the little food we need to live a healthy life, without supplements and medicines, in harmony with the nature that surrounds us. Let's let the people who struggle to come up with this idea and produce that food, make money, and let us eat what supports our bodies to function according to the same nature that we selfishly kill.
Let's raise those who produce our food to a higher level.
The goal of growing plants and animals is precisely a rounded cycle that we need to manage in accordance with reason.

Organized agriculture uses appropriate biological and chemical materials to produce unpolluted food in an ecologically justifiable and economically beneficial way - sustainable agriculture in which ecology and economy are reconciled.

Let's be free people and not slaves to our positions and high salaries, freedom is taken for granted but still chosen. Every normal person, who as a good host takes care of his house, family, household, offspring, future, will accept healthy food as taking care of his health and our planet.
The awareness that man is a part of Nature, something that is above everything and all of us, has existed since ancient times.
Man's attitude is inconsistent with awareness of this. As he "conquered" nature more and more, he behaved less and less in accordance with the respect for its sublimity. Reciprocally to that behavior, a retrograde attitude towards people's health is established. The increasing use of chemistry as a justification for "preventing" hunger on the planet has not solved that problem. We are witnessing dying of hunger in African countries as well as in megalopolises. An even more tragic consequence of such behavior is the increasing contamination of the soil with chemicals, which again creates the need for new chemicals that will "defeat" the bad condition. That cycle must be broken to reconnect with nature. A great resistance to this is provided by those who created this situation.

It is up to us who are aware of the situation to work on it and take from the realm of nature what is offered as the possibility of healing the land, water, air and food we produce for ourselves and the animal species we have. cruelly torn from nature.
One of the sure ways is to use minerals that come from the Earth's crust to stimulate and protect the plants and clean the soil from the presence of added chemicals.

Agriculture is essentially one big business with the goal of finding a person anywhere on the planet at a table with a plate of food. From the basic necessity of life, a situation has arisen, on one side are food producers, and on the other are consumers. We have conflicting interests, the producer's goal is profit, and the goal of all our users (we are the majority) is health through a balanced diet.

"AZARTRADE" is a company that follows new technology, but in a way that we use knowledge and expertise to process what nature has in different forms, NATURAL MINERALS. By grinding the three types of minerals to a micronized form, we make a product that supports the nature of the plants, we do not change the plants, we just follow their needs. They reward us with healthy fruits, which again with knowledge we can bring into various forms, and all of them have the expected smell and taste. We don't need chemical additives for flavor, color. For us, plants are not a labyrinth - we know where and how Mineral forte Plus should work.
Food production in harmony with nature is our mission!!!

"WE DO NOT CHANGE NATURAL LAWS BUT SUPPORT THE PROPER NUTRITION AND PHYSIOLOGY OF PLANTS"

REFERENCES

[1] Znaor, D., (1996), Ecological agriculture, tomorrow's agriculture, Publishing house Globus, p. 26.
[2] https://smartkolektiv.org/evropski-zeleni-plan-eu-green-deal
[3] Sredojević, Z. Oljača, S., Kresović, B., (2017), Organic agricultural production – basics of business planning and analysis. University of Belgrade, Faculty of Agriculture, Zemun,
[4] Cvijanović, G., Dozet, G., Cvijanović, D., (2013), Management in organic plant production, Institute for Agricultural Economics, Belgrade,Bošković, J., Hojka, Z., Zečević, V., Prodanović, R., Vukić, M., (2016), Significant resources of sustainable agriculture and organic food production system in Serbia, Acta Agriculturae Serbica, Vol.21., No.41. p. 65-851.
[5] Lampkin, N. H., (1990), Organic farming, Farming Press, Ipswich,
[6] Cvijanović, D., Cvijanović, G., Subic, J., (2007), Ecological, Economicand Marketing Aspectsofthe Application of Biofertilisers in the Production of Organic Food, Chapterin book: Environmental Technologies, New Developments, pp. 5-40.
[7] Rade Biočanin, Saša Stepanov, Mirko Tešić, (2021), "Sustainable development and environmental protection", International University of Travnik, BiH
[8] Ugrenović V., (2017), New products of cereals and pseudocereals from organic production (No. III 46005) project of Integral and Interdisciplinary Research of the Ministry of Education, Science and Technological Development of the Republic of Serbia
[9] Radoja, L., (2020), Food production in harmony with nature, Belgrade: Draslar partner,
[10] Milić, V., Jarak, M., Mrkovački, N., Milošević, N., Govedarica, M., Đurić, S., Marinković, J. (2004), Application of microbiological fertilizers and testing of biological activity in order to protect the soil. Proceedings, Scientific Institute for Agriculture and Vegetables, Novi Sad, Serbia, Sv. 40, 153 - 169.
[11] Martinov, M., Konstantinović, M., (2002), Proper distribution of mineral nutrients, Review of agronomic knowledge, Novi Sad, No. 6, pp. 12-14
[12] https://www.mineralforte-plus.com

[13] https://www.azermineral.rs/mineral-forte-plus/
[14] Ministry of Agriculture and Environmental Protection of the Republic of Serbia 321-01-00453/2022-11 - Register of funds for plant nutrition and land improvers, List of funds for organic production in 2022.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

METHANE MITIGATION STRATEIGIES IN RUMINANTS

STRATEGIJE UBLAŽAVANJA METANA KOD PREŽIVARA

Muhittin Tutkun, Assoc. Prof. Dr.[1]

Abstract: *The aim of this review was to analyze the published data on practices that reduce methane (CH_4) emissions from ruminants. Methane is the main greenhouse gas (GHG) emitted by ruminants. Reduction strategies are needed to reduce this negative impact on the environment while maintaining ruminant productivity and health. Strategies to reduce CH_4 emissions in ruminants are considered in the context of rumen ecology, biochemistry and animal performance. The study focuses on defaunation and inhibition of archaea, bacteriocins, methane inhibitors and analogs, probiotics, saponins, tanins, ionophores, organic acids and lipids. Defaunation or elimination of protozoa to reduce CH_4 emissions as a function of diet. The reduction of CH_4 emissions by rumen microbes can be achieved by using different chemicals.*
In conclusion, further research is needed to provide effective and efficient solutions to reduce methane production in ruminants worldwide and thus make a positive contribution to climate change.

Key words: *Ruminants, methane, Greenhose gas, ruminal microorganism*

Apstrakt: *Cilj ovog pregleda bio je da se analiziraju objavljeni podaci o praksama koje smanjuju emisiju metana (CH_4) od preživara. Metan je glavni gas staklene bašte (GHG) koji emituju preživari. Potrebne su strategije smanjenja kako bi se smanjio ovaj negativan uticaj na životnu sredinu uz održavanje produktivnosti i zdravlja preživara. Strategije za smanjenje emisije CH_4 kod preživara razmatraju se u kontekstu ekologije buraga, biohemije i performansi životinja. Studija se fokusira na defaunaciju i inhibiciju arheja, bakteriocina, inhibitora i analoga metana, probiotika, saponina, tanina, jonofora, organskih kiselina i lipida. Defaunacija ili eliminacija protozoa da bi se smanjile emisije CH_4 kao funkcija ishrane. Smanjenje emisije CH_4 mikroba buraga može se postići upotrebom različitih hemikalija.*
U zaključku, potrebna su dalja istraživanja kako bi se obezbedila efikasna i efikasna rešenja za smanjenje proizvodnje metana kod preživara širom sveta i na taj način dala pozitivan doprinos klimatskim promenama.

Ključne reči: *preživari, metan, gas staklenika, mikroorganizam u preživaju*

1. INTRODUCTION

As an important sector in livestock systems, ruminants have great significances for humans, as they can convert the energy stored in plant biomass polymers that are indigestible for humans, to digestible food products in the form of milk and meat [1]. The global demand for beef and dairy milk has increased rapidly in recent decades, and is estimated to continue increasing in upcoming decades due to human population expansion and improved living standards [2, 3, 4]. However, these animals always emit methane, which is a highly potent greenhouse gas with nearly 25 times greater warming potential than carbon dioxide (CO_2) [5]. Methane emission from ruminants contributes to nearly 16% of the global greenhouse gas emissions, as well as 33% of global anthropogenic methane emissions [6].

[1] Dicle University, Faculty of Agriculture, Department of Animal Science, Diyarbakır, 21280, Türkiye, e-mail: muhittin.tutkun@dicle.edu.tr

Together with carbon dioxide (CO_2) and nitrous oxide (N_2O), methane (CH_4) is one of the three most important greenhouse gases (GHG). The production of greenhouse gases from livestock and their impact on climate change is a major problem worldwide [7]. The contribution of these three gases to the various livestock activities was estimated using the life cycle assessment method. Enteric CH_4 is reported to be the most important greenhouse gas (50-60%) emitted in ruminant production systems at farm level [8]. Methane also represents a significant energy loss for the animal, ranging from 2% to 12% of gross energy (GE) ingested [9]. Therefore, reducing the production of CH_4 in the gut of ruminants without altering animal production is desirable both as a strategy to reduce global greenhouse gas emissions and as a means to improve feed conversion efficiency.

Methanogenesis (methane formation), in the rumen of ruminants as a result of anaerobic fermentation of nutrients The CO_2 and H_2 formed is released by the methanogenic bacteria.It is the process of reduction to methane (CH_4) [10-11].

The sustainability of methane suppression strategies is an important issue. There is an urgent need for supporting models capable of evaluating the effectiveness of both existing and new technologies to reduce methane emissions [12, 13]. Despite intensive research in this area, our understanding is far from complete. There are many reports showing different responses to feed additives such as ionophores, yeast products, fumaric acid, etc., and due to the complexity of the rumen system, it is very difficult to translate in vitro data to in vivo experiments [14, 15, 16]. However, such research is expensive and time-consuming.

In recent years, numerous reviews have been published on the various strategies to reduce enteric CH_4 production in ruminants, reflecting the importance and rapid development of knowledge in this area of research,

In this paper, an updated review of the proven and some potential mitigation options and their known mode of action was presented. The nutritional strategies that are most developed and can be applied in practise are presented in more detail and critically.

2. MITIGATION STRATEGIES

2.1. MITIGATION THROUGH FEED MANIPULATION

Changing feed composition remains the simplest and most cost-effective approach to reducing intestinal methane exposure [17, 18]. This strategy alone could reduce up to 70% of methane emissions from ruminants, depending on the method or type of dietary intervention [19, 20].

The predominant approach is to change the type or quality of forage or adjust the ratio of concentrates to forage. Younger plants that contain more fermentable carbohydrates, less non-digestible fiber (NDF) and a lower C:N ratio make high quality forage and provide higher digestibility and passage rate, which can direct rumen fermentation towards propionate [21, 22]. Since propionate also serves as an alternative H_2 sink, increased propionate production results in less H_2 being available for methanogenesis [23]. However, green fodder alone is not sufficient to increase animal performance, as concentrates are usually added to the feed in varying proportions, as they contain fewer cell walls and easily fermentable carbohydrates (starch and sugar) [24, 25]. It has been observed that CH_4 production decreases when 35% or 60% concentrates are added to the diet, while at the same time productivity increases [26]. Conversely, many groups have reported that high concentrations of concentrates can increase the concentration of lactic acid and volatile fatty acids (VFA) in the rumen, contributing to health disorders such as subacute ruminal acidosis (SARA) [27, 28].

2.2. MITIGATION THROUGH ADDITIVES

Generally, additives are added to the feed, consisting of either inorganic or organic compounds or probiotics fed directly. These additives either specifically inhibit methanogens or alter metabolic pathways, leading to a reduction in the substrate for methanogenesis [17, 29].

These additives employ different modes of action by changing the structure or the role of some key drivers of methane formation, acting as methane inhibitors, or as rumen fermentation modifiers. Some of the most popular additive inhibitors are 3-nitrooxypropanol (3-NOP) and red seaweed (*Asparagopsis taxiformis*). The rumen fermentation modifiers, on the other hand, lead to favorable changes in the rumen environment, improving animal productivity, animal health, and efficiency and increasing the availability of dietary protein for the animal by protecting the protein from microbes' utilization. These fermentative modifiers additives are composed of ionophores, tannins, and essential oils. Some of these inhibiting or modifying feed additives are commercially available, while others are still in the research stage

2.2.1. 3-nitrooxypropanol (3-NOP)

The methane inhibitor 3-Nitrooxypropanol (often referred to as 3-NOP, with the commercial name Bovaer) was developed by DSM, a giant Dutch corporation active in the fields of animal health and nutrition. 3-NOP has been approved for use as a feed additive in Europe and some Latin American countries such as Brazil and Chile but has not yet been approved by the U.S.
Food and Drug Administration. 3-NOP inhibits methane by acting similar to the enzyme responsible for the last step of methane synthesis in the rumen [30]. Different studies have shown an effective reduction of methane of 28%- 36% in dairy cattle as well as an increase in milk fat content of 0.19%, or 0.21 pounds per day by feeding animals around 123 g of 3-NOP per dayA 50% reduction in methane production was also seen in beef cattle [31].

2.2.2. Red Seaweed

Seaweeds are macroalgae and multicellular organisms that grow in marine and freshwater environments. Several species of seaweed have been suggested as an ingredient in the diet of ruminants, due to the digestibility, and the concentrations of secondary metabolites that achieve the mitigation of methane gas production. Red algae contain high concentrations of bromoform and the function of this is to prevent the binding between the vitamin B12 cofactor (necessary for methane formation) with an enzyme, causing the non-formation of methane. Several studies demonstrated the reduction of methane production per kg of dry matter intake of up to 55% in dairy cattle and around 98% in beef cattle. Consequently, in dairy cattle showed some residue of iodine and bromide concentrations in the milk and impacts on the animal health and performance [30].

The capability of seaweed to promote well-being and health in livestock is facilitated to a great extent by bioactive secondary metabolites that are synthesized by some seaweed species[32, 33]. Some of these secondary metabolites are responsible for antimethanogenic properties [34, 35] but often health benefits come from various other nutrients (e.g., minerals, protein, and unsaturated fatty acids contents; [36, 37]. Recent in vitro and *in vivo* studies suggest that the halogenated compound-containing red seaweeds *Asparagopsis taxiformis* and *Asparagopsis armata* have the potential to reduce CH_4 production when added to grass- and grain-based diets [38, 39, 40]. Red seaweed is effective in the short-term [41]. The long-term feeding efficacy of red seaweed is still unknown. When seaweed is added to cattle diets, the effects on diet palatability, animal health, and reproduction, as well as milk and meat quality are not consistent. Furthermore, seaweeds occasionally accumulate heavy metals, iodine and other minerals: feeding contaminant-laden seaweeds could have negative effects on animal and human health [42].

Other seaweeds contain CH_4 reducing potential due to alternative bioactives to bromoform such as tannins, polyphenols, or prebiotic oligosaccharides. Seaweeds like Alaria esculenta, *Ascophyllum nodosum*, and *Chondrus crispus* were reported previously to have a CH_4-reducing effect [43].

2.2.3. Ionophores

In 1975, the United States FDA approved ionophores as a cattle feed supplement [44].
Ionophores benefit animal metabolism by enhancing the efficiency of energy metabolism, improving ruminal nitrogen metabolism while reducing the risk of bloating and acidosis [45, 46]. Commercially available ionophores such as monensin (Rumensin), lasalocid (Bovatec), salinomycin (Bio-cox, Sacox), and laidlomycin (Cattlyst) are used widely across many countries including Australia, Argentina, Brazil, Canada, New Zealand, South Africa, and the United States. It is used to manipulate ruminal fermentation, improving feed efficiency as it has been reported to modulate the ratio of propionic to acetic acid production [47, 48], resulting in body weight gain [49]. In addition, there is also a pronounced reduction of proteolysis in the rumen, decreasing ammonia as a by-product while increasing the total flow of protein into the small intestine for absorption [50]. Ionophores have been found to decrease methane production up to a rate of 31%, *in vitro* and *in vivo* Ionophores supplementation produced a modest reduction of methane production of 2% in dairy cattle and 15% in beef cattle [30].

2.2.4. Tanins

Tannins are natural chemical substances that belong to the group of PSM and are produced by plants in their intermediate metabolism. Plant secondary metabolites play a role of protection from herbivores, pests and pathogens. Secondary metabolites prevent toxicity and act as precursors to physical defence systems [51].

They are present in different concentrations in some plant tissues, especially in the dicotyledons, and are an important component of many types of plants' defense systems. One of the most recognized function of the tannins is the ability to bind to and denature proteins, reducing protein breakdown in the rumen by microbes. Some tannins exhibit bactericidal activities: they can adhere to bacterial membranes, especially in methanogenic bacteria and generate morphological changes, nutritional deficiencies and reducing the bacteria's growth [30].

Direct ruminal intervention represents one possible approach for the control of ruminant CH_4 emissions [52]. Methanogens are a distinct group of organisms that form a normal component of the rumen microbial ecosystem [53]. Hydrogen (H_2) and CO_2 are the principal substrates used by rumen methanogens to produce CH_4; therefore, compounds that directly inhibit the activity of methanogens are likely to reduce or eliminate CH_4 production [54]. The action of CT against methanogenesis can be attributed to indirect effects such as reducing the H2 production (and presumably reduced forage digestibility) and to direct inhibitory effects on methanogens [53]. Tannins suppress methanogenesis by directly reducing methanogenic populations in the rumen or indirectly by reducing the protozoal population (thereby reducing symbiotically associated methanogens). In addition, they found that tannin sources containing both HT and CT were more potent in suppressing methanogenesis than those containing only HT [55].Tannins have shown the potential for reducing methane emissions by 13% to 16% in dairy cattle. Consequently, the excess of tannins in the diet can cause less consumption of feed, due to the difficulty for cattle to digest these tannins, impacting animal performance [56].

2.2.5. Essential oils

The well documented antimicrobial activity of essential oils has prompted interest in whether these bioactive compounds can be used to selectively inhibit rumen methanogenesis. A number of studies

have recently evaluated the ability of essential oils to reduce enteric CH_4 production. Most studies conducted have been in vitro and short term. Essential oils derived from thyme, oregano, cinnamon, garlic, horse radish, rhubarb and frangula have decreased CH_4 production *in vitro* in a dose dependent manner. However, inhibition of CH_4 production occurred at high doses (i.e., >300 mg/L of culture fluid) and was, in many cases, associated with a decrease in total volatile fatty acid concentrations and feed digestion. Some essential oils, such as garlic, cinnamon, rhubarb and frangula, may exert a direct effect on methanogens [57].

Essential oils, like tannins, are volatile aromatic secondary metabolites compounds produced by plants, especially herbs and spices. One of the principal functions of essential oils is antiseptic and antimicrobial activity. Different studies demonstrated that the use of essential oils could decrease intra-ruminal nitrogen turnover and nitrogen excretion, slow degradation of starch-rich substrates, and inhibit methanogenesis. Recent studies demonstrated a reduction of 11% to 20% of methane intensity (methane/productive output for the cow; methane production/kg of energy corrected milk) in dairy cows supplemented with an Agolin concentration of 1g/head/day[56].

3. MITIGATION THROUGH BIOTECHNOLOGIES

3.1. IMMUNISATION AND BIOLOGICAL CONTROL (BACTERIOPHAGE, ACETOGENESIS REDUCTIVE)

Several biotechnological strategies are currently being explored. A vaccine developed from a three-methanogen mixture produced a 7.7% reduction (kg^{-1} DM) in methane emissions from sheep despite only one antigen being effective against the methanogenic species in the sheep. The vaccine was much more effective than the seven methanogen mix tested previously and was able to increase saliva and plasma antibody titres by 4 – 9 folds over the seven methanogen mixture. Successful elevation of antibody titres in saliva and a significant reduction in methane emissions offers real potential for a widespread application to ruminants in all environments. At present vaccines do not have sufficient efficacy for commercial use and funding has recently been curtailed. Opportunities through rumen additives, defaunation and specific compounds targeting methanogens provide several routes for reducing methane production. However these agents have not addressed the inevitable production of hydrogen from fermentation of fibre [58].

A vaccine against three selected methanogens decreased CH_4 production by nearly 8% in Australian sheep. However, vaccines prepared with a different set of methanogen species or tested in other geographical regions did not elicit a positive response [59]. The highly diverse methanogenic community present in animals reared under different conditions [60] and the replacement of the ecological niche left by the targeted species by another methanogens[61] might account for immunisation failures.

Passive immunisation was also recently assayed using antibodies, which were produced in laying hens, against three common methanogens present in the digestive tract of animals. Treatments using whole eggs decreased transiently CH_4 production *in vitro* but the effect was lost at the end of the 24-h incubation [62]. Up to now, immunisation has not delivered a clear, positive answer in reducing CH_4 emissions by ruminants, highlighting the difficulties of this approach.

3.2. PROBIOTICS

Probiotics are microbial feed additives that influence rumen fermentation directly resulting in improved animal productivity. The most widely used probiotics are yeast and *Aspergillus oryzae*. Some available products guarantee high numbers of live yeast cells and are sold as live yeast while other products are sold as yeast cultures containing both yeast cells and the media on which they are

grown. Although not yet clear, it is assumed that yeast cultures reduce methane production in four ways: (1) by increasing butyrate or propionate production [63]; (2) by reducing protozoan numbers [64] ; (3) by promoting acetogenesis [65]; and (4) by improving animal productivity [66].

3.3. IMMUNIZATION

One possible future pathway to reduce CH_4 output is to immunize animals against their own methanogens and protozoa. It was demonstrated the reduction in the numbers of *Streptococcus bovis* in the presence of antiprotozoal antiserum [67]. Scientists in Australia have claimed to invoke an immune response to rumen protozoa by administering an immunogenic preparation [68]. This will indirectly affect the activity of rumen methanogens as they have a commensal relationship with rumen protozoa.

It may be possible to immunize ruminants against their own methanogens with associated decrease in methane output and that such an approach can successfully reduce the members of *streptococci* and *lactobacilli* in the rumen [69]. An alternative strategy to reduce ruminal methanogenesis would be to re-channel substrates for methane production into alternative products. Acetogenic bacteria in the hindgut of mammals and termites, produce acid by the reduction of carbondioxide with hydrogen and reductive acetogenesis acts as an important hydrogen sink in hindgut fermentation [70].

The addition of acetogens into normal ruminal fermentations has not increased acetate production, probably because acetogens have much lower affinities for hydrogen than methanogens. Thus, they are unable to compete for substrate when the methanogens are present. However, when combined with methane inhibitors, acetogens have been able to alter ruminal fermentations [71]. A new generation of designer inhibitors may be developed based on knowledge of the genome of rumen methanogens[72].

4. CONCLUSION

Cattle farming is the most important source of global methane emissions. As the demand for high-quality meat and dairy products increases, methane emissions and global temperatures are rising. Therefore, one of the most effective strategies to mitigate climate change is to curb methane emissions from ruminants. Domestic livestock production produces 80-115 million tons of methane per year. Significantly reducing greenhouse gas emissions is an important topic of biological, ecological and environmental research in the world. Due to the higher global warming potential of methane, it has been the subject of many studies in recent years. Feed manipulation remains the most cost-effective approach that can achieve a significant 60% reduction in methane emissions simply by carefully selecting the type or quality of feed and optimizing the ratio of concentrates to forage.

Chemical additives such as 3-NOP, ionophores and halogenated compounds have shown an extraordinary decrease in methanogenesis in the rumen in vitro and in vivo; either by stimulating the growth of microbes competing for the same substrate used by methanogens or as a direct inhibitor of methanogens.

Methane production in the rumen is the result of the biochemistry of feed fermentation by the microbial community in the rumen. Methanogens are the direct producers of methane in the rumen, but other microorganisms such as ciliated protozoa, bacteria and fungi also interact closely with methanogens, either physically or functionally. A comprehensive understanding of the micro-ecosystem, such as the functional microorganisms or genes detected in the low and high methane producing animals, may allow more targeted manipulation for methane reduction.

The reduction of methane consumption comes to the fore on the basis of studies on rumen metabolism. In order to better utilise the energy of the feed, there are also studies on the reducing effect of some alternative additives (yeasts, organic acids, herbal extracts and probiotics) on CH4 release. The studies show that although the additives and biotechnological approaches used in animal feed are promising, their areas of application are limited. Therefore, in vivo studies need to be expanded to increase the efficiency in this area. It is important to disseminate ration studies that can be used more safely than other methods to reduce and suppress methane emissions. Another important question that should be investigated is how and to what extent methane production is affected during the application of the methods by determining the economic analysis of the costs of effective feeding strategies that reduce methane emissions.

Effective feeding strategies to suppress methane emissions should be studied in detail and new strategies should be developed through large-scale projects and research at national and international level.

REFERENCES

[1] Kamra, D.N., Pawar, M., Singh, B. (2012). Effect of Plant Secondary Metabolites on Rumen Methanogens and Methane Emissions by Ruminants. Springer Netherlands, pp. 351–370.

[2] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., et al. (2013). Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities. Food and Agriculture Organization of the United Nations, pp. 280–286.

[3] Caro, D., Davis, S.J., Bastianoni, S., Caldeira, K. (2014). Global and regional trends in greenhouse gas emissions from livestock. Clim. Chang. 126, pp. 203–216.

[4] Patra, A.K. (2014). Trends and projected estimates of GHG emissions from indian livestock in comparisons with GHG emissions from world and developing countries. Asian Australas. J. Anim. Sci. 27, pp. 592–599.

[5] Zhou, Y.Y., Mao, H.L., Jiang, F., Wang, J.K., Liu, J.X., Mcsweeney, C.S. (2011). Inhibition of rumen methanogenesis by tea saponins with reference to fermentation pattern and microbial communities in Hu sheep. Anim. Feed Sci. Technol. 166-167, 93–100.

[6] Scheehle, E.A., Kruger, D. (2006). Global anthropogenic methane and nitrous oxide emissions. Ener. J. 27, pp. 33–44.

[7] Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., Haan, C. (2006). Livestock's role in climate change and air pollution. In Livestock's long shadow: environmental issues and options (ed. H Steinfeld, P Gerber, T Wassenaar, V Castel, M Rosales and C de Haan), pp. 79–123. Food and Agriculture Organization of the United Nations, Rome, Italy.

[8] Ogino, A., Orito, H., Shimadad, K., Hirooka, H. (2007). Evaluating environmental impacts of the Japanese beef cow– calf system by the life cycle assessment method. Animal Science Journal 78, pp. 424–432.

[9] Johnson, K.A., Johnson, D.E. (1995). Methane emissions from cattle. Journal of Animal Science 73, 2483–2492.

[10] Klieve, A.V., Hegarty, R.S. (1999). Opportunities of biological control of ruminant methanogenesis. Aust. J. Agric. Res. 50: 1315-1319.

[11] Görgülü, M., Kolumnan Darcan, N., Göncü, S. (2009). Hayvancılık ve küresel ısınma. V. Ulusal Hayvan Besleme Kongresi, 30 Eylül-3 Ekim, Çorlu,

[12] Sejian, V., Naqvi, S.M. (2012). Livestock and Climate Change: Mitigation Strategies to Reduce Methane Production. In: Greenhouse Gases - Capturing, Utilization and Reduction, Guoxiang Liu (Ed.), Chapter 11, pp. 255-276. InTech.

[13] Mihina, S., Kazimirova, V., Copland, T.A. (2012). Technology for farm animal husbandry. 1st Issue. Slovak Agricultural University, Nitra (Slovakia). P. 99.
[14] Moss, A.R. (1994). Methane production by ruminants, Literature review of I. Dietary manipulation to reduce methane production, and II. Laboratory procedures for estimating methane potential ofdiets. Nutr. Abstr. Rev. Ser. B64:786-806.
[15] McGinn, S.M., Beauchemin, K.A., Coates,T., Colombatto, D. (2004). Methane emissions from beef cattle: effects of monensin, sunflower oil, enzymes, yeast, and fumaric acid. J. Anim. Sci. 82, pp. 3346–3356.
[16] Shibata, M., Terada, F. (2010). Factors affecting methane production and mitigation in ruminants. Animal Science Journal.81, pp. 2–10.
[17] Haque, M.N. (2018). Dietary manipulation: a sustainable way to mitigate methane emissions from ruminants. J. Anim. Sci. Technol. 60, pp. 15.
[18] Kebreab, E., Strathe, A., Fadel, J., Moraes, L., France, J. (2010). Impact of dietary manipulation on nutrient flows and greenhouse gas emissions in cattle. R. Bras. Zootec. 39, pp. 458-464.
[19] Benchaar, C., Pomar, C., Chiquette, J. (2001). Evaluation of dietary strategies to reduce methane production in ruminants: a modelling approach. Can. J. Anim. Sci. 81, pp. 563-574.
[20] Mosier, A.R., Duxbury, J.M., Freney, J.R., Heinemeyer, O., Minami, K., Johnson, D.E. (1998). Mitigating agricultural emissions of methane. Clim. Change 40, pp. 39-80.
[21] Ball, D.M., Collins, M., Lacefield, G.D., Martin, N.P., Mertens, D.A., Olson, K.E., et al, pp. 1-21. Understanding forage quality. American Farm Bureau Federation Publication,
[22] Hills, J.L., Wales, W.J., Dunshea, F.R., Garcia, S.C., Roche, J.R. (2015). Invited review: an evaluation of the likely effects of individualized feeding of concentrate supplements to pasture-based dairy cows. J. Dairy Sci. 98, pp. 1363-1401.
[23] Beauchemin, K.A., McAllister, T.A., McGinn, S.M. (2009). Dietary mitigation of enteric methane from cattle. CAB Rev. Perspect. Agric. Vet. Sci. Nutr. Natur. Resour. 4: 1-8.
[24] Agle, M., Hristov, A.N., Zaman, S., Schneider, C., Ndegwa, P.M., Vaddella, V.K. (2010). Effect of dietary concentrate on rumen fermentation, digestibility, and nitrogen losses in dairy cows. J. Dairy Sci. 93, pp. 4211-4222.
[25] Jiao, H.P., Dale, A.J., Carson, A.F., Murray, S., Gordon, A.W., Ferris, C.P. (2014). Effect of concentrate feed level on methane emissions from grazing dairy cows. J. Dairy Sci. 97: pp. 7043-7053.
[26] McGuffey, R.K., Richardson, L.F., Wilkinson, J.I. (2001). Ionophores for dairy cattle: current status and future outlook. J. Dairy Sci. 84: pp. 194-203.
[27] Ogata T, Kim YH, Masaki T, Iwamoto E, Ohtani Y, Orihashi T, et al. (2019). Effects of an increased concentrate diet on rumen pH and the bacterial community in Japanese Black beef cattle at different fattening stages. J. Vet. Med. Sci. 81: pp. 968-974.
[28] Owens, F.N., Secrist, D.S., Hill, W.J., Gill, D.R. (1998). Acidosis in cattle: a review. J. Anim. Sci. 76, pp. 275-286.
[29] Halmemies-Beauchet-Filleau, A. Rinne, M., Lamminen, M., Mapato, C., Ampapon, T., Wanapat, M., et al. (2018). Alternative and novel feeds for ruminants: nutritive value, product quality and environmental aspects. Animal 12, pp. 295-309.
[30] Hristov, A.N. (2020). https://animalscience.psu.edu/news/correct-dosage-of-methane-inhibiting-additive-in-dairy- cow-feed-shown-in-study.
[31] Pfau, A. (2023). https://www.farmprogress.com/dairy-cattle/feed-additives-can-diminish-methane-in-dairy-cattle
[32] Abdul Khalil, H.P.S., Tye, Y.Y., Chow, S.T., Saurabh, C.K., Tahir, P. Md., Dungani, R., Syakir, M.I. (2016). Cellulosic pulp fiber as reinforcement materials in seaweed-based film. BioResources, 12. pp. 29-42.
[33] Corona, Y. Ji, P. Anegboonlap, S., Hotchkiss, C., Gill, Y., Yaqoob, J.P.E., Spencer, I.R. (2016). Gastrointestinal modifications and bioavailability of brown seaweed phlorotannins and effects on inflammatory markers Br J Nutr, 115. pp. 1240-1253.

[34] Abecia, L., Toral, P.G., Martin - Garcia, A.I., Martinez, G., Tomkins, N.W., Molina Alcaide, E., Newbold, C., Yanez-Rui, A. (2012). Effect of bromochloromethane on methane emission, rumen fermentation pattern, milk yield, and fatty acid profile in lactating dairy goats J Dairy Sci, 95, pp. 2027-2036.
[35] Roque, B.M., Brooke, C.G., Ladau, J., Polley, T., March, L.J., et al. (2019). Effect of the macroalgae *Asparagopsis taxiformis* on methane production and rumen microbiome assemblage Anim Microb, pp. 1-14.
[36] Anderson, M.J., Blanton, J.R., Gleghorn, J., Kim, S.W., Johnson, J.W. (2006). *Ascophyllum nodosum* supplementation strategies that improve overall carcass merit of implanted English crossbred cattle Asian-Aust J Anim Sci, 19. pp. 1514-1518.
[37] Cian, R.E., Fajardo, M.A., Alaiz, M., Vioque, V., Gonzalez, R.J., Drago,S.R. (2013). Chemical composition, nutritional and antioxidant properties of the red edible seaweed *Porphyra columbina* Int J Food Sci Nutr, 1, pp. 1-7.
[38] Roque, B.M., Salwen, J.K., Kinley, R., Kebreab, E. (2019). Inclusion of *Asparagopsis armata* in lactating dairy cow's diet reduces enteric methane emission by over 50 percent, J Clean Prod, 234, pp. 132-138.
[39] Kinley, R.D., Martinez-Fernandez, G., Mathews, M.K., Nys, R.D., Magnusson, M., Tomkins, N.W. (2020). Mitigating the carbon footprint and improving the productivity of ruminant livestock agriculture using red seaweed J Clean Prod, 259 (6), pp. 1-10.
[40] Min, B.R., Genovese, G., Castleberry, L., Lockard, C., Waldrip, H.M., Parker, D.B., Miller, D.N., Akbay, A., Morabito, M., Manghisi, A., Spagnuolo, D., Brauer, D. (2021). The potential role of two red seaweeds that promote anti-methanogenic activity and rumen fermentation profiles under laboratory conditions. *J Anim Sci.* (Suppl 2), pp. 328.
[41] Mitsumori, M., Shinkai, T., Takenaka, A., Enishi, O., Higuchi, K., Kobayashi, Y., Nonaka, I., Asanuma, N., Denman, S.E., McSweeney, C.S. (2012). Responses in digestion, rumen fermentation and microbial populations to inhibition of methane formation by a halogenated methane analogue. *Br J Nutr.*108: pp. 482–491.
[42] Makkar, H.P.S., Tran, G., Heuze, V., Giger-Reverdin, S., Lessire, M., Lebas, F., Ankers, P. (2016). Seaweeds for livestock diets: a review. *Anim Feed Sci Technol.* 212, pp. 1–17.
[43] Abbott, D. W., Aasen, I. M., Beauchemin, K. A., Grondahl, F., Gruninger, R., Hayes, M., Huws, S., Kenny, D. A., Krizsan, S. J., Kirwan, S. F., Lind, V., Meyer, U., Ramin, M., (2020). Theodoridou K., Von Soosten D., Walsh P. J., Waters S., Xing X., *Animals* 10, pp. 2432.
[44] Russell, J.B., Strobel, H. (1989). Effect of ionophores on ruminal fermentation. Appl. Environ. Microbiol. 55: pp. 1-6.
[45] Richardson LF, Raun AP, Potter EL, Cooley CO, Rathmacher RP. (1976). Effect of monensin on rumen fermentation in vitro and in vivo. J. Anim. Sci. 43: pp. 657-664.
[46] Bergen, W.G., Bates, D.B. (1984). Ionophores: their effect on production efficiency and mode of action. J. Anim. Sci. 58: pp. 1465-1483.
[47] Thivend, P., Jouany, J.P. (1983). Effect of lasalocid sodium on rumen fermentation and digestion in sheep. Reprod. Nutr. Dév. 23: pp. 817-828.
[48] Singh, G.P., Mohini, M. (1999). Effect of different levels of rumensin in diet on rumen fermentation, nutrient digestibility and methane production in cattle. Asian-Austral. J.Anim. Sci.12: pp. 1215-1221.
[49] Odongo, N.E., Bagg, R., Vessie, G., Dick, P., Or-Rashid, M.M., Hook, S.E., et al. (2007). Long-term effects of feeding monensin on methane production in lactating dairy cows. J. Dairy Sci. 90: pp. 1781-1788.
[50] Marques, R.D., Cooke, R.F., (2021). Effects of ionophores on ruminal function of beef cattle. Animals 11: pp. 2871.
[51] Bennett, R.N., Wallsgrove, R.M., (1994). Secondary metabolites in plant defence mechanisms New Phytologist, 127 (4) , pp. 617-633.
[52] Williams, C.M., Eun, J.S., Macadam, J.W., Young, A.J., Fellner, V., Min, B.R. (2011). Effects of forage legumes containing condensed tannins on methane and ammonia

production in continuous cultures of mixed ruminal microorganisms. Animal Feed Science and Technology, 166-167, 364-372.
[53] Tavendale, M.H., Meaghe,r L.P., Pacheco, D., Walker, N., Attwood, G.T., and Sıvakumaran, S. (2005). Methane production from in vitro rumen incubations with Lotus pedunculatus and Medicago sativa, and effects of extractable condensed tannins fractions on methanogenesis. Animal Feed Science and Technology, pp. 123–124, 403–419.
[54] Baker S.K. (1999). Rumen methanogens and inhibition of methanogenesis. Australian Journal of Agricultural Research, 50, pp. 1293–1298.
[55] Hatta, R., Uyeno, Y., T Ajıma, K., T Akenaka, A., Y Abumoto, Y., N Onaka, I., E Nıshı, O. Kurıhara, M. (2009). Difference in the nature of tannins on in vitro ruminal methane and volatile fatty acid production and on methanogenic archaea and protozoal populations. Journal of Dairy Science, 92, pp. 5512–5522.
[56] Pfau, A. (2023). https://www.farmprogress.com/dairy-cattle/feed-additives-can-diminish-methane-in-dairy-cattle
[57] Benchaar, C., Greathead, H. (2011). Essential oils and opportunities to mitigate enteric methane emissions from ruminants. Animal Feed Science and Technology, pp. 166-167
[58] Waghorn, G, Woodward, S (2006). Ruminant Contributions to Methane and Global Warming - A New Zealand Perspective. Climate Change and Managed Ecosystems, pp. 233.
[59] Wright, A.D., Kennedy, P., O'Neill, C.J., Toovey, A.F., Popovski, S., Rea, S.M., Pimm, C,L., and Klein, L. (2004). Reducing methane emissions in sheep by immunization against rumen methanogens. Vaccine 22, pp. 3976–3985.
[60] Wright, A.D., Auckland, C.H. and Lynn, D.H. (2007). Molecular diversity of methanogens in feedlot cattle from Ontario and Prince Edward Island, Canada. Applied and Environmental Microbiology 73, pp. 4206–4210.
[61] Williams, Y.J., Popovski, S., Rea, S.M., Skillman, L.C., Toovey, A.F., Northwood, K.S., and Wright, A.D. (2009). A vaccine against rumen methanogens can alter the composition of archaeal populations. Applied and Environmental Microbiology 75, pp. 1860–1866.
[62] Cook, S.R., Maiti, P.K., Chaves, A.V., Benchaar, C., Beauchemin, K.A. and McAllister, T.A. (2008). Avian (IgY) anti-methanogen antibodies for reducing ruminal methane production: in vitro assessment of their effects. Australian Journal of Experimental Agriculture 48, pp. 260–264.
[63] Lila, Z.A., Mohammed, N., Yasui, T., Kurokawa, Y., Kanda, S., Itabashi, H. (2004). Effects of a twin strain of *Saccharomyces cerevisiae* live cells on mixed ruminal microorganism fermentation in vitro. J Anim Sci 82, pp. 1847–1854.
[64] Newbold, C.I., McIntosh, F.M., Wallace, R.J. (1998). Changes in the microbial population of a rumen simulating fermenter in response to yeast culture. Can J Anim Sci 78:241–244,
[65] Chaucheyras, F., Fonty, G., Bertin, G., Gouet, P. (1995). In-vitro H_2 utilisation by a ruminal acetogenic bacterium cultivated alone or in association with an Archea methanogen is stimulated by a probiotic strain of *Saccharomyces cerevisiae*. Appl Environ Microbiol 61, pp. 3466–3467.
[66] Bruno, R.G.S., Rutigliano, H.M., Cerri, R.L.A., Robinson, P.H., Santos, J.E.P. (2005). Effect of feeding a *Saccharomyces Cerevisiae* yeast culture on lactation performance of dairy cows under heat stress in ruminant nutrition, feed additives and Feedstuffs. J Anim Sci 85: Proquest Biology Journals, pp. 310.
[67] Shu, Q., Gill, H.S., Hennessy, D.W., Leng, R.A., Bird, S.H., Rowe. J.B. (1999). Immunization against lactic acidosis in cattle. Res Vet Sci 67: pp. 65–71.
[68] Baker, S.K., Gnanasampanthan, G., Purser, D.B., Hoskinson, R.M. (1997). Immunogenic preparation and method for improving the productivity of ruminant animals. Patent application: international publication number WO 97/0086.
[69] Baker, S. (1999). Rumen methanogens, and inhibition of methanogenesis. Crop and Pasture Science 50:1293-1298. Clark H, Pinares-Patiño CS, de Klein CAM (2005) Methane and

nitrous oxide emissions from grazed grasslands In: McGilloway DA (ed) Grassland: A Global Resource. Wageningen Academic, Wageningen, the Netherlands, pp. 279-293.
[70] Gworgwor, Z., Mbahi, T., Yakubu, B. (2006). Environmental Implications of Methane Production by Ruminants: A review. Journal of Sustainable Development in Agriculture and Environment 2, pp. 1-14.
[71] Kung, L., Smith, K., Smagala, A., Endres, K., Bessett, C., Ranjit, N., Yaissle, J. (2003). Effects of 9, 10 anthraquinone on ruminal fermentation, total-tract digestion, and blood metabolite concentrations in sheep. Journal of animal science 81, pp. 323-328.
[72] Attwood, G., McSweeney, C. (2008). Methanogen genomics to discover targets for methane mitigation technologies and options for alternative H2 utilisation in the rumen. Animal Production Science 48, pp. 28-37.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

EFFECT OF INSECTICIDES ON VARIATION OF MAIZE STEM DAMAGE CAUSED BY FEEDING OF LARVAE *Ostrinia nubilalis* Hbn.

EFEKAT INSEKTICIDA NA VARIRANJE OŠTEĆENJA STABLA KUKURUZA IZAZVANOG ISHRANOM LARVI *Ostrinia nubilalis* Hbn.

Dragan Grčak, assistant[1]
Desimir Knežević, full professor [2]
Milosav Grčak, assistant[3]
Snežana Gošić Dondo, research associate [4]
Željko D. Popović, full professor [5]
Miroljub Aksić, full professor [6]
Ljiljana Andjušić, assistant professor [7]
Danijela Kondić, full professor [8]

Abstract: *European corn borer (Ostrinia nubilalis Hbn.) is a pest where the larval feeding injury disrupts nutrient flow within the plant, and causing significant losses of yield. An insecticide is used to suppress EBC larvae attacks and reduce plant damage. The aim of study was to determine variation of length of channals on plant stem in maize genotypes, caused by feeding of larvae corn borer, under application of insecticides. The experimental investigation was carried out in Maize Research Institute "Zemun Polje" on the field in 2019 vegetation season. For study used three maize genotypes, ZP 434, ZP 600 and ZP 666 and three insecticides chlorantraniliprole, bifenthrin and [lufenuron+(cypermethrin + chlorpyrifos], which were applied only after the maximum flight of the first generation to protect plants from attack of European corn borer. In analysis were established the significant differences between the maize genotypes according to total length of channels in the stem of plants, which caused by the feeding of larvae European corn borer. The smallest channel length in stem was found on treatment with insecticide chlorantranaliprole in two maize genotype ZP 600 (181.67 cm) and ZP 434 (186.67 cm) while on treatment with befentrin was the smallest length of channels in ZP 666 (218,33 cm). In all three maize genotypes on the control variant (without insecticide application) was the largest length of channels (ZP 434 -295.00 cm; ZP 600 - 316.67 cm and ZP 666 -311.67 cm). The determined differences for total length of the channels depended on genotype and type of insecticide applied.*

Key words: *maize, genotype, pest, insecticide, length of channels*

[1] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kosovo and Metohia, Serbia, e-mail: dragangrcak@gmail.com
[2] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kosovo and Metohia, Serbia, e-mail: deskoa@ptt.rs
[3] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kosovo and Metohia, Serbia, e-mail: milosavgrcak@gmail.com
[4] Maize Research Institute "Zemun Polje", Belgrade, Serbia, e-mail: sgosic@mrizp.rs
[5] University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia, e-mail: zeljko.popovic@dbe.uns.ac.rs
[6] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kosovo and Metohia, Serbia, e-mail: miroljub.aksic@pr.ac.rs
[7] University of Pristina temporary settled in Kosovska Mitrovica, Faculty of Agriculture, Lesak, Kosovo and Metohia, Serbia, e-mail: ljiljana.andjusic@pr.ac.rs
[8] University of Banja Luka, Faculty of Agriculture Banja Luka, Avenue Vojvode Petra Bojovića, 1A, 78000 Banja Luka, Republic of Srpska, Bosnia and Herzegovina, e-mail: danijela.kondic@agro.unibl.org

Apstrakt: *Kukuruzni plamenac (Ostrinia nubilalis Hbn.) je štetočina kukuruza i čija larva pri svojoj ishrani oštećuje tkiva biljnih organa, narušava protok hranljivih materija unutar biljke i uzrokuje značajne gubitke prinosa. Insekticidi se koristi za suzbijanje napada larvi evropskog kukuruznog plamenca (EBC) i smanjenje oštećenja biljaka. Cilj istraživanja bio je da se utvrdi varijacija dužine kanala na stabljici biljke kod genotipova kukuruza, uzrokovana ishranom larvi kukuruznog plamenca, primenom insekticida. Eksperimentalno istraživanje je sprovedeno u Institutu za kukuruz „Zemun Polje" u poljskim uslovima u vegetacionoj sezoni 2019. godine. Za proučavanje su korišćena tri genotipa kukuruza, ZP 434, ZP 600 i ZP 666 i tri insekticida hlorantraniliprol, bifentrin i [lufenuron+(cipermetrin + hlorpirifos], koji su primenjeni tek nakon maksimalnog leta prve generacije za zaštitu biljaka od napada evropskog kukuruznog plamenca. Analizom su utvrđene značajne razlike između genotipova kukuruza prema ukupnoj dužini kanala u stabljikama biljaka, koji su nastali ishranom larvi evropskog kukuruznog plamenca. Najmanja dužina kanala u stabljici utvrđena je pri tretiranju insekticidom hlorantranaliprolom kod dva genotipa kukuruza ZP 600 (181,67 cm) i ZP 434 (186,67 cm), dok je na tretmanu befentrinom najmanja dužina kanala kod ZP 666 (218,33 cm). Kod sva tri genotipa kukuruza na kontrolnoj varijanti (bez primene insekticida) bila je najveća dužina kanala (ZP 434 -295,00 cm; ZP 600 - 316,67 cm i ZP 666 -311,67 cm). Utvrđene razlike za ukupnu dužinu kanala zavisile su od genotipa i vrste primenjenog insekticida*

Ključne reči: kukuruz, genotip, štetočina, insekticid, dužina kanala

1. INTRODUCTION

The numerous insect species attack and consume maize plant organs. Among them European corn borer (*Ostrinia nubilalis* Hbn) Lepidoptera: Crambidae attacks all above-ground organs of the maize plant (panicle leaf, stem, cob) and larval feeding, cause damage of the green surface, producing the channels that can reduce intensity of photosynthesis and reduce yield up to 30% and more, which is equivalent to world-wide losses of 311.3 million tons every year [1]. The larvae feed on the epidermis of the leaves and the pollen from the inflorescences. During the it passes through the larval stages, it pierces the nerve of the leaves, and formed channels in stalk pit disrupts nutrient flow within the plant, i.e. translocation from from grean area to ear, and increase the lodging of plants [2,3]. Also, larvae pierces the cobs consuming the seed within the cob causing direct damage to kernels and increasing infections by mycotoxin-producing fungus [4,5].

The European corn borer's shows its high adaptability to different climate conditions in Europe and America. European corn borer appears from one to three generation per year (from June to September) depends of region. The maximal flight of the first generation of adults occurs at the beginning of June (160th–165th day of the year), the second generation achieve maximal flight the beginning of August (215th–220th day of the year), and maximal flight of the third generation is most present at the end of August or early September (240th–245th day of the year) [6]. In warmer condition, appear two complete generation, because the higher temperature influence biological cycle of *Ostrinia nubilalis* is shorter, it mean increase number of generations, reducing the diapause time, and extending the development period of insects [7–10]. In northen Europe appears one –two generation while in south Europe two-three generation. In [11,12]. Serbia appear two generation and activity of the first and second generations of adults is usually monitored to manage the treatments against this insect [13,14]. The control of European corn borer population for prevention of damages are control is based on the introduction of resistant corn hybrids into production, adequate soil cultivation, agrotechnics, and chemical protection of crops using insecticides (pesticides) [15-18]. In Southeastern Europe, in the production of corn, the use of pesticides is predominant, i.e. chemical protection and damage control from EBC attacks. The most effective application of insecticides is time before the larvae enter in the stem, and that time is 10-15 days after egg laying, i.e. 0-4 days after the maximum flight of adult insects [13, 19].

2. MATERIAL AND METHODS

As part of this study, research was conducted on three maize hybrids of different maturation groups (ZP 434, ZP 600 and ZP 666) with four variants of treatment: control variant (C) - without chemical

protection and three insecticides: (T1) chlorantraniliprole (200 g l^{-1}), (T2) bifenthrin (100 g l^{-1}) and T3 [lufenuron (50 g l^{-1})+(cypermethrin (50 g l^{-1}) + chlorpyrifos (500 g l^{-1}))], which were applied only after the maximum flight of the first generation to protect plants from attack of European corn borer.

On the grounds of the „Zemun Polje“ maize research institute in Belgrade, the experiment was carried out in 2019. The experiment was designed in three repetitions on a plot of 10.5 m². The sowing of maize hybrids was performed by machines in three rows of 5 m length with a distance between rows of 0.7 m and a distance between plants in a row of 0.25 m.

After the maize harvest was completed, the plants were cut to the ground and tied into bundles according to the treatments. Later, these plants were dissected, and among other morphometric measurements, the total length of all channels per experimental group was measured.

The obtained results were statistically processed, using various statistical methods of the program package "SPSS Statistics 20" (trial version). The significant differences among the average values were estimated according to the LSD test

3. RESULTS AND DISCUSSION

In the studied maize hybrids in the 2019 growing season, a variation in the total length of all channels formed by the feeding of the larvae of the European corn borer in the maize plants, and measured during dissection, was found. The average length of all the channels created by the feeding of *O. nubilalis* larvae varied from a minimum of 181.67 cm in hybrid ZP 600 treated with the insecticide chlorantraniliprole to a maximum of 316.67 cm in same hybrid ZP 600, in the control variant (without application of insecticide). The total length of all channels in the stems formed by feeding on *O. nubilalis* was the smallest in hybrid ZP 434 (230.00 cm) and the largest in hybrid ZP 666 (251.25 cm) - table 1. The average length of all channels formed by feeding ECB was highly different ($p<0.01$) between ZP 666 and the ZP 434, while the channel length between ZP 434 and ZP 600, and betreen ZP 600 and ZP 606 was not significantly different (table 2).

In Table 1, lowercase letters above the length of stems channels produced by pest feeding indicate whether there was a statistically significant difference between treatments ($p<0.05$) - the same letters indicate no statistically significant difference, including and comparing all treatments and all three hybrids. Among the studied maize hybrids, the total length of all channels in the stems formed by the feeding of *Ostrinia nubilalis* larvae was highly significantly greater ($p<0.01$) in the control varieties than in the treatments with insecticides.

Table 1. Variation of the total length of the channels in stems formed by feeding of larvae *Ostrinia nubilalis* in maize plants on treatment with insecticide application only during the flight of the first generation

Treatments*	Maize hybrids							
	ZP 434		ZP 600		ZP 666		Average	
	$\bar{X}$ (cm)	CV (%)	$\bar{X}$ (cm)	CV (%)	$\bar{X}$ (cm)	CV (%)	$\bar{X}$ (cm)	CV (%)
Control (C)	295,00^{b}	4,48	316,67^{a}	1,82	311,67^{a}	0,93	307,78	3,99
Chlorantraniliprole (T1)	186,67^{e}	8,61	181,67^{e}	20,29	246,67^{c}	8,19	205,00	18,81
Bifenthrin (T2)	218,33^{d}	1,32	223,33^{d}	2,59	218,33^{d}	1,32	220,00	1,97
L+C+C (T3)	220,00^{d}	6,01	243,33^{c}	1,19	230,00^{d}	3,77	231,11	5,60
Average	230,00	5,11	241,25	6,47	251,67	3,55	240,97	7,59

L+C+C =[lufenuron (50 g l^{-1})+(cypermethrin (50 g l^{-1}) + chlorpyrifos (500 g l^{-1}))]

Looking at all three hybrids, we can see that the expected significantly the largest channel length in maize plants due to ECB feeding was in controls (untreated plants) compared to all three insecticide treatments.

In hybrid ZP 434, we observe that the treatment with chlorantraniliprole had significantly the smallest channel length (186.67 cm) in the stems compared to the other two insecticide treatments. There were no significant differences between the other two treatments i.e. between treatment with bifenthrin and [lufenuron + (cypermethrin + chlorpyrifos)] in hybrid ZP 434.

Analyzing the ZP 600 hybrid, we observe that the treatment with chlorantraniliprole had significantly the smallest channel length (181.67 cm) in the stems compared to the other two insecticide treatments. There was significant differences between the other two treatments, i.e. on the treatment with bifenthrin was significantly the smallest channel length [lufenuron + (cypermethrin + chlorpyrifos)].

Unlike the two previously described hybrids, in ZP 666 hybrid, we observe that the treatment with chlorantraniliprole had significantly the largest channel length (246.67 cm) in the stems compared to the other two insecticide treatments. There were no significant differences between the other two treatments (bifenthrin and [lufenuron + (cypermethrin + chlorpyrifos)]) in hybrid ZP 666.
In this year (2018), was extremely unfavorable conditions for the growth and development of *Ostrinia nubilalis*, all insecticides showed a protective effect against the attack of the pest compared to the attack of the pest on the control. In comparison to damage on control (without protection by insecticides) variant, in average for all three maize genotypes was found lower damages for 25% on treatment [lufenuron + (cypermethrin + chlorpyrifos)]), 38,6% on treatment with bifentrin and 43,6% on treatment with Chlorantraniliprole.

The obtained results of our research coincide with the results of the research of [20]. Similar results obtained in study [21] of maize genotypes damages under treatment insecticide cyantraniliprole which belongs to the same class of synthetic insecticides as chlorantraniliprole. Also, in other research showed good effect of insecticide Lufenuron [22] and moderate effect in controlling European corn borer [14].

The analysis of variance shows that in the growing season of the study, highly significant and significant differences ($p<0.01$, $p<0.05$) were manifested for the total length of all channels in the stems, caused by the feeding of the larvae of the ECB between the hybrids, between the insecticide treatments, as and in the hybrid/treatment interaction (Table 2).

Table 2. Analysis of variance for the total length of channel in the stems, caused by the feeding of *Ostrinia nubilalis* larvae on maize plants with the application of insecticides only during the flight of the first generation (Zemun Polje, 2019)

Source	df	Sum of Squares (SS)	Mean Square (MS)	F test	LSD 0,05	LSD 0,01
Genotype	2	2818,056	1409,028	6,631	12,3329	16,7132
Treatment	3	56646,528	18882,176	88,857	14,2408	19,2988
Gen x Tre	6	6676,389	1112,731	5,236	24,6658	33,4265
Error	24	5100,000	212,500			
Total	35	71240,972				

The differences between C - control variant (without insecticide protection) and other three variants T1- (chlorantraniliprole), T2- (bifenthrin) and T3- ([lufenuron + (cypermethrin + chlorpyrifos)]) with application of different insecticides were significant. In this study, we found that with the application of insecticides with the active substance chlorantraniliprole in all three hybrids, the length of the channels from ECB in the stems was the lowest. The average channel length in all

three hybrids in the treatment with the insecticide chlorantraniliprole - (T1) was 205.00 cm, in the treatment with bifenthrin (T2) was 220.00 cm , while treatment with the combination of active substances [lufenuron + (cypermethrin + chlorpyrifos)]- (T3) was the highest length of channels 231.11 cm, i.e. the worst results.

The strength and intensity of attacks by pest insects on host plants also differed in relation to the genetic composition of the host plant [23]. Channel length varied by genotype and differed by age, indicating that genotype and environmental conditions play a significant role [24] in his three-year study presents that the average length of the channel made by ECB in the stem in sweet corn (21.2 cm) was significantly higher than the average length of the channel in fodder corn (13.7 cm). Varying damage to plants caused by the attack of the ECB was established in the research of 18 different hybrids of maize in natural and artificial conditions, which were aimed at forecasting the reaction of genotypes to the attack of the ECB in 2013 and 2014 [20]. The intensity of damage in different hybrids varied from 20% to 100%, and the degree of damage varied depending on the maize hybrid [9]. Also in the research carried out in Moldova [25], it was found that the ECB attack differed depending on the maize genotype and that the most vulnerable genotype had the longest length of channels formed by the feeding of *Ostrinia nubilalis* larvae.

4. CONCLUSION

Based on the analyzed results, it can be concluded that the insecticide with the active substance chlorantraniliprole had the best effect on the length of the channels in the stems that resulted from feeding ECB in maize hybrids, which confirms the results of other research. The treatment with insecticide (T1- chlorantraniliprole) proved to be the most effective in hybrid ZP 600 with a length of 181.67 cm of channels formed by feeding ECB. The best results on plants treated with the insecticide bifenthrin (T2- bifenthrin) are found in hybrid ZP 434 and ZP666 with a same channel length of 218.33 cm, while the treatment (T3- [lufenuron + (cypermethrin + chlorpyrifos)] - T3) had the best results on the same hybrid (ZP 434) with 220.00 cm. All three hybrids in the experiment had a similar response to the length of the channels in the stems, the least resistant hybrid was ZP 666, but the average channel length in all three hybrids was not significantly different.

5. ACKNOWLEDGMENT

The research was funded by the Ministry of Education, Science &Technological Development of Republic of Serbia by the Project TR 31092 and program 451-03-68/22-14/200189

REFERENCES

[1] Meissle, M., Mouron, P., Musa, T., Bigler, F., Pons, X., Vasileiadis, V.P., Otto, S., Antichi, D., Kiss, J., Pálinkás, Z., et al. (2010,). Pests, pesticide use and alternative options in European maize production: Current status and future prospects. J. Appl. Entomol. 134, pp. 357–375

[2] Blandino, M., Scarpino, V., Vanara, F., Sulyok, M., Krska, R., Reyneri, A. (2015). Role of the European corn borer (*Ostrinia nubilalis*) on contamination of maize with 13 Fusarium mycotoxins. Food Addit. Contam.—Part A Chem. Anal. Control Expo. Risk Assess., 32, pp. 533–543.

[3] Georgescu, E., Toader, M., Cana, L., Rîsnoveanu, L. (2019). Researches concerning European corn borer (*Ostrinia nubilalis* Hbn.) control, in South-East of the Romania; Scientific Papers; Series A; Agronomy: Bucharest, Romania, LXII, pp. 301–308.

[4] Butrón, A., Santiago, R., Mansilla, P., Pintos-Varela, C., Ordás, A., Malvar, R.A. (2006). Maize (*Zea mays* L.) genetic factors for preventing fumonisin contamination. J. Agric. Food Chem., 54, pp. 6113–6117.

[5] Trotuş, E., Buburuz, A.A., Ursache, P.L. (2018). New data regarding the appearance, evolution and the attack produced by *Ostrinia nubilalis* Hbn. species, at maize crop, under the Center of Moldavia conditions. Rom. Agric. Res., 35, pp. 229–236.
[6] Ivezić, A., Mimić, G., Trudić, B., Blagojević, D., Kuzmanović, B., Kaitović, Ž., Petrović, K. (2023). Development of a Predictive Model of the Flight Dynamics of the European Corn Borer, *Ostrinia nubilalis* Hübner, 1796 (Lepidoptera: Pyralidae), in the Vojvodina Region, Serbia— Implications for Integrated Pest Management. Agronomy, 13, 1494.
[7] Pintilie, P.L., Trotus, E., Tălmaciu, N., Irimia, L.M., Herea, M., Mocanu, I., Amarghioalei, R.G., Popa, L.D., Tălmaciu, M. (2023). European Corn Borer (*Ostrinia nubilalis* Hbn.) Bioecology in Eastern Romania. Insects, *14*, 738
[8] Kocmánková, E., Trnka, M., Eitzinger, J., Dubrovský, M., Štěpánek, P., Semerádová, D., Žalud, Z. (2011). Estimating the impact of climate change on the occurrence of selected pests at a high spatial resolution: A novel approach. J. Agric. Sci., 149, pp. 185–195.
[9] Porter, J.H., Parry, M.L., Carter, T.R. (1991). The potential effects of climatic change on agricultural insect pests. Agric. For. Meteorol., 57, 221–240.
[10] Trnka, M., Muška, F., Semerádová, D., Dubrovský, M., Kocmánková, E., Žalud, Z. (2007). European corn borer life stage model: Regional estimates of pest development and spatial distribution under present and future climate. Ecol. Model., 207, 61–84.
[11] Bereś, P.K. (2012). Flight dynamics of *Ostrinia nubilalis* Hbn. (Lep., Crambidae) based on the light and pheromone trap catches in Nienadówka (South-Eastern Poland) in 2006-2008. J. Plant Prot. Res., 52, pp. 130–138.
[12] Pintilie, P.L., Trotuş, E., Tălmaciu, N., Irimia, L.M., Herea, M., Mocanu, I., Amarghioalei, R.G., Popa, L.D., Tăalmaciu, M. (2023). European Corn Borer (*Ostrinia nubilalis* Hbn.) Bioecology in Eastern Romania. Insects, 14, 738.
[13] Gošic-Dondo, S., Grčak, D., Grčak, M., Kondić, D., Hajder, D., Popovic, Z., Knežević, D. (2020). The effect of insecticides on the total percentage of *Ostrinia nubilalis* Hbn attack on maize hybrids. Genetika, 52, pp.351–365.
[14] Grčak, D., Gošić Dondo, S., Grčak, M., Ristić, D., Kondić, D., Hajder, Dj., Popović, Ž., Knežević, D. (2022). Influence of maize hybrids and applayed insecticides on *Ostrinia nubilalis* Hbn. attack, Genetika, 54(1), pp. 289-306
[15] Papst, C., Utz, H.F., Melchinger, A.E., Eder, J., Magg, T., Klein, D., Bohn, M. (2005). Mycotoxins produced by *Fusarium spp*. in isogenic ***Bt*** vs. non-***Bt*** maize hybrids under European corn borer pressure. Agron. J., 97, pp.219–224.
[16] Folcher, L., Jarry, M., Weissenberger, A., Gerault, F., Eychenne, N., Delos, M., Regnault-Roger, C.(2009). Comparative activity of agrochemical treatments on mycotoxin levels with regard to corn borers and Fusarium mycoflora in maize (*Zea mays* L.) fields. Crop. Prot., 28, 302–308.
[17] Barzman, M., Bàrberi, P., Birch, A.N.E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B., Sattin, M. (2015). Eight principles of integrated pest management. Agron. Sustain. Dev., 35, 1199–1215.
[18] Grčak, D., Grčak, M., Gošić Dondo, S., Popović, D. Ž., Tatić, V., Uzelac I., Kondić, D., Knežević, D. (2023): Influence of insecticides application on channel length in stem of maize plants caused by feeding of larvae of European corn borer (*Ostrinia nubilalis* Hbn.). Book of proceedings of the XIV International Scientific Agriculture Symposium "Agrosym 2023", Jahorina, October 05-08, 2023, pp. 563-569
[19] Mazurek, J., Hurej, M., Jackowki, J. (2005). The effectiveness of selected chemical and biological insecticides in control of European Corn Borer (*Ostrinia nubilalis* Hbn.) on sweet corn. J. Plant Prot. Res., 45, pp. 41–47.
[20] Georgescu, E., Cană, L., Rîșnoveanu, L. (2015). Behavior of some maize hybrids to the European corn borer (*Ostrinia nubilalis* Hbn) attack, at NARDI Fundulea, 2013-2014. Seria Agronomie. Lucrări Ştiinţifice –58(1), pp. 129-134
[21] Pintilie, P. L., Tălmaciu, M., Trotuş, E., Amarghioalei, R. G., Isticioaia, S. F., Zaharia, R., Popa, L. D. (2022). Research regarding the *Ostrinia nubilalis* Hbn. (Lepidoptera:

Crambidae) attack at maize crops under the central of Moldova conditions, Romania. Romanian Agricultural Research, 39. pp. 1-12

[22] Kos, T., Ivček, M., Kinel, A., Židovec, V. (2013). Suppression of European Corn Borer (*Ostrinia nubilalis* Hbn.) on chrysanthemums in the greenhouse. 48. Hrvatski i 8. Međunarodni Simpozij Agronoma, Dubrovnik, Hrvatska, 17.-22. veljač 2013. Zbornik Radova, pp. 345-348.

[23] Wetzel, W. C., Aflitto, N. C., Thaler, J. S. (2018). Plant genotypic diversity interacts with predation risk to influence an insect herbivore across its ontogeny. Ecology, 99(10), pp. 2338-2347.

[24] Bereś, P. (2012). Damage caused by Ostrinia nubilalis Hbn. to fodder maize (*Zea mays* L.), sweet maize (*Zea mays* var. *saccharata* [Sturtev.] LH Bailey) and sweet sorghum (*Sorghum bicolor* [L.] Moench) near Rzeszów (south-eastern Poland) in 2008–2010. Acta Scientiarum Polonorum, Agricultura, 11(3), pp. 3-16.

[25] Pintilie, P. L., Tălmaciu, M., Trotuș, E., Amarghioale, R. G., Isticioaia, S. F., Buburuz, A. A., Eșanu, S. A. (2021). Research on the attack produced by *Ostrinia nubilalis* Hbn. Larvae at different genotypes of maize in the conditions of central Moldova. Lucrari Stiintifice, Universitatea, Seria Horticultura, 64(1), pp. 59-64.

WHEAT HYBRIDS UNDER CONDITIONS OF STRESS AND YIELD

HIBRIDI PŠENICE U USLOVIMA STRESA I PRINOS

Seddiq Mohamed Ahmed El Musafah, researcher[1]
Snezana Janković, principal research fellow[2]
Divna Simić, research associate[2]
Danica Mićanović, principal research fellow[3]
Sladjan Stanković, research associate[2]
Slađana Savić, research associate[4]
Danijela Šikuljak, principal research fellow[4]

Abstract: *Selection of tolerant hybrids is an important step in achieving good yields. The effect of water is considered one of the most important factors in plant production. The aim of these studies was to determine the most reliable parameter (germination, coleoptile and root length, fresh and dry weight) for the monitor and confirm Libyan H1, H2, H3, H4 and H5 hybrids sensitivity to moisture deficit. Based on the results all tested hybrids classified in the category tolerant to water stress. All tested parameters are considered reliable parameters for testing the sensitivity of hybrids to moisture deficit.*

Key words: wheat hybrids, water deficit, parameters

Apstrakt: Izbor tolerantnih hibrida je važan korak u postizanju dobrih prinosa. Uticaj vlage se smatra jednim od najvažnijih faktora u biljnoj proizvodnji. Cilj sprovedenih istraživanja bio je da se utvrdi najpouzdaniji parametar (klijavost, dužina koleoptila i korena, sveža i suva masa) za praćenje i potvrdu osetljivost libijskih H1, H2, H3, H4 i H5 hibrida na deficit vlage. Na osnovu rezultata svi testirani hibridi svrstani su u kategoriju tolerantnih na stress uzrokovan nedostatkom vlage. Svi ispitivani parametri smatraju se pouzdanim parametrima za ispitivanje osetljivosti hibrida na deficit vlage.

Ključne reči: *hibridi pšenice, nedostatak vlage, parametri*

1. INTRODUCTION

Wheat is one of the most important and most cultivated plants, not only in our country but also in Europe and the world. Because it is widespread many different ecosystems, wheat plants face various abiotic challenges, such as drought and rising temperature, due to global warming, which results in huge yield loss [1,2]. Numerous others factors during the growing season affect the achievement of high yields. In the world wheat it is grown on 220 million hectares and in Libya about 180 thousand hectares [3]. In order to achieve good yields, in addition to the application of different crop care measures, an important factor that affects the achievement of high yields is the presence of the required amount of moisture. Research has shown that during the development of

[1] Biotechnology Research Center, Tripoli, Libya
[2] Institute for Science Application in Agriculture, Belgrade, Serbia, e-mail: sjankovic@ipn.bg.ac.rs
[3] Serbian Chamber of Commerce, danica.micanovic@pks.rs
[4] Institute for plant protection and environment, bonita.sladja@gmail.com, danijelapavlovicdk@gmail.com,

wheat it requires 650-750 mm of precipitation [4]. Environmental factors, especially the lack of moisture, caused osmotic stress and irreversible damage to plants, reduces quality and yield and food production generally [5-7]. The consequences of lack of moisture and osmotic stress manifest in the inhibition of cell elongation, stomata closure, reduction of photosynthetic activity, disturbances in water and ion uptake, translocation of assimilates, and changes of various metabolic processes. Wheat plants can mitigate or neutralize the negative effects of stress [8-10]. That is why it is important to monitor the crops and their reaction to the moisture content of the soil during the growing season, especially during periods of sowing and flowering of plants [11]. Reduction of the osmotic potential caused by water deficiency leads to a reduction in the percentage and speed of seed germination. For studying the effects of osmotic stress, usually are used Polyethylene-glycol (PEG), mannitol or sorbitol. The aim of these research was examination of the germination parameters effected by low water potential which was generated by polyethylene glycol (PEG), related to drought stress and growth of five (H1, H2, H3, H4 and H5) wheat genotype.

2. MATERIAL AND METHODS

Five diverse wheat genotypes (H1, H2, H3, H4 and H5) were laboratory tested for germination and growth response under osmotic stress induced by polyethylene glycol (PEG). Osmotic stress was induced by 10 and 15% polyethylene glycol (PEG). The sensitivity of hybrids was tested by measuring parameters: percentage of germination, coleoptile and root length, fresh and dry mass of shoot and root. Seeds of each hybrids were placed in Petri dishes (10 seeds per dish) in three replicates. Petri dishes were placed in 12 h light/dark period at 20 ˚C ten days. Measurements done after 14 days and results were analyzed by LSD test (ANOVA) and t-test (Statistics 7).

3. RESULTS AND DISCUSSION

The analysis of the measured parameters confirmed that all the measured parameters proved to be good indicators of the response of wheat hybrids to the lack of moisture. Tested concentrations of PEG did not affect the germination of the seeds of the H3 hybrid, and the weakest germination (50%) was shown by the seeds of the hybrid H4 after the application of a 15% PEG solution.
Hybrids H1 and H2 had over 80% germination in both tested PEG concentrations. Statistical analysis of germination of wheat hybrids showed in table 1. Based on the percentage of germination, it can be concluded that all tested hybrids are tolerant to water deficit and the germination percentage parameter proved to be reliable for measuring the susceptibility to water deficit.

Table 1. Statistical analysis of germination (LSD)

hybrid	H1	H2	H3	H4	H5
C vs 10%	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	*	NS
SD	14.35	14.85	16.97	26.78	18.01

10 and 15% PEG; NS-nonsignificant difference, $p<0.05$*; SD-standard deviation; C-control;

The obtained results are in accordance with the research of other authors who also confirmed the sensitivity of wheat hybrids and other crops to lack of moisture based on the percentage of germination. [12-14]. Based on the mentioned parameter, the authors performed the first classification of hybrids/crops into several categories (sensitive, particularly sensitive, tolerant). However, group of authors [15] concludes that varieties that have a similar germination percentage are water deficit tolerant even when drought intensifies. In contrast, Kiani et al. [16] point out that germination decreases in drought conditions. But in general, variation in seed germination is due to a complex of environmental and genetic factors during seed formation [17]. Water deficit mostly affects seed germination, but significantly reduces shoot and root length, root emerge before other parts of plants [18]. General water deficit might reduce the potential length of the coleoptile and the

development of seedling by inhibiting cell growth [19]. Mohammed et al. [20] pointed that should be careful when making conclusions based on shoot length because value may be affected more by the duration of the germination process than by the lack of moisture. The analysis of the effect of moisture deficiency on the length of coleoptiles and roots is shown in able 2. The classification of the examined hybrids was done on the basis of RSR (root vs coleoptile) parameters from tolerant to sensitive: H4, H1, H5, H2 and H3 (Table 2).

Table 2. Statistical analysis of the examined parameters (LSD test)

hybrid	H1	H2	H3	H4	H5
	Length of coleoptile				
PEG 10%	*	**	**	*	**
PEG 15%	**	**	**	**	**
	Length of root				
PEG 10%	**	**	*	ns	ns
PEG 15%	**	**	**	**	**
Root vs coleoptile	1,3	1,5	1,4	1,3	1,3
	Fresh shoot weight				
PEG 10%	**	**	**	**	**
PEG 15%	**	**	**	**	**
	Fresh root weight				
PEG 10%	**	**	**	**	**
PEG 15%	**	**	**	**	**
Fresh root weight vs fresh shoot weight	0,2	0,2	0,2	0,2	0,1
	Dry shoot weight				
PEG 10%	*	**	**	NS	*
PEG 15%	**	**	**	**	**
	Dry root weight				
PEG 10%	*	NS	NS	NS	NS
PEG 15%	*	NS	**	*	**
Dry root weight vs dry shoot weight	0,5	0,5	0,5	0,5	0,4

10 and 15% PEG, NS-nonsignificant difference, $p<0.05$*, $p<0.01$**

Comparison hybrids based on vegetative parameters showed (t test): no differences between hybrids based on the shoot and root length and statistically significant differences ($p<0.05$*) between H2 vs H5, H3 vs H5 and H4 vs H5 based on parameter fresh root weight and between H2 vs H5 and ($p<0.01$**) between H4 vs H5 based on dry root wight.

In table 3 can see that changes in fresh root and shoot proved to be reliable parameters and in dry shoot and root weight parameters dray shoot weight was more reliable for separating the sensitivity of the tested hybrids to stress. Conclusion the group of authors [21] agree with our results. They conclude that the weight of shoot parameter is a more reliable parameter, changes occur because of reduced transport of nutrients. Also, longer root length in water deficit conditions occurs due to the tendency to grow in the direction of soil volume for water [22] and photosynthesis related characteristics decline [23]. Belachew et al. [24] point out that the reductions in fresh and dry mass can be double higher in water deficit conditions. T-test based on the dry shoot and root weight showed that the most drought tolerant hybrid is H5.

4. CONCLUSION

The most important agro-ecological factor of plant production is water regime. Seed and hybrid screening and scientific knowledge of moisture tolerance is a reliable guide for testing and selecting

drought-tolerant hybrids. Based on the results of these studies, it can be concluded that the most reliable parameters for defining resistance/tolerance to drought are: germination percentage, shoot and root length, fresh weight of root and shoot, and dray shoot weight. The obtained results showed that the most tolerant to drought were H3 Libyan hybrid.

5. ACKNOWLEDGMENT

The authors express their appreciation to the Ministry of Science, Technological Development and Innovation of the Republic of Serbia for providing the financial support (Grants No. 451-03-47/2023-01/200010 and No. 451-03-47/2023-01/200045).

REFERENCES

[1] Yan, M., Xue, C., Xiong, Y., Meng, X., Li, B., Shen, R., Lan, P. (2020). Proteomic dissection of the similar and different responses of wheat to drought, salinity and submergence during seed germination. J. Proteom., 220, 103756.

[2] Herman, J. J., Sultan, S. E., Horgan-Kobelski, T., Riggs, C. (2012). Adaptive transgenerational plasticity in an annual plant: Grandparental and parental drought stress enhance performance of seedlings in dry soil. Integr. Comp. Biol., 52, 77-88.

[3] Faostat (may 2022). www.fao.org/faostat.

[4] Latković, D., Marinković, B., Crnobarac, J., Jaćimović, G., Berenji, J., Sikora, V. (2015). Cultivation of alternative field plants. University of Novi Sad, Faculty of Agriculture, 114-125. (In Serbian).

[5] Saruhan Güler, N., Saglam, A., Demiralay, M., Kadioglu, A. (2012). Apoplastic and symplastic solute concentrations contribute to osmotic adjustment in bean genotypes during drought stress. Turk. J. Biol., 36, 151-160. doi:10.3906/biy-1101-177.

[6] Lisar, S. Y., Motafakkerazad, R., Hossain, M., Rahman, M. M. I. (2012). Water Stress in Plants: Causes, Effects and Responses. In: Water Stress (Rahman, I. M. M. and Hasegawa, H., eds.), InTech, Croatia, 1-14. doi:10.5772/39363.

[7] Blum, A. (1997). Crop responses to drought and the interpretation of adaptation. In: Drought Tolerance in Higher Plants: Genetical, Physiological, and Molecular Biological Analysis (Belhassen, E. ed.), Dordrecht, the Netherlands: Kluwer Academic Publishers, 57–70.

[8] Aspinall, D., Paleg, L. G. (1981). Proline accumulation, physiological aspects. In: The Physiology and Biochemistry of Drought Resistance in Plants (Paleg, L. G., Aspinall, D., eds.), NY, USA, Academic Press, 206–240.

[9] Zhu, J. K. (2001). Plant salt tolerance. Trends in Plant Science, 6 (2), 66-71. doi: 10.1016/ S1360-1385(00)01838-0.

[10] Silva, A. C., Suassuna, J. F., Melo, A. S., Costa, R. R., Andrade, W. L., Silva, D. C. (2017). Salicylic acid as attenuator of drought stress on germination and initial development of sesame. Revista Brasileira de Engenharia Agrícola e Ambiental, 21 (3), 156-162. doi: 10.1590/1807-1929/agriambi.v21n3 p156-162.

[11] Dodig, D., Zoric, M., Jovic, M., Kandic, V., Stanisavljevic, R., Surlan-Momirovic, G. (2015). Wheat seedlings growth response to water deficiency and how it correlates with adult plant tolerance to drought. The Journal of Agricultural Science, 153 (3), 466-480. doi: 10.1017/S002185961400029X.

[12] Mahpara, S., Zainab, A., Ullah, R., Kausar, S., Bilal, M., Latif, I. M., Arif, M., Akhtar, I., Al-Hashimi, A., Elshikh, S. M., Zivcak, M., Zuan, A. T. K. (2022). The impact of PEG-induced drought stress on seed germination and seedling growth of different bread wheat (*Triticum aestivum* L.) genotypes. PLoS ONE, 17 (2), 1-15. e0262937. https://doi.org/10.1371/journal. pone.0262937.

[13] Asilan, K. S., Sanavy, S. A. M. M., Alikhani, M. A., Sharif-Abad, H. H., Mir, S. R. (2009). The effect of water deficit stress on germination traits of ten perennial alfalfa (*Medicago sativa* L.) ecotypes. Iranian Journal of Field Crop Science, 40 (3), 95-102.
[14] Salehi, F. M. (2010). The effect of drought stress on seedling germination and growth in 8 genotypes of bean. Proceeding of the 11th Congress on Iranian Agronomy and Plant Breeding, Shahid Beheshti University. https://civilica.com/papers/l-7655/
[15] Khan, A. A. (1980). The Physiology and Biochemistry of Dormancy and Germination. North-Holland Publishing Company, Oxford, UK.
[16] Kiani, M., Bagheri, A., Nezami, A. (1998). The response of lentil genotypes to drought stress resulting from polyethylene glycol 6000 at germination stage. Journal of Agricultural Science and Industry, 12, 42– 55.
[17] Wang, R.Y., Yu, Z.W., Pan, Q.M., Xu, Y.M. (1999). Changes of endogenous plant hormone contents during grain development in wheat. Acta Scientiarum Agronomy, 25, 227–231.
[18] Duman, I. (2006). Effects of Seed Priming with PEG or K_3PO_4 on Germination and Seedling Growth in Lettuce. Pakistan Journal of Biological Science. 9(5), 923-928. https://dx.doi.org/10.3923/pjbs.2006.923.928
[19] Gull, A., Allan, R. E. (1976). Stand establishment of wheat lines under different levels of water potential. Crop. Sci., 16, 611-615.
[20] Mohammed, G., Shroyer, J., Kirkham, M., Paulsen, G. (1997). Wheat Coleoptile and Root Growth and Seedling Survival after Dehydration and Rehydration. Agronomy Journal, 89. 10.2134/agronj1997.00021962008900050017x.
[21] Mohammadi, N., Mojaddam, M. (2014). The effect of water deficit stress on germination components of grain sorghum cultivars. Indian Journal of Fundamental and Applied Life Sciences, 4 (4), 284-291.
[22] Sharp, R. E., Davies, W. J. (1989). Regulation of growth and development of plants growing with a restricted supply of water. In: Plants under stress (Jones, H. G., Flowers, T. L., Jones, M. B., eds.), Cambridge: Cambridge University Press, 71–93.
[23] Khalil, A. M., Murchiel, E. H., Mooney, S. J. (2020). Quantifying the influence of water deficit on root and shoot growth in wheat using X-ray Computed Tomography. AoB Plants, 12(5), plaa036.
[24] Belachew, K. Y., Nagel, K. A., Poorter, H., Stoddard, F. L. (2019). Association of Shoot and Root Responses to Water Deficit in Young Faba Bean (*Vicia faba L.*) Plants. Front Plant Sci. doi: 10.3389/fpls.2019.01063. PMID: 31552067; PMCID: PMC6738164.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

INTEGRATED WEED MANAGEMENT IN THE FUNCTION OF PRODUCTION OF HEALTHY AND SAFE FOOD

INTEGRALNO SUZBIJANJE KOROVA U FUNKCIJI PROIZVODNJE ZDRAVE I BEZBEDNE HRANE

Sava Vrbničanin, full-time professor[1]
Dragana Božić, full-time professor[1]
Danijela Šikuljak, science advisor[2]

Abstract: *Food is very important for all the people in the world. Whether food is of plant or animal origin, it must be prepared in an adequate way. Since we live in a time when people do not have much time to prepare food, they are forced to use ready-made meals from bags, fried food, food prepared on the grill, and insufficiently thermally processed food. This kind of food is anything but healthy. In order for people to eat a healthy meal, they must first have some knowledge of what is healthy and what is not. This paper presents results of an anonymous survey of students of the Academy of Technical Educational Vocational Studies to see if they are informed about what healthy food is, if they eat healthy meals and which food will be beneficial in the future. The survey contained 10 questions, which had to be answered with YES, NO or MAYBE.*

Key words: *healthy food, characteristics, importance and role*

Apstrakt: *Hrana je jako bitna za sve ljude na svetu. Bilo da je hrana biljnog ili životinjskog porekla ona mora da bude pripremljena na adekvatan način. Pošto se živi u vremenu, kada ljudi nemaju puno vremena da pripremaju hranu, često pribegavaju da koriste gotovu hranu iz kesica, prženu hranu, hranu pripremljenu na roštilju, nedovoljno termički obrađenu itd. Ovakva hrana često ne nosi epitet „zdrave hrane". Kako bi ljudi pojeli zdrav obrok, prvo moraju da imaju određeno znanje o tome šta je zdravo a šta ne. U ovom radu prikazani su rezultati anonimne ankete studenata Akademije tehničko vaspitačkih strukovnih studija kako bi se videlo da li su upućeni o tome šta je „zdrava hrana", da li jedu zdrave obroke i koja će hrana u budućnosti imati prednosti. Anketa je sadržala 10 pitanja, na koja je trebalo da se odgovori odgovorom sa DA, NE ili MOŽDA.*

Ključne reči: *zdrava hrana, karakteristike, značaj i uloga*

1. INTRODUCTION

Sustainable weed control could be based on the implementation of the Integrated Weed Management (IWM) strategy, with the aim of producing healthy and safe food. The top priority in crop production should be to optimise output and maximise profit. This goal does not require that weeds are eradicated, but that their density is reduced to an acceptable level in order to increase crop yield and contribute to the environment [1-2]. In general, any single control measure is unlikely to be effective on its own in the long term [3]. Moreover, the available non-chemical techniques usually have lower individual efficacy than herbicides, so IWM requires the combination of different (preventive and direct) measures. The concept of IWM is to maintain a balanced weed

[1] University of Belgrade, Faculty of Agriculture, Belgrade, Serbia, e-mail: sava@agrif.bg.ac.rs; dbozic@agrif.bg.ac.rs
[2] Institute for Plant Protection and Environment, Belgrade, Serbia, e-mail: dulekaca@yahoo.com

flora and reduce the dependence of weed control systems on herbicides by using all available tools to reduce weed pressure, competition and yield losses. To meet food safety requirements, weed management practices could be based on IWM principles.

2. **IWM STRATEGY IN FUNCTION OF THE PRODUCTION OF HEALTHY AND SAFE FOOD**

In general, IWM strategy is not a set of quick and hard rules, but a set of guidelines to be followed in the specific and unique circumstances of a particular operation. The key actions in developing an IWM strategy are [4]:

- monitoring the weed species present,
- evaluating the role of crop residue management,
- evaluating the different effects of tillage methods on the weed seed bank in the soil and on weed populations,
- consideration of the incorporation of stale seedbeds before sowing,
- selection of competitive crop varieties,
- consideration of mechanical methods of weed control,
- consideration of an economic threshold and a critical time for weed removal,
- mapping heavy weed patches to enable precise treatment,
- consider the role of weeds as a habitat for beneficial species,
- consider weeds as a resource for wildlife, etc.

A key approach to weed management in function of food safty and security is to minimise the occurrence of weed problems in crops and in the environment and to manage weed populations with mechanical, physical, biological and sustainable chemical measures. The following management decisions contribute to the development of IWM on crop land are:

- monitoring and identification of weed species,
- soil and cultivation practises,
- crop rotations and management of weed seed banks in the soil,
- nutritional strategy for crops,
- crop hygiene,
- landscape management, etc.

In addition, economic thresholds and critical times for weed removal need to be identified to prioritise IWM, and different methods of weed control, including crop choice, timing of interventions and sustainable use of herbicides, need to be incorporated [5-6].

Furthermore, in modern agriculture, where safe food is produced, there are several reasons why the IWM system is the most appropriate long-term strategy for weed control: 1) increasing concern about the effects of herbicides on human health and the environment, 2) evolution of herbicide-resistant weeds, 3) weed shifts, 4) invasive weeds and climate change, 5) slow development of new herbicides, etc. [3]. Finally, weed control has been a key issue in European agriculture over the last two decades for the following reasons: 1) frequent herbicide treatments on most crops across Europe, except of course in organic farming, 2) herbicides are the most commonly found pesticide residues when analyzing the quality of surface and groundwater, 3) the development of weed populations, resistant to the most frequently used herbicides poses a real threat to the sustainability of current chemical weed control strategies, 4) the increase in the cost of chemical crop protection due to the withdrawal of several old and cheaper herbicides [7]. Thus, these are the key points for the implementation of innovative strategies that focus on reduced pesticide use and combine all available weed control methods within the IWM approach.

2.1. MONITORING AND IDENTIFICATION OF WEED SPECIES

Weed monitoring is the first step in an IWM system, i.e. examining each field after crop harvest. If an annual crop (corn, soybeans, sunflowers, sugar beets, cereals, etc.) is to be grown next year, this information is used to assess the importance of each weed species and select the appropriate management strategy for the next crop. For annual crops, the fields are also monitored after the crop has emerged to assess the effectiveness of the chosen management alternative and determine whether additional management measures are required. For perennial crops (alfalfa, red clover, hops, etc.), an assessment of weed composition is conducted after the previous crop is harvested to determine the appropriate management tactic for the establishing crop. For an established crop, the fields are examined to determine if additional weed control measures are required. Today, a variety of platforms, cameras, sensors and image analysis techniques exist to detect and map the presence and abundance of weeds in crop fields lands [8].

2.2. SOIL AND CULTIVATION PRACTICES

One step of the IWM system is to minimise the likelihood of weed seeds shedding onto the soil surface and being incorporated into the weed seed bank in the soil. A second goal is to minimise the weed seedlings that emerge in the crop [9]. This may mean deliberately encouraging weed seed germination prior to crop sowing by using a stale-seedbed technique. Techniques to minimise soil disturbance can reduce the uptake of weed seeds into the soil seed bank, reduce the return of buried seeds to near the surface where they could germinate, and reduce environmental incentives for germination [10]. The type of tillage also needs to take into account whether the technique favours certain weeds. For example, ploughing helps to minimise the occurrence of Bromus sterilis species, while reduced tillage has little effect on the populations of this species [1]. Compared to herbicides, mechanical and physical weed control methods such as harrowing, hoeing, disking, brush weeding, torsion and finger weeding or flaming are generally less effective, both in the short and long term [11]. However, inter-row cultivation is widely used in both conventional and organic farming for row crops. In addition, primary and secondary tillage can help to reduce the abundance and spread of certain perennial weed species [12]. In addition, flame weeding has proven to be particularly promising in the last ten years, especially in organic farming [13].

2.3. CROP ROTATION AND MANAGEMENT OF WEED SEED BANKS IN THE SOIL

With crop rotation, in addition to intensive changes in agricultural techniques during each season, weed control measures also changes. This contributes to the fact that crops grown in rotation have fewer weeds compared to crops grown in monoculture [14-15]. Sometimes it is desirable to interrupt even a well-planned crop rotation (spring barley-sunflower-winter wheat) with the fourth crop (oilseed rape), as this changes the agrotechnics but also reduces weediness [16]. Crop rotation as part of the IWM strategy can enable the production of food that is safe for human health by reducing weed density and herbicide use. Crop rotation and the type of tillage can significantly influence the seed bank in the soil [17]. Therefore, managing the seed bank of weeds in the soil is directly related to the IWM strategy for safe food production. Understanding the influence of crop rotations and their concomitant effects on the weed seed bank provides useful information to improve decision making systems [18].

2.4. CROP ESTABLISHMENT

The time of sowing, the sowing rate and the variety have a major influence on the interaction between the plant and the weeds and ultimately on the crop yield. All these elements are important for the decision-making process at IWM. A late sowing date usually leads to yield losses [1].

Sowing too early, sowing when the temperature is above the optimum, also leads to poor plants, and even a higher sowing rate cannot compensate for the low yield. Under optimal weather conditions (temperature, humidity), on the other hand, early sowing with an optimal seedling rate promotes plant growth and nutrient uptake, which leads to a higher yield [19]. The choice of crop variety is also an important consideration in the decision-making process for IWM. Increasing crop competitiveness also improved herbicide efficacy, especially when herbicides were used at reduced doses. Using competitive crops to discourage weeds is an important IWM strategy. To maximise crop production while minimising the impact of weeds, replacement and supplemental rows have been recommended for intercrop, cover crop and green manure selection [20]. The biomass and canopy of a cover crop help it to compete with weeds [21]. A well-established crop, which generally requires less weed control and less herbicide consumption, is thus positively correlated with environmental protection and healthy food production.

2.5. SITE-SPECIFIC WEED MANAGEMENT

Information and technology-based agricultural management system to identify, analyze and manage spatial and temporal variation within fields for optimal profitability, sustainability and environmental protection [22]. Site-specific weed management can be an option when weeds are not evenly distributed across the field but occur in patches. By cultivating beds, herbicide use can be effectively reduced as herbicides are only applied to parts of the field. Long-term herbicide use can also be reduced by controlling patches of new or hard-to-control weeds early and preventing them from spreading across the field. This strategy was widespread before the introduction of herbicides, with these areas being removed from fields before mature seed production. Site-specific weed control can result in herbicide savings and environmental and economic benefits. Indeed, the results with patch spraying show that at least 50 % of herbicides can be saved in various crops without incurring additional costs for weed control in subsequent years [23].

2.6. APPLICATION OF HERBICIDES

IWM allows the use of herbicides as one of the most effective weed control measures. It is considered essential that it is neither the first nor the only method of weed management. As a rule, fewer herbicides are used in the context of integrated farm management. A long-term study in Sweden [24] has shown that reducing the amount of herbicide used each year provides better long-term weed control than not using herbicides every other year and applying the full recommended rate in the remaining years. Reduced herbicide rates have been suggested as a means of slowing the development of herbicide resistance in weeds [25]. However, there is also an opposing view that the use of lower doses of herbicides can promote herbicide resistance in weeds. In implementing IWM to avoid this problem, two key aspects have been considered: 1) diversification of weed management practices and use of multiple herbicide modes of action (MOAs) and 2) educating farmers about MOAs and raising awareness that discovery of new herbicide chemistries is rare and that indiscriminate herbicide use leading to rapid evolution of herbicide resistant weeds may result in the loss of all herbicide options. The general recommendation can be the optimization and sustainable use of herbicides that is positively related to environmental protection and the production of healthy and safe food.

2.7. FUTURE RESEARCH OPPORTUNITIES ON IWM IN FUNCTION OF PRODUCTION HEALTHY AND SAFE FOOD

Future IWM research should focus on advancing the principles of weed science. It is important to move from descriptive to predictive science to overcome the barriers to acceptance of the scientific discipline. There are generally more measures that can be integrated into the IWM system. Each measure must be adapted to local living, economic and agricultural conditions, so a single measure

will not be sufficient for all crops, no matter where they are grown. Herbicides will continue to be an important part of the IWM system, but should only be used when absolutely necessary and controlled. Therefore, the use of herbicides must be reduced to make crop production more sustainable and the life of herbicide use longer and more effective [3].
Research should be conducted to develop a more efficient IWM system that minimizes costs, optimizes weed control and is sustainable under changing economic and environmental conditions. These systems will not solve all weed management problems, but they will enable healthy and safe food production. Integrated systems stabilize weed populations at low abundance by applying a range of high-quality, fit-for-purpose weed control measures. IWM systems will evolve and change over time if they fail to prevent the spread of alian invasive weed species, if resistance to herbicides develops, if soil, water, flora and fauna need to be protected, etc. [26-27]. Realistically, weeds will never be eradicated, but they can be managed. Therefore, future weed management should consider different weed management strategies, previous field information and real-time environmental conditions to recommend the most appropriate weed management strategy [28]. These systems would help to meet farmers' needs for simple, effective and flexible weed management while at the same time promoting of IWM and healthy and safe food production.

3. CONCLUSION

The challenge for weed scientists is to develop innovative, economical and sustainable IWM systems that can be integrated into current and future economic, social and environmental problems to reduce the negative impact of native and alien invasive and harmful weed species on the production of safe and healthy food and on environmental protection.

4. ACKNOWLEDGMENT

We thank the Ministry of Education, Science and Technological Development of Republic of Serbia, grant number: 451-03-47/2023-01/200116 and 451-03-47/2023-01/200010.

REFERENCES

[1] Naylor, R. E. L. (ed.) (2002). Weed management Handbook. 9th edition, Blackwell, BCPC.
[2] Pavlović, D., Vrbničanin, S., Anđelković, A., Božić, D., Rajković, M., Malidža, G. (2022). Non-Chemical Weed Control for Plant Health and Environment: Ecological Integrated Weed Management (EIWM). Agronomy, 12, 1091. https://doi.org/10.3390/agronomy 12051091
[3] Malidža, G., Vrbničanin, S. (2015). Integrated weed management in field crops: sustainability and practical implementation. In: D. Marčić, M. Glavendekić, P. Nicot (Eds.) Proceedings of the 7th Congress on Plant Protection. Plant Protection Society of Serbia, IOBC-EPRS, IOBC-WPRS, Belgrade, 33-41.
[4] Zimdahl, R. L. (2018). Fundamentals of Weed Science, 5th edition, AP San Diego, London, Boston, New York, Sydney, Tokyo, Toronto.
[5] Nedeljković, D., Knežević, S., Vrbničanin, S. (2019). Uticaj meteoroloških prilika na kritičan period suzbijanja korovai prinos kukuruza u Srbiji. Acta herbologica, 28 (1), 17-31.
[6] Nedeljković, D., Knežević, S., Pavlović, P., Božić, D., Anđelković, N., Milošević, L., Vrbničanin, S. (2021). Uticaj brojnosti korova na početak kritičnog vrema suzbijanja korova i prinos kukuruza u Srbiji. Acta herbologica, 30 (2), 105-119.
[7] Tataridas, A., Kanatas, P., Chatzigeorgiou, A., Zannopoulos, S., Travlos, I. (2022). Sustainable Crop and Weed Management in the Era of the EU Green Deal: A Survival Guide. Agronomy, 12, 589. https:// doi.org/10.3390/agronomy12030589

[8] Esposito, M., Crimaldi, M., Cirillo, V., et al. (2021). Drone and sensor technology for sustainable weed management: a review. Chemical and Biological Technologies in Agriculture, 8, 18. https://doi.org/10.1186/s40538-021-00217-8
[9] Radosevich, S. R., Holt, J. S., Ghersa, C. M. (2007). Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management. John Wiley & Sons, Inc.
[10] Auškalnienė, O., Auškalnis, A. (2009) The influence of tillage system on diversities of soil weed seed bank. Agronomy Research 7 (Special issue I), 156-161.
[11] Melander, B., Lattanzi, B., Pannacci, E. (2015). Intelligent versus non-intelligent mechanical intra-row weed control in transplanted onion and cabbage. Crop Protection, 72, 1-8.
[12] Carter, M. R., Sanderson, J. B., Ivany, J. A., White, R. P. (2002). Influence of rotation and tillage on forage maize productivity, weed species, and soil quality of a fine sandy loamin the cool–humid climate of Atlantic Canada. Soil & Tillage Research, 67, 85–98. PII: S0167-1987 (02)00043-0
[13] Rajković, M., Malidža, G., Tomaš Simin, M., Milić, D., Glavaš-Trbić, D., Meseldžija, M., Vrbničanin, S. (2021). Sustainable Organic Corn Production with the Use of Flame Weeding as the Most Sustainable Economical Solution. Sustainability 2021, 13, 572. https://doi.org /10.3390/su13020572
[14] Cardina, J., Herms, C. P., Doohan, D. J. (2002). Crop rotation and tillage system effects on weed seed banks. Weed Science, 5l, 448-460.
[15] Saulić, M., Oveisi, M., Djalović, I., Božić, D., Pishyar, A., Savić, A., Prasad, V., Vrbničanin, S. (2022). How Do Long Term Crop Rotations Influence Weed Populations: Exploring the Impacts of More than 50 Years of Crop Management in Serbia. Agronomy, 12, 1772. https://doi.org/10.3390/agronomy12081772
[16] Macák, M., Đalović, I., Smatana, J., Kiss Roháriková, A., Saulic, M., Kulina, M. (2020). Temporal Changes of Elytrigia repens Density in Intensive Cereal-Based Cropping Systems. International Journal of Agriculture and Biology, 24 (2), 195-200.
[17] Mishra, J. S., Kumar, R., Mondal, S., et al. (2022). Tillage and crop establishment effects on weeds and productivity of a rice-wheat-mungbean rotation. Field Crop Research, 1, 284, 108577. doi: 10.1016/j.fcr.2022.108577
[18] Hosseini, P., Karimi, H., Babaei, S., Mashhadi, H. R., Oveisi, M. (2014). Weed seed bank as affected by crop rotation and disturbance. Crop Protection, 64, 1-6.
[19] Fazily, T. (2021). Effect of Sowing Dates and Seed Rates on Growth and Yield of Different Wheat Varieties: A Review. International Journal of Agricultural Science and Technology, 8 (3), 10-26.
[20] Maxwell, B. D., Donovan, O. J. T. (2007). Understanding weed-crop interactions to manage weed problems. In Non-Chemical Weed Management, Principles, Concepts and Technology (Upadhyaya, M.K, Blackshaw, R.E. eds.), CABI International.
[21] Liebman, M., Davis, A. S. (2000). Integration of soil, crop and weed management in low-external-input farming systems. Weed Research, 40, 27-47.
[22] Robert, P. C., Rust, R. H., Larson, W. E. (1994). Preface. In: Site-Specific Management for Agricultural Systems. Madison (Robert, P.C., Rust, R.H., Larson, W.E. eds.), WI: American Society of Agronomy, 2–8.
[23] Gerhards, R., Sanchez, D. A., Hamouz, P., Peteinatos, G. G., Christensen, S., Fernandez-Quintanilla, C. (2022). Advances in site-specific weed management in agriculture - A review. Weed Research, 62 (2), 123-133.
[24] Bostrom, U., Fogelfors, H. (2002). Long-term effects of herbicide-application strategies on weeds and yield in spring-sown cereals. Weed Science, 50, 196-203.
[25] Beckie, H. J., Kirkland, K. J. (2003). Implication of reduced herbicide rates on resistance enrichment in wild oat (Avena fatua). Weed Technology, 17, 138-148.
[26] Vrbnicanin, S., Pavlovic, D., Bozic, D. (2017). Weed Resistance to Herbicides. In: Herbicide Resistance (ed. Z. Pacanoski). InTech open science/ open minds, 7-36.
[27] Vrbničanin, S. (2020). Rezistentnost korova na herbicide. Acta herbologica, 29 (2), 79-96.

[28] Swanton, C. J., Mahoney, K. J., Chandler, K., Gulden, R. H. (2008). Integrated Weed Management: Knowledge-Based Weed Management Systems. Weed Science, 56 (1), 168-172.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

THE IMPORTANCE OF INNOVATIVE BIOGEOCHEMICAL TECHNOLOGIES IN THE SOIL REMEDIATION

ZNAČAJ INOVATIVNIH BIOGEOHEMIJSKIH TEHNOLOGIJA U REMEDIJACIJI ZEMLJIŠTA

Larisa Jovanović, emeritus prof. dr [1]
Vadim Ermakov, prof. dr [2]

Abstract: *Modern society is characterized by an increase in disintegration aspirations, a search for sources of energy and raw materials. In most cases, the system of consumption and production, the relationship between man and nature, and the principles of thrift, biodiversity protection and sustainable development are violated. People are constantly faced with unfavorable factors, including natural and man-made disasters, mass diseases of endocrine and viral nature. This condition largely determines the technogenic transformation of the biosphere and reflects certain changes in the social life of the population. This state of society and the biosphere as a whole can be characterized as a stage of adaptation to modern challenges. Society is faced with biogeochemical problems and they become problems of life. Biogeochemistry is a system of knowledge, a systematic science about the elemental composition of living matter and its role in the migration, transformation and concentration of chemical elements and their compounds in the biosphere, about geochemical processes involving organisms, their interaction with the geochemical environment and geochemical functions.*

Key words: *soil, pollution, oil, pesticides, DDT, HCH, PAHs, bioremediation, sorbents*

Apstrakt: *Savremeno društvo karakteriše porast dezintegracionih težnji, potraga za izvorima energije i sirovina. U većini slučajeva narušen je sistem potrošnje i proizvodnje, odnos čoveka i prirode, principi štedljivosti, očuvanja biodiverziteta i održivog razvoja. Ljudi su stalno suočeni sa nepovoljnim faktorima, uključujući prirodne i izazvane katastrofe, masovne bolesti endokrine i virusne prirode. Ovo stanje u velikoj meri određuje tehnogenu transformaciju biosfere i odražava određene promene u društvenom životu stanovništva. Ovakvo stanje društva i biosfere u celini može se okarakterisati kao faza prilagođavanja savremenim izazovima. Društvo se suočava sa biogeohemijskim problemima i oni postaju životni problemi. Biogeohemija je sistem znanja, sistematska nauka o elementarnom sastavu žive materije i njenoj ulozi u migraciji, transformaciji i koncentraciji hemijskih elemenata i njihovih jedinjenja u biosferi, o geohemijskim procesima koji uključuju organizme, njihovoj interakciji sa geohemijskom sredinom i geohemijske funkcije.*

Ključne reči: *zemljište, zagađenje, nafta, pesticidi, PCB, DDT, HCH, PAH, bioremedijacija, sorbenti*

1. INTRODUCTION

In general, the problems of society come down to the well-known triad: energy, nutrition, environmental quality. These are closely related to the state of raw materials, environmentally acceptable materials and waste disposal.

Currently, we are witnessing the 4th industrial revolution - one of the stages in the evolution of society and the biosphere (technogenesis). The development of the modern biosphere is associated with technogenesis and is accompanied by the fast formation of the technosphere. It reflects not

[1] Alfa BK University, Palmira Toljatija 3, Belgrade, e-mail: larisa.jovanovic@alfa.edu.rs
[2] Vernadsky Institute of Geochemistry and Analytical Chemistry, RAS, Moscow, Russia

only new forms of interaction between man and nature, but also the state of biodiversity and energy of the biosphere. The development of the modern biosphere is associated with the use of new materials and information technologies. As a result of the limited resources of the biosphere and "useful" space, there is a need to form a new planetary economy and strategy for the development of society.
The Fourth Industrial Revolution has included in its portfolio a large selection of new materials and innovative technologies, developed from the middle of the last century to the present. Nanorobots allow the introduction of new nanomedicine methods. A powerful innovation potential in the development of nanobiomaterials enables the successful synthesis of biological and pharmaceutical products. 3D printing enables the production of parts for machines, toys, making organs for transplantation in medicine.

The rapid development of immunotherapy, vaccines, bio-pharmacy, and stem cell application opens new opportunities for successful treatment of the most serious diseases, including COVID-19.

As predicted by Klaus Shwab [17], the Fourth Industrial Revolution will realize the applicability of many innovative technologies and new sciences methods in order to successfully combine physical, chemical, digital and biological worlds. These worlds connect many interdisciplinary sciences, first of all Life sciences: Biochemistry, Biogeochemistry and Computer sciences. The need to diversify the technology portfolio in different industrial applications requires a combination of compatible technologies and methods: nanotechnology biogeochemical methods and biotechnology, nanotechnology and biocomputing. Bio sciences play very important role in wide spheres:

- Biochemistry – study of chemical composition and analyses of essential biocomponents.
- Biogeochemistry – monitoring of water and soil composition with the purpose of determination of
  deficient microelements and prevention of viral diseases by supplements use (Se,Zn,Cu,Mg, K,Mn).
- Biotechnology - technology of drugs, supplements and vaccines manufacturing.
- Bioengineering - manufacturing of drugs, vaccines and equipment
- Nanobiotechnology – the type of technology that uses nanomaterials (1-100 nanometers) and biologically derived materials (molecules DNA, proteins).

Multidisciplinary variants of innovative technologies and innovative materials in various sectors of industry, agriculture, medicine, veterinary medicine, pharmacy, education of people during natural and technological disasters, environmental protection enable the safety of human life on the Earth. With the variations and changes of technology, the ways of work and life of people change, and thus the methods of doing business. The problem is that modern changes are happening at a speed not known before, in human history [14].

Bioeconomy is important part of economy comprehends all sectors of production connected with biological resources. The bioeconomy covers those parts of the economy that include renewable biological resources (land and marine ecosystems and the services they provide), all sectors of primary production that produce and use biological resources and all other industrial sectors that include biological resources for food production, feed, organic products, energy and services. It includes an extremely wide variety of productions, products, activities and services related to the use and management of biological resources and has very great prospects for development. Given the depletion of fossil resources, climate change and the world's growing population, sustainable and resource-efficient strategies are increasingly being sought to ensure the well-being of society. The bioeconomy is a response to these challenges, as it enables the use of biological resources and innovative technologies to replace unsustainable products and processes based on fossil resources with more sustainable ones. An important goal of the bioeconomy, in addition to reducing the consumption of non-renewable resources in production, is to reduce harmful emissions of carbon dioxide and the negative impact of industrial processes on the environment [15]. The bioeconomy

not only replaces fossil resources with renewable raw materials, but also aims to increase resource efficiency through cascading and life cycle management. This is a good way to improve the resilience of the economy.

One of the very important sectors in which organic production can develop, as part of the bioeconomy, is organic farming. Organic farming is a form of specific cultivation of plants and animals, plant and animal products, their processing into organic food and their sale on the market. According to the European Plan for Organic Food and Green agriculture, organic farming is a comprehensive production management system that promotes and strengthens the sustainability of the agrosystems, and soil biological activities. It is carried out through the use of agronomic, biological and biochemical methods, as a counterbalance to the use of microelements for increase productivity and efficiency of the agrosystem. Organic farming is a comprehensive system for management of agriculture and food production, which combines best practices in terms of environmental protection and natural resources, applies high standards and methods for the production of food, feed and more organic products, as well as animal welfare, natural substances and processes are used in accordance with the requirements and preferences of consumers [13,16].

The paper discusses the methods of soil bioremediation and the achieved results. New innovative technologies of soil bioremediation with biochar-based sorbents on which microbial cells are immobilized, which have the ability to destroy polyaromatic hydrocarbons (PAH) and adsorb heavy metals (HM), are presented. The essence of the bioeconomy and its role in the transition to sustainable and efficient economic growth are also discussed.

2. PRESENT PROBLEMS OF BIOGEOCHEMISTRY AND ITS CONSEQUENCES UNDER CONDITIONS OF THE PANDEMICS MANIFESTATION

The role of biogeochemistry is sharply increasing under conditions of the biosphere composition and function. This is a priority scientific direction. Currently, the problems of biogeochemical evolution of biosphere taxa, dynamic biogeochemistry, the interaction of macro - and trace elements in natural and technogenic cycles.

It is necessary to study a theoretical basis for the biogeochemistry in the field of bioeconomy and geochemical ecology. Diagnosis and correction of complex microelementhoses is very important. By combining the methods of molecular genetics, and biotechnology, it was possible to obtain effective microbiological preparations containing not only trace elements – iodine, selenium, copper and zinc, but also cobalt and molybdenum, which are used to correct microelementhoses in animals and man, as well as drugs that control viral pathologies.

Extensive research shows that one of the chemical elements, its deficiency in the food of humans, plays a crucially important role in the development of the currently most dangerous diseases. This element is selenium [7,11].

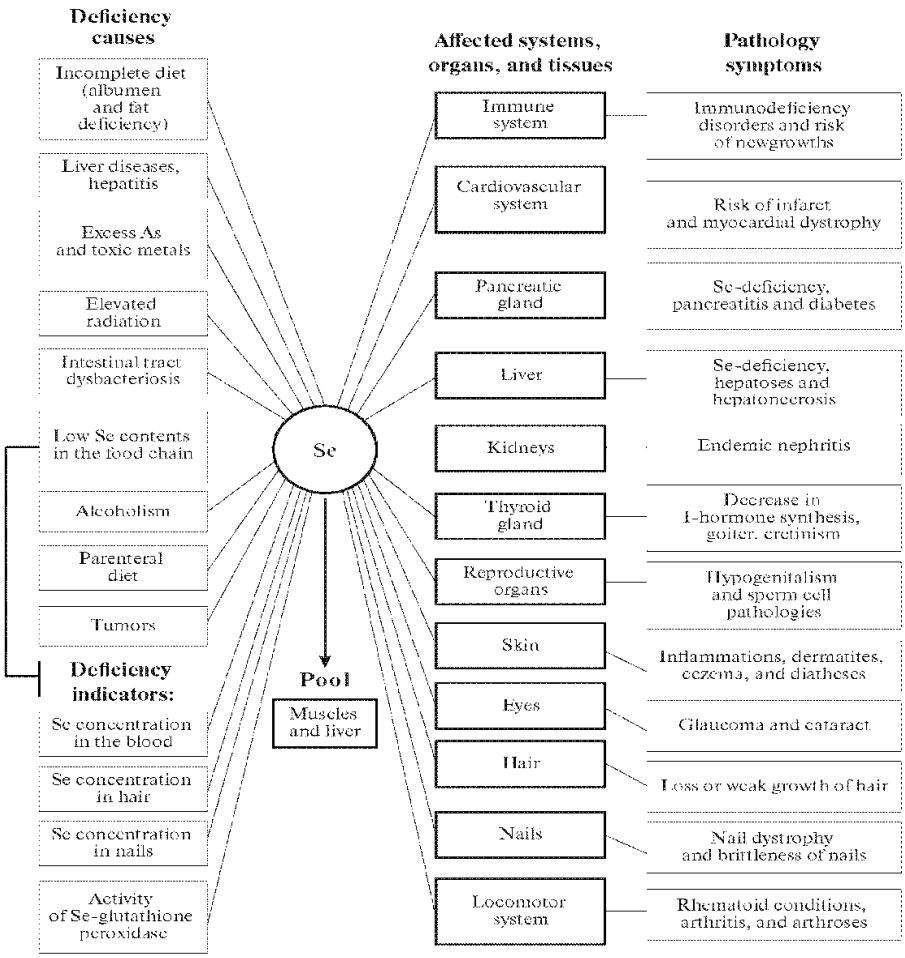


Fig. 1. Effect of Se deficiency on human health [6,7].

More than thirty animal and human pathologies, including cardiovascular and tumorous ones, are thought to be related to Se deficiency, fodder, forage, and food [8]. Selenium is necessary for the living cell to enable its growth. For example, cultures of immune and nerve cells can grow in serum free media only if Se, insulin, and transferrin are added. The main biological functions of Se are antioxidative, membrane-protecting, immune-regulating, endocrinous, and antimutagenic.

Both microorganisms and parasites are highly resistant to the effects of particularly high toxic concentrations of metal ions [9].

The secondary protective mechanism is based on the production of reactive oxygen and nitrogen by immune cells of the host, which can damage tissues and organs of the host. Furthermore, gas transmitters of nitrogen oxide and carbon oxide are involved in other metabolic processes related to the immune response.

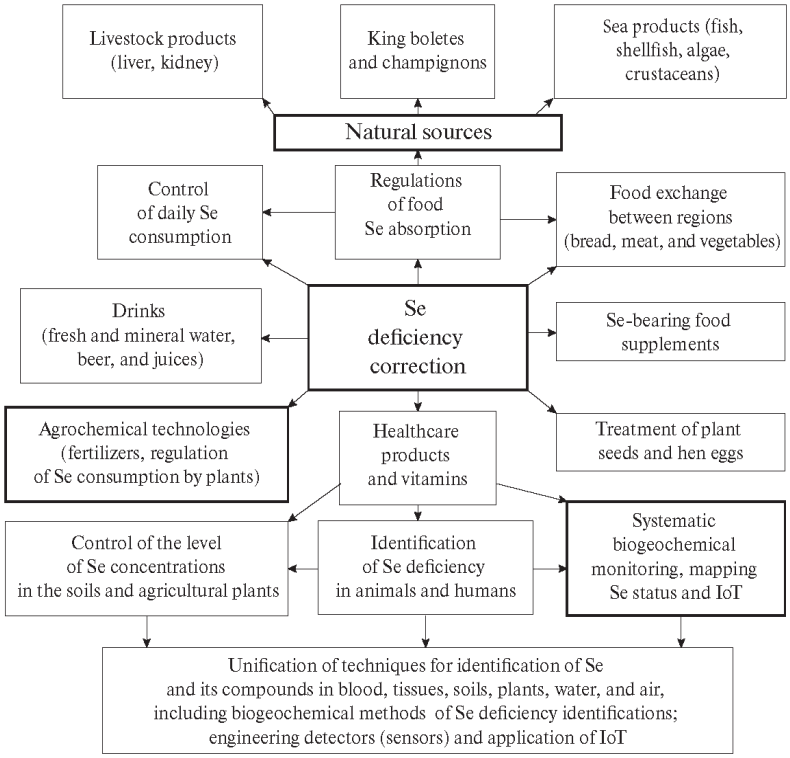


Fig. 2. Correction technologies for selenodeficiency [8].

Copper deficiency disturbs the metabolic processes, and diminish the phosphatides concentration in the white matter of the brain and disorders in the myelination of the central nervous system, (decrease in the hemoglobin concentration, partly in relation to a retardation in erythrocyte maturation and a decrease Copper in their lifetime), synthesis of elastin and collagen (damages of the connective tissues and ruptures of the aorta) [8].

Disorders in Cu metabolism and oxidative processes in tissues of the nervous system and pathological-morphological changes in them are reflected in the clinical symptoms of ataxia: the hindquarters of the lambs are unstable at standing, their movements are discoordinated at walking, and they are affected by convulsions and paralysis).

The spectrum of Cu action on microorganisms is broad. Results of independent experiments conducted at laboratories of the United States Environmental Protection Agency in compliance with approved EPA protocols have proved that more that 99.9% bacteria die on copper, brass, and bronze surfaces within 2 h. These bacteria are

- aurococcus (Staphylococcus aureus),
- aerobacter (Enterobacter aerogenes),
- coliform bacillus (Escherichia coli),
- blue pus bacillus (Pseudomonas aeruginosa),
- listeria monocytogene (Listeria monocytogenes),
- vancomycin-tolerant enterococcus [Enterococcus faecalis (VRE)],
- vancomycin- and methicillin-resistant aurococcus [meticillin-resistant Staphylococcus aureus (MRSA)],
- Clostridium difficile,

- salmonella (bacillus Gartner, Salmonella enteriditis)
- tubercle bacillus (Tubercle bacillus),
- acinetobacter Baumannii (Acinetobacter baumannii).

Copper kills grippe A virus, adenovirus, poliovirus, Candida albicans, and Aspergillus niger. No other materials, even silver-bearing, are equally efficient. Thereby COVID-19 is deactivated in copper surfaces within a few hours by Cu ions, which attack the lipid membrane of the virus, invade it, and destroy its nucleic acids.

Table 1. Physiological and biochemical properties of copper [7].

Biological role	Cytochrome-C-oxidase, ceruloplasmin, superoxide dismutase, tyrosinase, lisil oxidase, and monoamine oxidase
Uptake	>20% of the uptaken amount in stomach and small intestine
Release	With bile and urine, species specificity
Antagonists	S, Mo, Cd, Pb, Fe, P, Ca, Ag, vitamin C, fructose
Minimum requirement	4 mg/kg dry forage for monogastric animals, 8 mg/kg dry forage for ruminants, and <1 mg/kg dry food for humans, recommended 1 mg/day for adults
Deficiency symptoms	A decrease in forage consumption, growth retardation, early fatality of embryos, abortion, edema, ataxia, changes in skeleton, changes in blood vessels, depigmentation of hair, disorders of keratin synthesis, nervous disorders, myelin synthesis disorders, irregular estrum with long intervals, diarrhea, immune system weakening
Indicator organs	Brain, liver, blood serum, hair
Deficient territories	Bogged territories, peat massifs, sandy diluvium areas, granites
Excess	Sheep is very sensitive: 15 mg/kg dry forage; 100 mg/kg dry forage for cattle, and >250 mg/kg dry ration for swine
Genetic syndrome	Menke syndrome (Cu deficiency), disease of Indian children, hereditary copper intoxication (Wilson disease)

Nowadays biosphere is engulfed by technogenesis and is in a state of ecological crisis. Problems of planetary development, energy and raw material resources, food quality and the habitat of organisms in general are the determining factors of this environmental crisis. Technogenesis (anthropogenesis) of the biosphere is the transformation of biosphere taxa as a result of modern human economic activity. The total addition of anthropogenic energy to the energy released by the entire biosphere of the Earth reaches 35%, and 30% of all known resources of the planet have already been consumed. Meanwhile, the world's population is growing steadily.

The increasing scale of technogenic transformation of the biosphere stimulates scientific research in the field of nature conservation and monitoring of territories with varying degrees of anthropogenic impact. Along with the biological indication of environmental distress, technologies for biogeochemical indication and engineering biogeochemistry [1] are being developed.
People are constantly faced with adverse factors, including natural and man-made disasters, mass diseases of the endocrine and viral nature, as a result of high population density and the manifestation of unforeseen pandemics. In most cases, society faces with problems of life. This causes disruption of the connections between organisms and activation of microorganisms and viruses. The present biosphere is undergoing a state of adaptation: the stage of correction of man-made activity and the beginning of the emergence of reasonable resource-saving technologies. In this case, the state of adaptation is considered as homeostasis of the biosphere and technologies used to the bioresources are very important.

The results of scientific research in biogeochemistry are determined by the level of development of methods for analyzing substances. Despite the use of such methods as XRF, AAS, ICP emission spectrometry, ICP mass spectrometry, electrochemistry, chromatography, methods for the quantitative determination of selenium, zink, copper, iodine, fluorine, rhenium and other trace

elements are not sufficiently effective. Of particular interest are methods for determining complex compounds of microelements, metalloproteins, metalloporphyrins and other biologically active compounds.

By combining the methods of molecular genetics, biotechnology and geochemical ecology, it was possible to obtain effective microbiological preparations containing not only microelements - iodine, selenium and iron, but also cobalt and molybdenum, which are used to correct microelementosis in animals and humans. In addition, biogeochemical approaches are effective in the biotechnology of medicinal plants with a given chemical composition, in the search and extraction of rare chemical elements from dumps, and in soil reclamation.

Zinc is a very important microelement of all living organisms [8]. Children with Zn-deficiency symptoms are subject to a higher risk of growth retardation, diarrhea, and such respiratory diseases as acute infections of the lower respiratory tracts (bronchiolitis and pneumonia in children). Zinc plays an important role in processes related to immune resistance and blocking bacterial and viral pathologies.

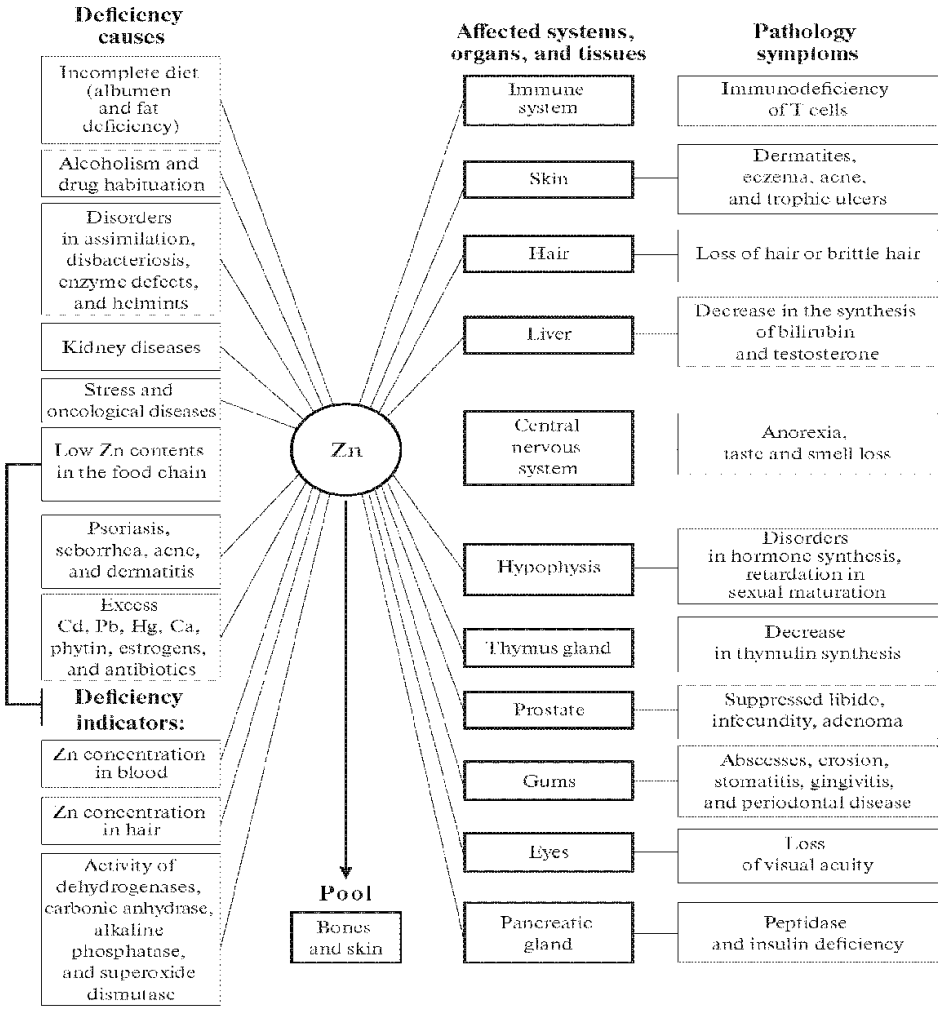


Fig. 3. Pathology symptoms and influence of Zn deficiency on human health [4,5].

3. ENVIRONMENT POLLUTION AND THE REMEDIATION OF POLLUTED SOIL

Rapid growth of industry and lack of cleaning constructions has led to the fact that a huge amount of pollutants, including pesticides, heavy metals, and antibiotics, are discharged into sewage. After treatment, wastewater is discharged into the environment. Heavy metals are commonly associated with wastewater treatment plant sludge. Sewage sludge, after disposal, is usually used as fertilizer. Heavy metals can contaminate agricultural products.

Excessive use of antibiotics has led to the development of antibiotic resistance in microorganisms. Antibiotics end up in wastewater through human and animal feces, drug waste, and effluent from pharmaceutical plants. Water treatment at wastewater treatment plants does not effectively remove antibiotics and, as a result, antibiotic-resistant bacteria may be present in wastewater. Human resistance to antimicrobial agents can occur due to mutations in bacterial DNA. Acquired resistance, resulting in the inability to treat the infection in a clinical setting, becomes a difficult problem to solve. Determination of bacterial resistance to antibiotics was carried out using the replica method on agar-agar medium containing various concentrations of antibiotics. The isolated heavy metal-resistant bacteria were assessed for multidrug resistance. One of the main sources of soil pollution is the release of various pollutants into the environment, such as heavy metals (HMs) and polyaromatic hydrocarbons (PAHs).

It has been established that the initial raw materials for the production of biochar and their modification after production largely determine the number of viable cells in the resulting biosorbent. The development of new nature-like technologies using indigenous strains of microorganisms is the most promising method for remediation of contaminated soils.

Biosorbents promote the chemical binding and degradation of pollutants through biological processes. The development of new generation biosorbents based on biochar is a promising direction in the field of environmental protection. Existing methods of neutralizing contaminants are often ineffective and require a lot of time and money. Biochar can be identified as one of the promising materials used in the remediation of contaminated soils. Biochar is an effective material for creating biosorbents because it has high surface activity and the ability to immobilize bacteria. These properties make it possible to create a new generation of biosorbents that effectively remove heavy metals and PAHs from the environment. It is known that strains of microorganisms have mechanisms due to which the degradation of PAHs is carried out, as well as the sorption of HM ions. Immobilization of bacteria on the surface of biochar will increase the efficiency of the sorbent and provide a more stable binding of pollutants [19].

An innovative technology of adsorptive bioremediation has been developed for soils contaminated with different classes of organic pollutants in different soil and climatic conditions. It is based on the use of natural sorbents for accelerated microbial degradation of some degradable pollutants through in situ activation of degrading microorganisms due to a decrease in their toxicity and an improvement of water-physical regime. In case of highly persistent pollutants carbonaceous sorbents can sharply decrease their availability due to strong binding those molecules in a nanoporous space of activated carbon or biochar.

The presence of petroleum products in soil ecosystems has a significant negative impact on the ecological functions of the soil and its fertility [1]. Petroleum hydrocarbons change the physical and chemical properties of soils, reduce the number and activity of soil microorganisms [2]. High levels of oil pollution lead to failure of seed germination and stunting of mature plant populations. Heavier oil fractions, which have significant density and viscosity, reduce the water and air permeability of soils. One of the promising areas for cleaning soils from oil and oil products is the use of biological treatment based on oil-destructing bacteria [3]. Recently, methods have been developed based on

the use of oil-degrading bacteria together with humic acids (HA) as part of bioorganic compositions [12].

Pollution of environmental objects with hydrocarbons from oil and petroleum products is one of the largest types of pollution. This work assessed the remediation ability of humic acids (HA), bacteria Rhodococcus erythropolis S67, Rhodococcus erythropolis X5, Pseudomonas fluorescens 142NF and bioorganic compositions based on them in relation to soil contaminated with oil products. Additionally, the residual content of aromatic petroleum products was determined by fluorimetry. It has been established that the maximum biodegradation of petroleum products is observed under the action of a bioorganic composition based on HA and the association of all three strains of bacteria [10].

In connection with the increasing level of chemical contamination of soils, one of the most important modern problems of biogeochemistry is the development of methods for their remediation. The most promising method of soil remediation is considered to be in situ bioremediation, based on the ability of soil microorganisms to completely decompose organic pollutants or convert them into non-toxic products. This approach is highly economical, environmentally friendly and low energy intensive. However, the choice is not always made in its favor, especially in the case of heavily contaminated soils. Most often, they resort to more radical methods of excavating contaminated soil and then burning or burying it.

The main problems of bioremediation are associated with the difficulties of adaptation of microorganisms in toxic environments, as well as with the high probability of migration of pollutants into adjacent environments. As a result of 30 years of research into the behavior of pollutants of different classes, it has been proven that the introduction of various natural sorbents can significantly expand the possibilities of soil bioremediation under “in situ” conditions The experience of many years of research on the development of biotechnology for sorption bioremediation of soils contaminated with pollutants of different classes (herbicide, petroleum products, polychlorinated biphenyls (PCBs, polycyclic aromatic hydrocarbons (PAHs)) and organochlorine pesticides: DDT and HCH is summarized [10].

Biogeochemistry of persistent pesticides – DDT, HCG, etc., studying the features of their migration and accumulation in various ecological chains (soil–water–man, soil–water–plant– man, soil–water–plant (forage) is presented–pets–human) in order to steadily reduce the negative impact of these chemicals on humans.

An innovative technology has been developed for soil bioremediation in different climatic conditions for various classes of organic pollutants. This technology based on the use of natural sorbents to accelerate the decomposition of biodegradable pollutants by “in situ” activation of microorganisms-destructors. The remediation process passed due to the reduction of soil toxicity as well as reducing the availability of highly persistent pollutants due to their strong binding in the nano-space of activated carbon or biochar [18].

4. TECHNOLOGICAL PROBLEMS OF ENGINEERING BIOGEOCHEMISTRY

SCPs are mainly associated with the development of a system of remediation and preventive measures that contribute to a stable reduction in the negative impact of SCPs on humans through various ecological chains, which include:

- zoning the soil cover of agricultural landscapes in order to identify the most contaminated areas of agricultural products based on the results of the analysis of these substances in the soil. As a criterion for appropriate zoning, the maximum permissible concentration of substances for soil or an indicator of their abnormally increased content relative to background quantities is used.

- microbiological remediation of soils in the most contaminated areas from agricultural products by liming acidic soils and applying organic fertilizer in the form of cattle manure or alfalfa green mass until the maximum permissible concentration of these substances is reached in this environment;
- diking, and planting with shrubs the most polluted areas located next to water bodies, which will delay the flow into them from the surface;
- drainage and groundwater runoff of agricultural residues;
- systematic hygienic monitoring of the content of chemical substances in drinking water and products of plant and animal origin;
- identification of the source and time of contamination of the environment and human biological substrates with the pesticides

5. CONCLUSION

The main task of engineering biogeochemistry of SCPs is to study the characteristics of their migration and accumulation in various ecological chains (soil–water–human, soil–water–plant–human, soil–water–plant (forage –domestic animals–human) in order to stable reduction of the negative impact of these chemicals on humans. The risk of the presence of SCPs in the soil is associated with their migration from soil to humans through links in food chains in which accumulation of substances occurs. Reducing the risk of migration and accumulation of SCPs in ecological chains must be done through the use of a number of remediation and preventive biogeochemical technologies.

The same goal is followed by calculating the magnitude of geo-ecological risks in the context of climate change. The obtained values characterize the probability of a change in natural vegetation (mosses and lichens are replaced by grasses and sedges, which reduces the thermoprotective properties of vegetation) in impact zones during the operation of gas production enterprises and gas pipelines. In these zones, it is also necessary to use biogeochemical technologies for the restoration of ecosystems. In most cases, these innovative technologies can be used to create test models, in agroecosystems.

The modern development of biogeochemistry is closely related to the need to assess the state of the environment and its impact on the quality of agricultural products and public health. Such assessments should be based on the results of fundamental and applied biogeochemical studies of biosphere. There is a real need to intensify the focus of biogeochemical research in connection with the relevance of developing a systems approach when studying the evolutionary transformations of the biosphere and the migration of matter in past geological eras. Currently, the problems of biogeochemical evolution of biosphere dynamic biogeochemistry, mutual influence of macro - and microelements in natural-technogenic cycles, differentiation of natural and technogenic components of cycles and the dependence of the status of macro-and microelements on the technogenic transformation of natural complexes are becoming particularly relevant. These issues are directly related to the effective correction of microelementosis and the optimal use of special food additives and microfertilizers in medicine, veterinary medicine and crop production.

Diagnosis and prevention of microelementosis is a complex and very important problem. Its solution is associated with a systematic study of the status of both individual microelements and their groups, as well as macroelements, the development and application of new methods of biochemistry, molecular biology, genetics and analytical chemistry. The processes of microelements absorption and their regulation, pool formation, and synthesis of biologically active compounds remain the most pressing issues along with the development of agrochemical and biogeochemical technologies.

It should be noted that along with establishing the high degree of contamination of certain territories with toxic metals and compounds, radionuclides, and organic substances, it is necessary to develop technologies for their detoxification and remediation. In addition, there is a gap between the description of the actual biogeochemical situation and the resulting consequences of react of organisms.

There is a need for a sharp reduction in a number of environmentally hazardous industries, the search and introduction of new materials, energy sources, and the transition to energy-saving technologies, the development of bioeconomy and a green economy. It is necessary to create National research and information and analytical centers for studying the current state of the biosphere with corresponding regional services for operational monitoring of the chemical state and quality of soils, waters, atmosphere, flora and fauna, carried out on a unified methodological basis. Such centers are an urgent need to create a unified data bank of geochemical information and conduct an independent, reasonable assessment (including economic) of the quality of the living environment within the framework of government digitalization programs. To solve multidisciplinary problems, it is advisable to create complex biogeochemical groups or scientific associations that include specialists in various fields.

REFERENCES

[1] Башкин, В.Н. (2018), Инженерная биогеохимия и биогеохимические технологии, Инноватика и экспертиза, 23(2), 140-144.

[2] Bashkin, V.N., Galiulina, R.A. (2023), Biogeochemical technologies for the reclamation of poluted and disturbed soils in gas-oil industry impacted areas, Ecologica, 30(112), 617-624, doi: 10.18485/ecologica.2023.30.112.15.

[3] Bashkin, V.N. (2022), Biogeochemical Engineering: Technologies for Managing Environmental Risks. Adv. Environ. Eng. Res. 3(4), 040, doi:10.21926/aeer.2204040.

[4] Ermakov, V., Jovanović, L. (2023), The importance of biogeochemistry in environmental protection and green growth. In: L. Jovanović, V. Ermakov, S. Ostroumov (Eds.), Second International Thematic Monograph: The role of green economy transition in green growth and environmental protection, Ecologica, Belgrade, pp. 1-28. doi:10.18485/ tgesd.2023.2.ch1.

[5] Ermakov, V.V., Jovanović, L.N. (2010), Biodiversity and the biosphere technogenesis, Ecologica, 17(58). 77-85.

[6] Ermakov, V.V., Jovanović, L.N. (2010), Selenium deficiency as a consequence of human activity and its correction, J. Geochem. Explor. 107(2), 193-199.

[7] Ermakov, V.V., Jovanović, L.N. (2022), Biological role of trace elements and viral pathologies, Geochemistry International, 60(2), 93-109.

[8] Ермаков, В.В., Тютиков, С.Ф., Сафонов, В.А. (2018), Биогеохимическая индикация микроэлементозов. Москва, изд. РАН.

[9] Gabrashanska, M., Tsocheva-Gaytandzhieva, N., Nanev, V. (2016), Selected trace elements in experimental fasciolosis with diethylnitrosamine treatment, Ecologica, 23(83), 525-528.

[10] Галиулин, Р.В., Башкин, В.Н., Галиулина, Р.А. (2015), Агрогеохимия стойких пестицидов, Вестник Российской академии наук, 85(2), 152-154

[11] Golubkina, N.A., Sindireva, A.V., Zaitsev, V.F. (2017), Intraregional variability of seleniumn status of the population, Med. Ekologiya, 12(1), 107-127.

[12] Герцен, М.М., Переломов, Л.В. (2023), Ремедиация нефтезагрязненных почв биоорганическими композициями на основе гуминовых кислот, В: Эволюция биосферы, биогеохимические циклы и биогеохимические технологии: связь фундаментальных и прикладных исследований. Материалы Международной биогеохимической школы-конференции, Пущино, 25-29.09.2023. Пущинский научный центр биологических исследований, Институт физико-химических и

биологических проблем почвоведения РАН, Институт геохимии и аналитической химии РАН, Пущино, 2023, стр. 272-275.
[13] Janković, M., Bogdanović Jović, A., Ivannikov, N., Kijački, D. (2023), Organic production as a concept of preserving the ecological specificities of rural areas. Ecologica, 30(110), 224-230, doi:10.18485/ecologica.2023. 30.110.8.
[14] Јовановић, Л., Лукиновић, М. (2019), Примена иновација у 4. индустријској револуцији, Ecologica, 26(95), 427-431.
[15] Pavićević, N. (2023), Creating a model of the process of improving the development of the green economy concept: IDEF methodology application, Ecologica, 30(111), 409-414, doi:10.18485/ecologica.2022.30.111.9.
[16] Ristić, L., Despotović, D., Veselinović, P. (2022), Organic agriculture as a factor in the development of green economy. Ecologica, 30(112), 505-515, doi:10.18485/ecologica.2023.30.112.1
[17] Schwab, K. (2017), The Fourrh Industrial Revolution, World Economic Forum.
[18] Vasilyeva, G. et al. (2022), Use of natural sorbents for accelerated bioremediation of grey forest soil contaminated with crude oil, Sci. Total. Environ. 850, N157952, doi:10.1016/j.scitotenv.2022.157952.
[19] Загайнов, Е.А., Бояршинов, В.А., Козьменко, С.В., Лобзенко, И.П., Горовцов, А.В., Минкина, Т.М. (2023), Иммобилизация бактерий на биоугле для создания биосорбентов нового поколения, В: Эволюция биосферы, биогеохимические циклы и биогеохимические технологии: связь фундаментальных и прикладных исследований. Материалы Международной биогеохимической школы-конференции, Пущино, 25-29.09.2023. Пущинский научный центр биологических исследований, Институт физико-химических и биологических проблем почвоведения РАН, Институт геохимии и аналитической химии РАН, Пущино, 2023, стр. 276-279.

MARKET TRENDS IN MEAT AND MEAT PRODUCT PRICES: ANALYZING THE COST PRICE OF ENERGY VALUE IN MEAT PRODUCTS

TRENDOVI PROMENA TRŽIŠNIH CENA MESA I PROIZVODA OD MESA: ISPITIVANJE CENE KOŠTANJA ENERGETSKE VREDNOSTI PROIZVODA OD MESA

Tamara Stamenić, research assistant [1]*
Maja Petričević, research associate [2]
Tanja Keškić, research associate [3]
Boris Pisinov, research associate [4]
Ljiljana Samolovac, senior research associate [5]
Zoran Sekulić, PhD - environmental protection engineer [6]
Andrijana Milošević Georgiev, Assistant Professor [7]

Abstract: *This study provides an overview of food prices in the Republic of Serbia from 2016 to 2023 amidst the challenges faced by the meat processing industry. Household spending trends reveal a notable shift, marking an increase since 2016. The study explores meat products' affordability and nutrient density, challenging conventional assumptions. Mortadella emerges as the most nutrient-dense despite its lower calorie content due to high protein content, while pâté commands a higher market price despite its lower nutrient quality.*

***Key words**: price trends, meat processing industry, nutrient density, energy density*

Apstrakt: *Studijom je obuhvaćen pregled cena hrane u Republici Srbiji od 2016. do 2023. godine i uticaj izazova sa kojima se suočava mesna industrija. Trendovi potrošnje domaćinstava otkrivaju promenu, označavajući porast u odnosu na 2016. Studija istražuje pristupačnost mesnih proizvoda i gustinu nutrijenata, dovodeći u pitanje konvencionalne pretpostavke. Mortadela se izdvaja kao namirnica sa najboljim odnosom cene u odnosu na nutrijente uprkos nižem sadržaju kalorija usled visokog sadržaja proteina, dok pašteta ima višu tržišnu cenu uprkos nižem kvalitetu hranljivih materija.*

Ključne reči: *trendovi cena, industrija prerade mesa, gustina hranljivih materija, gustina energije*

[1] Institute for Animal Husbandry, Autoput Beograd – Zagreb 16, 11080 Belgrade, Serbia, e-mail: tstamenic@istocar.bg.ac.rs, (*Corresponding author)
[2] Institute for Animal Husbandry, Autoput Beograd – Zagreb 16, 11080 Belgrade, Serbia, e-mail: mpetricevic@istocar.bg.ac.rs
[3] Institute for Animal Husbandry, Autoput Beograd – Zagreb 16, 11080 Belgrade, Serbia, e-mail: tkeskic@istocar.bg.ac.rs
[4] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia, e-mail: boriss752002@yahoo.com
[5] Institute for Animal Husbandry, Autoput Beograd – Zagreb 16, 11080 Belgrade, Serbia, e-mail: ljsamolovac@istocar.bg.ac.rs
[6] Institute of Public Health of Belgrade, Bulevar Despota Stefana 54a, 11108 Belgrade, Serbia, e-mail: zoran.sekulic@zdravlje.org.rs
[7] Faculty of Pharmacy, University of Belgrade, Vojvode Stepe 450, 11221 Belgrade, Serbia, e-mail: andrijana.milosevic@pharmacy.bg.ac.rs

1. INTRODUCTION

While the global community is in the process of recovering from the impact of the recent pandemic COVID-19, this rebound is taking place unevenly both among and within countries. Compounding these challenges, the world is currently contending with the ramifications of the ongoing conflict in Ukraine, causing significant disruptions in food price markets. Agricultural and food systems continue to be highly susceptible to shocks and disturbances stemming from conflicts, on and off going animal diseases, and economic downturns [1]. As urbanization and incomes continue to rise, households typically consume larger and more varied amounts of food. This includes dairy, fish, meat, legumes, fresh fruits and vegetables, along with an uptick in the consumption of processed foods [2,3]. This, coupled with population growth, signals significant escalations in the production and supply of specific food types to meet the heightened demand.

A confluence of factors, including elevated feed prices, diseases, and surging global demand, has led to unprecedented increases in the prices of beef and pork, thereby impacting the prices of meat and meat products in the Republic of Serbia's market as well.

Researchers exploring the relationship between nutrient density and the monetary cost of foods require access to comprehensive data on both nutrient composition and pricing. Dietary energy density [4] has also been employed as a metric for assessing diet quality. An analysis that linked fifty food prices to dietary survey data from the Val de Marne study [4,5] demonstrated that higher-quality diets were linked to increased energy-adjusted diet costs [4].

Several studies have consistently shown that specific food and nutrient intakes are inversely correlated with energy-adjusted diet costs. Diets rich in energy-dense foods (kcal/100 g), often characterized by higher sugar and fat content (typically considered more affordable raw materials), tend to have lower diet costs per 100 kcal. This pattern is often a result of compensating for the lack of nutrient-rich components such as animal-source proteins, vegetables, or fruits [4,6].

This research aimed to provide an overview of the present condition of food prices on the market of the Republic of Serbia, particularly those related to meat and meat products, concerning consumer income and inflation levels spanning from 2016 to 2023. Additionally, the study sought to reassess the current market prices of chosen meat products through comparative metrics for food costs. It also aimed to examine cost-to-energy ratios and protein-to-fat ratios to ascertain whether nutrient-dense meat products are appropriately priced.

2. MATERIAL AND METHODS

The paper is divided into two sections: the first involves data collection and subsequent discussion, focusing on average household budgets, yearly net salary growth, and expenditures on food and beverages. Special attention is given to meat and meat products, along with tracking the inflation rate of these products in relation to the average net salary growth. The second section utilizes surveys to delve into the prices of commonly available processed meat products in the market. It involves calculating their average price, as well as their average energy, protein, and fat content. Ratios of different nutrients, such as protein and fat, compared to overall energy, are also computed. Additionally, in the paper we calculated the price (in EUR) compared to the energy content of these products.

We conducted a literature search using data from the Statistical Office of the Republic of Serbia, including Household Budget Surveys spanning 2016 to 2023. Additionally, direct communication with support services was utilized. Our aim was to gather information on average household size, net income (excluding non-monetary income), prices of selected meat varieties and processed meat

products, and meat consumption per household for the period of 2016-2022, considering both urban and rural regions.

A formal inquiry was made to the Statistical Office of the Republic of Serbia to obtain data on the inflation rate of meat and processed meat products. Calculations for meat and meat product consumption per capita were derived from the average household size and the household consumption data. Monthly household income and budgets allocated for food and beverages, meat (poultry, pork, beef), and processed meat products were converted to euros using a conversion rate of 1 EUR = 118 RSD (Serbian Dinar).

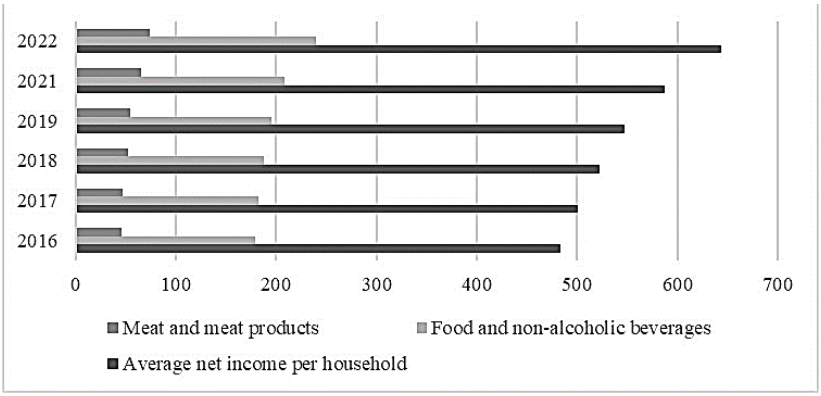
Meat product retail prices and nutrient composition information were sourced from supermarkets and the Internet. Researchers adhered to a pricing protocol, obtaining prices from at least two supermarket or hypermarket chains (or their websites) and calculating the average price for each item. Family-sized packaging was prioritized when making selections. In cases where prices were sourced from a food cost survey conducted from the market, the average price (weighted mean by quantities bought) was determined. The prices of the products were selected to accurately reflect the current pricing landscape (data was collected over a 7-day period at the beginning of January 2024, considering only the full prices of the products).

Nutrient composition data provided by manufacturers allowed us to calculate each item's energy value (kcal/100g) [7]. The energy value, protein-fat ratio, the purchase price (converted to euros from the domestic currency), and the energy cost for selected items were then expressed for the chosen meat products [6].

3. RESULTS AND DISCUSSION

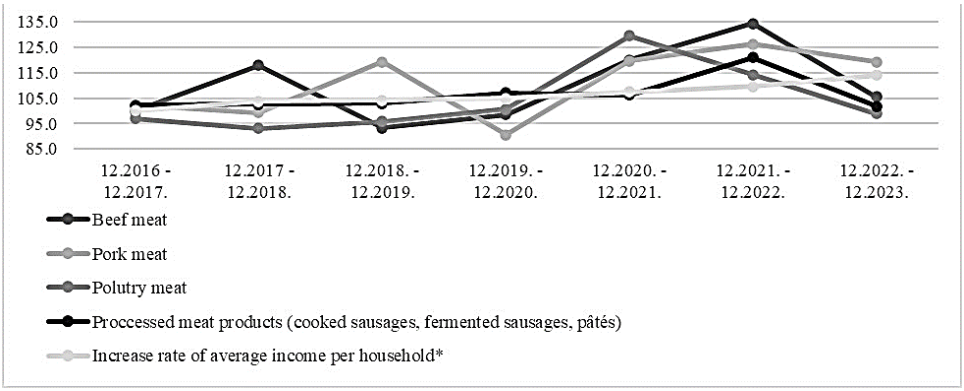
Household Spending on Meat Products and the Impact of Global Dynamics on the Meat Processing Industry

In order to gain a better insight into average annual expenditure on food and beverages, particularly the allocation of meat and processed meat products concerning the annual average wage, we searched through the existing datasets offered by the Statistical Office of the Republic of Serbia. While many studies on household expenditure patterns tend to concentrate on broader categories of goods [6,8,9], often treating food and beverages as a single aggregate class marked at a status of necessary goods, a limited number of studies have undertaken a more detailed examination of food consumption. Graph 1 presents the average monthly spending per household compared to net income (EUR). The data used are the 2016-2023 Household Budget Survey for the Republic of Serbia, covering 37645 households over a 7-year period (except for 2020, which was skipped due to the COVID-19 pandemic). The primary benefit of utilizing these methods over individual diet and nutritional data lies in the fact that individuals are queried about their purchases rather than directly about their eating habits. This approach makes the interview process feel less intrusive, reducing the likelihood of individuals providing inaccurate information intentionally [10].



Graph 1. Average monthly spending per household compared to average net income (EUR)

We displayed the price trends, represented as the inflation rate (% change/year) from 2016 to 2023 for meat and processed meat products (we considered the cumulative price trend for all processed meat products, encompassing fermented and cooked sausages, as well as pâtés), concerning the annual growth in income (refer to Graph 2). Additionally, our analysis incorporated the prices of poultry, pork, and beef meat, given their significance as primary components of the meat processing industry. In the Republic of Serbia, households allocated more than a third of their disposable income (36%) to food and beverages in the past year, marking an increase compared to 2016, when this expenditure was almost 2% lower.



Graph 2. Inflation rate of the goods compared to income net growth

Our analysis showed that in the years preceding pandemic, specifically from 2016 to 2019, the average monthly consumption per household (inclusive of both urban and rural areas) showed a 2% decrease when compared to the post-COVID-19 period.

As reported by FAO [11], the outbreak of African swine fever began affecting Asian countries in late 2018 and persisted through 2019 and 2020. This significantly contributed to a substantial decline in global pig meat production between 2018 and 2019, particularly impacting China, and continued to impede production in 2020 and 2021 across Europe. However, there was a resurgence in pig meat production in late 2021, leading to a robust increase in global meat production.

In the Republic of Serbia, despite the initial detection of African swine fever in late 2019 along the borders with Romania and Bulgaria within the wild boar population, a substantial 1637 outbreaks in domestic pigs were reported from September 2020 to August 2021 [12]. This situation triggered widespread slaughters across the county, significantly impacting the overall prices of pork meat. Notably, there was a significant surge in prices of pork, with inflation rates reaching 119.7% and 126.3% in mid-2020 and 2022, respectively. Given that pork meat is a primary raw material used in the meat processing industry (along with poultry meat), the prices of meat products followed this spike with a +121% inflation rate within the period of December 2021 to December 2022. This marks a notable increase compared to the previous year when the inflation rate stood at 106% (Graph 2).

Meanwhile, the beef industry in the EU faced mounting challenges related to campaigns advocating for a reduction in red meat consumption, linking red/beef meat with environmental protection, and highlighting its negative impact on climate change. Over the past two decades, there has been a noticeable trend of a continuous decline in the number of cattle [13], reaching its lowest level in 2021 [14]. In contrast, chicken meat production experienced the most significant growth since 2000 and became the most produced type of meat in 2021, according to FAO [11].

The FAO Food Price Index, which monitors monthly fluctuations in the international prices of globally-traded food commodities, recorded its highest value ever between May 2020 and March 2022 [15]. This surge was attributed to a combination of factors, including the repercussions of the COVID-19 pandemic on supply chains, the resurgence in activity and demand experienced in 2021, and disruptions to exports from the Russian Federation and Ukraine (major suppliers of crops used for animal feed) [11]. These global shifts have significantly influenced the meat processing industry, as the prices of meat products continue to mirror the fluctuations in prices in relation to the accessibility of meat (Graph 2).

Coalescing meat product prices with nutrient composition data – the current state of the market

The data on expenditure of food purchased for 256 meat products was recorded (Table 1). We estimated the affordability of processed meat products by energy density and nutrient quality. Assessing the financial impact of meat products based on retail prices, whether local or national, may not always paint dietary trends or health implications. For instance, the decrease in particular food prices in Brazil [8] and Mexico [9] has been associated with an increase in obesity rates and different cardiometabolic diseases. However, a decline has mainly been observed in the prices of energy-dense, less healthy, items such as sweetened beverages and sweetened grains [9]. In contrast, the prices of fresh meat continue to rise [8, 9]. In France, vegetable prices have surged, while dietary fat prices have declined [6]. Conversely, our research in Serbia revealed a significant spike in meat prices, while the average cost of animal fat remained stagnant over the study period, accompanied by a minimal inflation rate (+100.8%) compared to 2016 (data not presented in this paper).

Comparative metrics for food costs have been established based on energy and nutrient content per 100g of the edible portion. Table 1 illustrates the energy density (in kcal/100g), the price (EUR/100g), and the energy cost (EUR/100kcal) of selected meat products commonly available in Serbian retail stores. Given the economic significance of achieving 2000 kcal/ day at a reasonable cost, the preferred strategy for comparing food prices is per calorie rather than per serving or unit weight [6].

Generally, studies have shown that the average price per 100 kcal for ultra-processed foods such as some grains, fats, and sweets are linked to lower per-calorie food costs, whereas animal-sourced

proteins, some meat products, fruits, and vegetables (processed foods and unprocessed/minimally processed foods) tend to have higher per-calorie food costs [6, 16].

Table 1. Analysis of average energy content, protein to fat ratio, fat to energy and protein to energy value ratio, purchase price, and cost of energy for selected meat products in the Serbian market.

Name of the product (sample size, N)	Energy value (kcal/100g)	Protein/ Fat ratio	Fat to energy value ratio	Protein to energy value ratio	Purchase price (EUR/ 100 g)	Cost of energy (EUR/ 100 kcal)
Dry-fermented sausages						
Čajna sausage, N=10	430	6.78	76.1	20.6	1.64	0.42
Kulen sausage, N=11	432	6.66	78.6	20.9	1.57	0.48
Sucuk sausage, N=4	394	8.16	73.1	23.9	2.05	0.52
Salami sausage*, N=27	422	6.93	77.5	21.5	1.90	0.45
Emulsion-type cooked sausages						
Hot dogs*, N=46	286	5.55	79.7	17.7	0.75	0.26
Mortadella, N=11	241	7.89	71.0	22.4	1.20	0.50
Parizer*, N=39	201	6.50	87.4	22.7	0.56	0.28
Alpska sausage*, N=18	236	7.28	73.9	21.5	0.65	0.27
Grill sausage*, N=43	284	6.49	76.6	19.9	0.99	0.35
Boiled sausages						
Pâté (* all categories) N=47	290	4.16	82.4	13.7	1.12	0.39

Products labeled with * correspond to categories categorized as "under a different name" according to the Rulebook [17].

Studies on the relative cost of energy-dense versus nutrient-dense foods heavily rely on accurate metrics of nutrient density. Recent advances in nutrient profiling techniques have allowed for a more objective assessment of the nutritional value of different foods [6, 18, 19]. Foods can be ranked or rated based on their nutrient content relative to calories. Numerous studies based on databases have consistently shown that higher nutrient density scores are directly associated with higher per-calorie costs. In essence, more nutrient-rich foods tend to be more expensive per kcal than foods with lower nutritional value [6, 18].

Similarly, our research has identified consistent patterns—specifically, the cost of energy (EUR/100 kcal) aligning with trends observed in the calculated protein-to-fat ratio and the energy value (kcal/100g) of meat products. Dry-fermented sausages, in particular, exhibited a higher cost of energy, nearly doubling the energy value compared to other groups, except for Mortadella. Despite its lower calorie content per 100 g, Mortadella exhibited a higher cost of energy, potentially attributable to its elevated protein-to-fat ratio—ranking highest among all the groups. Hence, it could be regarded as the most nutrient-dense food among the groups under study. Furthermore, the purchase price followed a similar trend, with one notable exception and irregularity observed in the pâté category. The cost of energy and, consequently, the purchase price per 100 g were assessed as exceptionally high for pâté based on its energy value and the protein-to-fat ratio, which was the

lowest among the groups. This irregularity in pricing may be attributed to the cost of packaging (typically canned, as opposed to other meat products considered in this research, which are usually packaged in natural or plastic casings that are more cost-effective), a factor not accounted for when calculating the final price-to-energy ratio.

4. CONCLUSION

The findings underscore the complex interplay between global events and market dynamics. This study elucidates the nuanced landscape of food prices in the Republic of Serbia from 2016 to 2023, as well as intricate challenges for the meat processing industry. Navigating the impacts of the uneven recovery from pandemic and the ongoing conflict in Ukraine on global food markets, environmental concerns, and African swine fever outbreak that has led to surging meat prices with rise of inflation rates. Household spending patterns reveal a notable shift, with 36% of disposable income directed toward food and beverages in the past year, signaling a significant increase since 2016.

Moreover, the study delved into meat products' affordability and nutrient density, utilizing metrics such as energy density, protein-to-fat ratio, and cost-to-energy ratios. Findings challenge conventional assumptions, and raise some questions about pricing of certain meat products on the market.

As we navigate these complexities, understanding the nuanced relationship between nutrient density and the cost of food becomes pivotal for informed policy decisions and consumer education. According to the authors' knowledge, surveys on consumers' motivations for purchasing meat and meat products, along with insights into the factors influencing their food choices in the Republic of Serbia, are yet to be conducted. Therefore, this research offers a foundation for future studies and policy considerations in the ever-evolving meat processing industry.

5. ACKNOWLEDGMENT

This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, on the basis of the Agreement on the realization and financing of scientific research work of SRO No. 451-03-47/2023- 01/200022.

REFERENCES

[1] FAO, IFAD, UNICEF, WFP, and WHO, (2023), The State of Food Security and Nutrition in the World 2023, Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum, FAO, pp. 18-20
[2] Abay, K. A., Tiberti, L., Woldemichael, A., Mezgebo, T. G., Endale, M., (2023), Can Urbanisation Improve Household Welfare? Evidence From Ethiopia, Journal of African Economies, 32(1), pp. 81-109.
[3] van Zutphen, K. G., Barjolle, D., van den Berg, S., Gavin-Smith, B., Kraemer, K., Musard, C., Prytherch, H. Woltering, K., (2023), Secondary cities as catalysts for nutritious diets in low-and middle-income countries, Science and Innovations for Food Systems Transformation, pp. 305-316.
[4] Darmon, N., Briend, A., Drewnowski, A., (2004), Energy-dense diets are associated with lower diet costs: a community study of French adults, Public health nutrition, 7(1), pp. 21-27.
[5] Drewnowski, A., Darmon, N., Briend, A., (2004), Replacing fats and sweets with vegetables and fruits—a question of cost, American journal of public health, 94(9), pp. 1555-1559.
[6] Darmon, N., Drewnowski, A., (2015), Contribution of food prices and diet cost to

socioeconomic disparities in diet quality and health: a systematic review and analysis, Nutrition reviews, 73(10), pp. 643-660.
[7] European Parliament and Council. Regulation (EU) No. 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, Official Journal of European Union, 2011, L304, pp. 18–63.
[8] Mello, A. V. D., Sarti, F. M., Fisberg, R. M, (2022), Associations among diet costs, food prices and income: Elasticities of risk and protection food groups for cardiometabolic diseases in Sao Paulo, Brazil (2003–2015), Nutrition and Health, 02601060221104579.
[9] Batis, C., Gatica-Domínguez, G., Marrón-Ponce, J. A., Colchero, M. A., Rivera, J. A., Barquera, S., Stern, D., (2022), Price trends of healthy and less healthy foods and beverages in Mexico from 2011–2018, Journal of the Academy of Nutrition and Dietetics, 122(2), pp. 309-319.
[10] De Agostini, P, (2014), The effect of food prices and household income on the British diet, ISER Working Paper Series No. 2014-10
[11] FAO, (2023), World Food and Agriculture-Statistical Yearbook 2023, FAO, Rome, pp.16-17
[12] Prodanov-Radulović, J., Mirčeta, J., Djurdjević, B., Lazić, S., Aleksić-Kovačević, S., Petrović, J., Polaček, V., (2023), African Swine Fever Outbreak in an Enclosed Wild Boar Hunting Ground in Serbia, Pathogens, 12(5), 691.
[13] Kučević, D., Brka, M., Plavšić, M., Čobanović, K., Papović, T., Gantner, V., (2023), Organic beef production as a sustainable solution for the EU market: A case study of the Republic of Serbia, Biotechnology in Animal Husbandry, 39(1), pp. 1-14.
[14] EUROSTAT (2021): Organic Farming Statistics. Available at: https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Organic_farming_statistics#Organic_production (assessed on 29.12.2023.)
[15] FAO, (2023), FAO Food Price Index, FAO, Rome.
[16] Vandevijvere, S., Pedroni, C., De Ridder, K., Castetbon, K., (2020), The cost of diets according to their caloric share of ultraprocessed and minimally processed foods in Belgium, Nutrients, 12(9), 2787.
[17] Rulebook on minced meat, semi-finished, and meat products ("Official Gazette RS", No. 50/2019 and 34/2023).
[18] Maillot, M., Darmon, N., Darmon, M., Lafay, L., Drewnowski, A., (2007), Nutrient-dense food groups have high energy costs: an econometric approach to nutrient profiling, The Journal of nutrition, 137(7), pp.1815-1820.
[19] Drewnowski, A., Dwyer, J., King, J. C., Weaver, C. M., (2019), A proposed nutrient density score that includes food groups and nutrients to better align with dietary guidance. Nutrition reviews, 77(6), pp. 404-416.

AGRO-PROCESSING INDUSTRY: ADVANCED TECHNOLOGIES FOR MEAT INDUSTRY WASTEWATER TREATMENT: A REVIEW

AGRO-PRERAĐIVAČKA INDUSTRIJA: NAPREDNE TEHNOLOGIJE ZA PREČIŠĆAVANJE OTPADNIH VODA MESNE INDUSTRIJE: PREGLEDNI RAD

Tanja Keškić, research associate[1]*
Maja Petričević, research associate[2]
Tamara Stamenić, research assistant[3]
Violeta Mandić, principal research fellow[4]
Nikola Delić, research associate[5]
Boris Pisinov, research associate[6]
Sanja Đurović, research associate[7]

Abstract: *Wastewater from the meat industry contains high concentrations of organic matter. The composition of these wastewaters depends on the type of meat being processed, the frequency of slaughtering, the size of the plant, and the disinfectants used to maintain hygiene. In order to achieve satisfactory wastewater quality and reduce environmental pollution, the agroindustry applies and develops different technologies for wastewater treatment. This review paper provides a literature overview of some of the most commonly used methods in wastewater treatment within the meat industry.*

Key words: *agro-industry, wastewater, meat industry, purification*

Apstrakt: *Otpadne vode mesne industrije sadrže visoke koncentracije organskih materija. Sastav ovih otpadnih voda zavisi od vrste mesa koje se obrađuje, učestalosti klanja, veličine pogona i dezinficijenasa u cilju održavanja higijene. Da bi se postigao zadovoljavajući kvalitet otpadne vode i smanjilo zagađenje životne sredine, agroindustrija primenjuje i razvija različite tehnologije u tretmanima otpadnih voda. Ovaj pregledni rad daje literaturni pregled nekih najčešće korišćenih metoda u tretmanima otpadnih voda u industriji mesa.*

Ključne reči: *agroindustrija, otpadne vode, industrija mesa, prečišćavanje*

[1] Institute for Animal Husbandry, Autoput Belgrade - Zagreb 16, 11080 Belgrade, Serbia, e-mail: tkeskic@istocar.bg.ac.rs (*Corresponding author)
[2] Institute for Animal Husbandry, Autoput Belgrade - Zagreb 16, 11080 Belgrade, Serbia, e-mail: mpetricevic@istocar.bg.ac.rs
[3] Institute for Animal Husbandry, Autoput Belgrade - Zagreb 16, 11080 Belgrade, Serbia, e-mail: tstamenic@istocar.bg.ac.rs
[4] Institute for Animal Husbandry, Autoput Belgrade - Zagreb 16, 11080 Belgrade, Serbia, e-mail: vmandic@istocar.bg.ac.rs
[5] Institute for Animal Husbandry, Autoput Belgrade - Zagreb 16, 11080 Belgrade, Serbia, e-mail: ndelic@istocar.bg.ac.rs
[6] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia, e-mail: boriss752002@yahoo.com
[7] Institut for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia, e-mail: stojakovicsm@yahoo.com

1. INTRODUCTION

The main factor contributing to environmental pollution, both in developing and developed countries, is the rapid development of the agro-processing industry. This issue is particularly pronounced in developing countries, where approximately 90% of wastewater is directly discharged from industrial plants without prior treatment [1]. The swift growth of the agro-processing industry, coupled with the rapid advancement of technology, has resulted in the generation of large amounts of industrial and communal wastewater flowing into canals, lakes, or rivers, ultimately reaching groundwater. The primary challenge lies in the insufficiently rapid development of wastewater purification techniques in relation to the agro-industry's swift growth, leading to significant pollution of both surface and underground waters. Statistical data concerning the treatment of wastewater in Serbia, particularly in the meat industry, as well as in all other branches of agro-industry, is concerning [2]. According to 2019 statistics, a total of 119 million m^3 of wastewater from various industries was discharged in Serbia. Of this, 47% originates from the processing industry sector alone, with only 5%-8% of the wastewater being treated. The meat industry alone utilizes about 25% of the total water compared to other food and beverage processing industries [3] (Table 1). In Europe, Belgrade stands out as the only capital city without a wastewater treatment plant [4]. Currently, a global combined approach to wastewater management is being implemented. The member states of the EU, Norway, and the European Commission have collaboratively developed a joint strategy to support the implementation of Directive [5], establishing a framework for Community action in the field of water (Framework Directive on Water - Framework Directive 2000/60/EC). This strategy includes the control of emissions and the establishment of environmental quality standards [5].

Table 1. Water use in processing industries

Food industry - processing	Water use (%)
Meat	25
Milk	13
Drinks	12
Fruit	10
Vegetables	9
Oils	8

This Directive regulates the collection and treatment of urban wastewater and water from certain industries [6]. The most significant environmental challenge arises from agro-industrial wastewater, characterized by a high content of organic substances such as total nitrogen, total phosphorus, phenols, total salts, solids, sulfides, heavy metals, chemical oxygen consumption and biochemical oxygen consumption [7].

The growing concern for environmental protection has led to the introduction of strict legal environmental regulations and the adjustment of emission limit values defining the quality of discharged wastewater (effluent standards). Among various types of agro-industries, the meat and meat products industry are identified as one of the three major polluters of the environment, alongside the milk processing industry and the beverage industry [8].

In 2004, the US Environmental Protection Agency (US EPA) identified wastewater from meat industry slaughterhouses as one of the most harmful types for the environment. This wastewater poses a significant environmental challenge due to its high content of suspended organic solids and concentrated nutrients, including animal blood, fatty tissue residues, hair, animal skin residues, and slaughterhouse disinfectants [9]. Meat industry wastewater contains aerobic and anaerobic bacteria, both pathogenic and non-pathogenic [10]. These substances are the primary contributors to unpleasant odors in wastewater.

To mitigate environmental pollution resulting from the discharge of wastewater from slaughterhouses and other meat industry plants, new anaerobic wastewater treatment technologies, such as anaerobic digestion, are being developed. Environmentally friendly anaerobic biotechnologies offer superior treatment options compared to conventional aerobic technologies, given their cost-effectiveness and economic benefits [11].

2. DIFFERENT TECHNOLOGIES IN THE TREATMENT OF WASTEWATER OF THE MEAT PROCESSING INDUSTRY

The technology applied in the treatment of industrial wastewater primarily depends on the observed characteristics of the wastewater. Purifying wastewater from the meat industry is highly complex due to the presence of proteins, fibers, lipids, blood, intestinal mucus from the slaughter process, various microorganisms, and detergents and disinfectants left behind during the washing of slaughterhouses and facilities [12, 13]. Wastewater quality control helps prevent eutrophication and the pollution of surface and underground waters with heavy metals and toxic compounds, thereby minimizing their presence in the food chain [14].

Factors influencing the selection of the most efficient, suitable, and cost-effective technology in wastewater treatment include the composition and amount of wastewater, plant capacity, and financial considerations. It has been demonstrated that the best results are achieved with combined processes tailored to individual plants and their wastewater. Before any wastewater treatment, mechanical wastewater treatment is performed initially, involving the removal of large and solid components and particles from the wastewater generated during meat processing [13].

The removal of remaining particles, such as finely suspended particles of fat and oil, is carried out through sedimentation or floating, using various methods like dissolved air flotation, ecocoagulation and flocculation, electrocoagulation, phytoremediation, membrane processes, and anaerobic and aerobic biological treatment [15].

2.1. AEROBIC AND ANAEROBIC PROCESSES IN WASTEWATER TREATMENT

Various aerobic and anaerobic biological processes are employed to eliminate organic substances in wastewater, including nitrogen (via nitrification and denitrification), organic fractions of sludge, and the decomposition of excess microflora biomass from the biological wastewater treatment process (secondary sludge). Aerobic oxidation generates substantial amounts of free energy (ΔG_0) and oxidation products with low energy content. The advantage of aerobic oxidation lies in its high purification efficiency and rapid purification. In contrast, the anaerobic oxidation process produces oxidation products with high energy content, but it has the drawbacks of slower purification and a weaker purifying effect [15].

2.2. AEROBIC PROCESSES

Aerobic wastewater treatment processes are divided into techniques with suspended microflora and techniques with an immobilized layer, i.e., microflora immobilized on a suitable inert carrier. Aerobic processes with suspended microflora can include purification processes with activated sludge in bioaeration basins or aerobically aerated lagoons and lakes. The biologically active mass of aerobic microflora is called activated sludge, which is suspended in wastewater in the form of flocs. These flocs contain living microorganisms, dead cells of microorganisms, as well as various organic and inorganic substances left over from wastewater. The most important and abundant microorganisms in activated sludge are bacteria (gram-negative bacteria of the genus *Pseudomonas*,

Zooglea, Flavobacterium, Mycobacterium, and nitrifying bacteria *Nitrosomonas* and *Nitrobacter*), protozoa, and fungi [16].

2.3. ANAEROBIC DIGESTION (AD)

Anaerobic wastewater treatment processes are employed to treat highly polluted, mostly industrial wastewater. The process itself is based on biochemical reactions with the presence of bacterial microflora, which convert organic matter into a mixture of gases, the main components of which are methane and carbon dioxide. This process takes place without the presence of oxygen in a reducing environment and within a certain pH interval.

Currently, the most advanced anaerobic wastewater treatment technology is anaerobic digestion, also known as the activated sludge process [17]. Anaerobic digestion is a process in which microorganisms break down biodegradables (organic matter) under anaerobic conditions and transform them into CO_2 and CH_4 as end products. This type of wastewater treatment (AD), with a combination of the activities of various microorganisms, has found application in biogas production plants and is widely used as a source of renewable energy.

Biogas, which contains CH_4, CO_2 and various trace gases, has a dual application: direct use as fuel or further processing to produce biomethane - a substitute for natural gas. Important parameters that affect the formation of biogas during anaerobic digestion are temperature, pH value, increased concentration of fatty acids, and increased concentration of ammonia (which leads to the inhibition of the decomposition process). As technology advances, an increasing number of EU countries use anaerobic digestion as a source of renewable energy (such as Great Britain, Germany, Denmark) [12].

Digestion, or the formation of methane in anaerobic digestion, is divided into four phases: hydrolysis [18], acidogenesis [19], acetogenesis [20], and methanogenesis [21].

Hydrolysis, as the first phase of anaerobic digestion, occurs under the action of enzymes that break down complex organic substances (carbohydrates, proteins, and fats) into simple organic compounds (sugars, fatty acids, and amino acids). These compounds formed by enzymatic hydrolysis are a source of energy for the present microorganisms [18].

Acidogenesis is the stage in which bacteria, through anaerobic digestion, further break down hydrolysis products into volatile fatty acids with NH_3, CO_2, and H_2S as by-products [19].

The third phase, acetogenesis, is the phase in which microorganisms convert the products of acidogenesis into acetate and carbon dioxide. For this purpose, various microorganisms such as *Sintrophus, Clostridium*, and *Sintrobacter* bacteria are used, carrying out the process of acetogenesis [20].

The fourth and final phase, methanogenesis, is the key phase of anaerobic digestion. In strict anaerobic conditions, with the help of methanogenic bacteria, the products of all previous phases are converted into CH_4, CO_2, and H_2O [21]. The process of methanogenesis can be illustrated as follows:

$$CH_3COOH \rightarrow CH_4 + CO_2$$
$$CO_2 + 4H_2O \rightarrow CH_4 + 2H_2O$$

Methane and carbon dioxide constitute the largest mass fraction of biogas [22]. The critical factor in methanogenesis is the pH value, which must be in the range of 6.5 to 8 [21]. Any organic material that remains unprocessed by microorganisms during anaerobic digestion, along with the remains of

deceased microorganisms, is termed digestate [23]. This digestate serves as a high-quality fertilizer used in agricultural production.

2.4. ANAEROBIC FILTERS (AF)

The Anaerobic Filter, illustrated in Figure 1, is one of the earliest and simplest types of filters used in anaerobic digestion. It comprises a tall biological reactor filled with an inert medium where biomass grows. The biomass retains and binds solid particles to the supporting stationary material, allowing sludge to settle. Microorganisms reproduce either on the medium or within its interstices. Wastewater purification is achieved by passing water through the filter, either from top to bottom or vice versa [24].

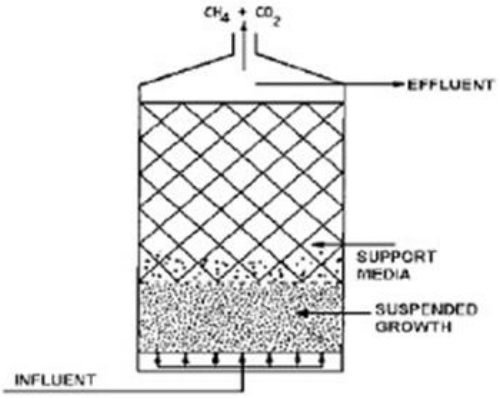


Figure 1. Anaerobic Filter

2.5. ANAEROBIC CONTACT PROCESSES

The anaerobic contact process ensures the longest retention time of matter, directly influencing the higher energy yield in anaerobic biogas production technology with a high yield rate [25]. An advantage of this technology is that microorganisms are retained and do not need to be added afterward. During the digestion process, organic matter is separated and concentrated in separate bioreactors with the return of the introduced matter.

This way, more degradable waste is converted into biogas, and a large part of the anaerobic bacteria remains preserved. There are two types of contact reactors: complete mixing reactors or continuous organic flow reactors. Anaerobic contact is widely used because the process ensures the longest retention time of matter, directly contributing to a higher energy yield. This technology stands out as one of the most cost-effective methods for biogas production [25].

2.6. COVERED ANAEROBIC LAGOONS

Covered anaerobic lagoons are large lakes widely used in the treatment of wastewater in the meat industry, as well as other types of industrial wastewater [26]. Wastewater from the slaughterhouse is piped to the lagoon, where sludge is deposited as the lower semi-solid layer, and a liquid upper layer forms above. This upper layer, preventing the passage of oxygen, enables anaerobic digestion and decomposition of organic matter in wastewater (Figure 2) [27].

The loading volumes of anaerobic lagoons, at 0.056-0.104 kg volatile solids (VS)/m^3/day, are relatively low compared to temperature-controlled anaerobic digesters [27]. The amount of biogas produced from the surface of anaerobic lagoons did not prove to be profitable, so it was not intensively studied [28].

The advantages of these anaerobic lagoons are low costs, simple construction, and a low level of technology. They belong to systems with a low rate of biogas yield. Disadvantages include durability issues, the occupation of large areas, and the accumulation of a large amount of sludge due to poor mixing.

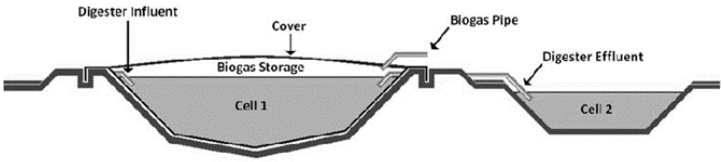


Figure 2. Covered Anaerobic Lagoon

2.7. ANAEROBIC FERMENTERS

For the large-scale production of biogas through anaerobic digestion, productive contact between bacteria and the substrate is necessary, primarily achieved by mixing the contents of the fermenter. Closed fermenters with thorough mixing are utilized in this type of anaerobic digestion (Figure 3) [29].

If the contents in the fermenter are not properly homogenized during the mixing process, over time, the separation of content and the formation of layers with different densities can occur. Due to the difference in density, most bacteria are retained in the lower sludge layer, while the substances needing decomposition are retained in the upper layer. This reduces the contact zone between the two layers, making anaerobic digestion challenging. Additionally, solids may float to the surface, creating a floating layer that hinders the release of biogas [30].

It is crucial that mixing is conducted at an intensity that provides the best conditions for anaerobic digestion. This is typically achieved in anaerobic fermenters with complete mixing using slow-moving rotary agitators, stirring the mixture in the reactor at well-defined time intervals [30,31].

The advantages of these anaerobic fermenters include their high technological level, the ability to receive and decompose various types of solid organic particles, and substantial biogas production. The disadvantage lies in the low mobility of the solid mass and the need for constant mixing [31]. Biological processes can also be combined with membrane processes, as is often done in the purification of wastewater from slaughterhouses in the meat industry. This combination of anaerobic processes and microfiltration removes over 95% of COD from wastewater [32], while the combination of aerobic processes and reverse osmosis removes 85.8% of COD [33].

Figure 3. Anaerobic Fermenter

2.8. CHEMICAL OXYGEN DEMAND (COD)

Chemical Oxygen Demand, or COD, quantifies the water's ability to utilize oxygen during the breakdown of organic matter in the water. In simpler terms, it represents the quantity of oxygen required to oxidize the organic substances present in a given water sample. COD analysis serves as an indirect measure of pollutants, specifically organics, within a water sample. This parameter holds significance in water quality analysis as it aids in mitigating risks to both humans and the environment [34].

Monitoring COD is a valuable method for assessing the efficiency of water treatment plants. Untreated or partially treated water discharge often contains effluent organics that can compete with downstream organisms for oxygen. This oxygen demand can potentially harm or inhibit life downstream of the discharge area. Therefore, accurate information about water quality, such as COD, plays a crucial role in minimizing the likelihood of pollutants causing environmental damage [35].

Why is Chemical Oxygen Demand important?
In modern societies with a high demand for water, there is a simultaneous production of various pollutants and environmental challenges. These issues pose serious health and biodiversity threats if left untreated, overwhelming natural recovery processes. Alongside products from the decomposition of natural substances, there is an accumulation of potentially harmful additives such as pesticides, effluents, and garbage, which contaminate drinking water supplies with their toxic or hormonal effects. These contaminants may also deplete oxygen levels in water resources [36].
High organic contamination in water discharged into tributaries and streams can result in several impacts, including toxicity of organic compounds affecting plants and wildlife, a reduction in dissolved oxygen leading to eutrophication, and adverse effects on fish populations. To prevent potential health hazards and protect species, it is essential to thoroughly assess water source quality before consumption or commercial use, with COD testing playing a pivotal role in this process. COD serves various purposes, including determining concentrations of oxidizable pollutants in wastewater, evaluating the effectiveness of wastewater treatment solutions, assessing the impact of wastewater disposal on the environment, and acting as an index for overall water quality. COD measures the oxygen required to break down organic substances that act as pollutants in water. A higher COD indicates elevated levels of oxidizable material in a sample, leading to reduced dissolved oxygen levels. In such cases, the environmental impact can be detrimental to higher aquatic lifeforms. Therefore, the goal of wastewater treatment is to minimize COD levels in water [37].

3. ADVANCED OXIDATION PROCESS TECHNOLOGY (AOP) / BIOTREATMENT TECHNOLOGY

Advanced oxidation technologies encompass processes that utilize powerful oxidizing agents to efficiently oxidize a broad range of organic compounds present in wastewater and gases. Various industrial applications of advanced oxidation process technologies (AOP) have been developed, including those for removing pesticides from drinking water and eliminating formaldehyde and phenol from industrial wastewater [38].

The development of such AOP applications is driven by increasingly stringent regulations, water resource pollution from agricultural and industrial activities, and the need for industries to meet wastewater discharge standards. These advanced wastewater treatment technologies possess the capability to adapt their microbiological and enzymatic composition to degrade all biological substances present in wastewater, such as starch, glycerol, hemicellulose, polyvinyl alcohols, and other substances [39].

Biological treatments effectively remove pollutants that are easily biodegradable. However, non-biodegradable components like waxes, oils, paraffin wax, and melamine resins pass through biological purification treatments unchanged. To address this, a combination of chemical oxidation and biological degradation is employed [40]. Advanced oxidation systems are designed to treat all types of contaminated water and wastewater.

4. CONCLUSION

The environmental impact of wastewater from the meat industry is highly detrimental, given its specific composition and the substantial presence of harmful organic substances. While various technologies and methods can be employed for treatment, anaerobic digestion, specifically through anaerobic reactors, has emerged as the most efficient system. This process yields biogas as a by-product, serving as a renewable energy source and an alternative to fossil fuels. Anaerobic digestion not only eliminates pathogenic organisms but also addresses unpleasant odors, enhancing the quality of recycled organic manure. Ongoing improvements in anaerobic digestion processes are crucial, as advancements in wastewater treatment technologies contribute to the reduction of greenhouse gas emissions

5. ACKNOWLEDGMENT

This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, on the basis of the Agreement on the realization and financing of scientific research work of SRO No. 451-03-47/2023- 01/200022.
The authors express gratitude for the financial support from the Institute for Animal Husbandry.

REFERENCE

[1] Rajagopal, R., Saady, N.M.C., Torrijos, M., Thanikal, J.V., Hung, Y.-T. (2013), Sustainable Agro-Food Industrial Wastewater Treatment Using High Rate Anaerobic Process, Water, 5, pp. 292-311.
[2] Manual for waste water management, (2022), Belgrade,
[3] Del Nery, V., Damianovic, M., Moura, R., Pozzi, E., Pires, E., Foresti, E. (2016), Poultry Slaughterhouse Wastewater Treatment Plant for High Quality Effluent, Water Sci. Technol., 73, pp. 309–316.
[4] Report on the State of the Environment in the Republic of Serbia for 2020, Ministry of Environmental Protection - Environmental Protection Agency, 2021 - http://www.sepa.gov.rs/
[5] Council Directive 2000/60/EC, O J L 327/1, 22.12.2000., pp. 1-72.
[6] Council Directive 91/271/EEC, O J L 135, 30.05.1991., pp. 40-52.
[7] Afonso, A., Ribeiro, C., Carvalho, M.J., Correia, T., Correia, P., Regato, M., Costa, I., Fernandes, A., Almeida, A., Lopes, A., (2024), Pretreated Agro-Industrial Effluents as a Source of Nutrients for Tomatoes Grown in a Dual Function Hydroponic System: Tomato Quality Assessment, Sustainability, 16, pp. 315.
[8] Alayu, E., and Z. Yirgu., (2018), Advanced technologies for the treatment of wastewaters from agro-processing industries and cogeneration of by-products: a case of slaughterhouse, dairy and beverage industries, International Journal of Environmental Science and Technology, 15, pp. 1581-1596.
[9] Sunder C.G., Satyanarayan S., (2013), Efficient treatment of slaughter house wastewater by anaerobic hybrid reactor packed with special floating media, Int J Chem Phys Sci, 2, pp. 73.
[10] Irshad, A., Sureshkumar, S., Raghunath, B.V., Rajarajan G., Kumar, M.G., Treatment of waste water from meat industry, (2016), Integrated Waste Management in India: Status and Future Prospects for Environmental Sustainability, pp. 251-263.

[11] Fang H.H.P., Liu Y. (2001), Anaerobic treatment in sub-tropical regions, Centre for Environmental Engineering Research, The University of Hong Kong, Hong Kong, pp 285–288.
[12] Ahring, B.K., (2003), Perspectives for anaerobic digestion. Biomethanation I, pp. 1-30.
[13] De Mes T.Z.D., Stams A.J.M., Reith J.H., Zeemem G., (2003), Bio-methane & Bio-hydrogen, Chapter 4 Methane production by anaerobic digestion of wastewater and solid wastes, pp. 60.
[14] Goswami R., Chattopadhyay P., Shome A., Banerjee S.N., Chakraborty A.K., Mathew A.K., Chaudhury S., (2016), An overview of physico-chemical mechanisms of biogas production by microbial communities: a step towards sustainable waste management. Biotech. 6, pp. 2–12.
[15] Bazrafshan, E., Mostafapour F.K., Farzadkia M., Ownagh K.A., , Mahvi. A.H., (2012), Slaughterhouse wastewater treatment by combined chemical coagulation and electrocoagulation process. PLOS One 12 (7), e40108.
[16] Shchegolkova, N.M., Krasnov, G.S., Belova, A.A., Dimitriev, A, Kharitonov, S.L., Klimina, K.M., Melnikova, N.V, Kurdyavtseva, A.V., (2016), Microbial community structure of activated sludge in treatment plants with different wastewater compositions, Frontiers in microbiology, 7, pp. 90.
[17] Lettinga, Gatze., (1995), Anaerobic digestion and wastewater treatment systems, Antonie van Leeuwenhoek, 67, pp. 3-28.
[18] Wilson, Christopher A., and John T. Novak., (2009), Hydrolysis of macromolecular components of primary and secondary wastewater sludge by thermal hydrolytic pretreatment, Water research 43.18, pp. 4489-4498
[19] Yu, H-Q., and H. H. P. Fang. (2002), Acidogenesis of dairy wastewater at various pH levels, Water Science and Technology 45.10, pp. 201-206.
[20] Sirianuntapiboon, Suntud, and Kunnatee Prasertsong., (2008), Treatment of molasses wastewater by acetogenic bacteria BP103 in sequencing batch reactor (SBR) system, Bioresource Technology, 99.6, pp. 1806-1815.
[21] Vítězová, M., Kohoutova, A., Vitez, T., Hanišakova, N, Kushkevych, I., , (2020), Methanogenic microorganisms in industrial wastewater anaerobic treatment., Processes, 8.12, pp. 1546.
[22] Allen, J. B. & Lowery, B. (1976)., Methane gas production from dairy, poultry and swine anaerobic lagoons. Paper presented at the 1976 Southeast ASAE Meeting, Mobile, AL, pp. 30.
[23] Lukehurst, Clare T., Peter Frost, and Teodorita Al Seadi., (2010), Utilisation of digestate from biogas plants as biofertiliser. IEA bioenergy, pp. 1-36.
[24] Bodkhe, Sandeep., (2008), Development of an improved anaerobic filter for municipal wastewater treatment., Bioresource technology, 99.1, pp. 222-226.
[25] Held J., Mathiasson A., Nylander A., (2008), Biogas from manure and waste products – Swedish case studies,
[26] Safley Jr, L. M., and P. W. Westerman., (1989), Anaerobic lagoon biogas recovery systems., Biological Wastes 27.1, pp. 43-62.
[27] Zupančič, Gregor D., and Viktor Grilc., (2012), Anaerobic treatment and biogas production from organic waste. Management of organic waste, pp. 2.
[28] Hill, D. T. (1984). Methane productivity of the major animal types, Trans. ASAE, 27(2), pp. 530-4.
[29] Kalia, A.K., and Singh S.P., (2001), Effect of mixing digested slurry on the rate of biogas production from dairy manure in batch fermenter., Energy Sources 23.8., pp. 711-715.
[30] Madigan, M.T., Martinko, J.M., Parker J., (2000) Biology of microorganisms. Ausgabe: 9th ed. Erschienen: Upper Saddle River, N.J. [u. a.], Prentice-Hall, ISBN 0-13-085264-3.
[31] Schulz, H., and Eder, B., (2006): Biogas – Praxis. Grundlagen, Planung, Anlagenbau, Beispiele, Wirtschaftlichkeit. 3. vollst. überarb. u. Erweiterte Auflage, ökobuch Verlag, Staufen bei Freiburg, ISBN 978-3-936896-13-8.

[32] Jensen, P.D., Yap, S.D., Boyle-gotla, A., Janoschka, J., Carney, C., Pidou, M., Batstone, D.J., (2015), Anaerobic membrane bioreactors enable high rate treatment of slaughterhouse wastewater, Biochem Eng J 97, pp. 132-141.
[33] Bohdziewicz, J., E. Sroka., (2005), Integrated system of activated sludge-reverse osmosis in the treatment of the wastewater from the meat industry, Process Biochem 40, pp. 1517-1523.
[34] Huijun, Z., Jiang, D., Zhang, S., Catterall, K., John, R., (2004), Development of a direct photoelectrochemical method for determination of chemical oxygen demand. Analytical chemistry 76.1, pp.155-160.
[35] L. Maya-Altamira, A. Baun, I. Angelidaki, J.E. Schmidt, (2008), Influence of wastewater characteristics on methane potential in food-processing industry wastewaters, Water Research, Volume 42, 8–9, pp. 2195-2203.
[36] Geerdink, R.B., van den Hurk R.S. and Epema, O.J., (2017), Chemical oxygen demand: Historical perspectives and future challenges. Analytica Chimica Acta 961, pp. 1-11.
[37] Usman, L. and Dickert, F.L., (2014), Chemical oxygen demand, Environmental Analysis by Electrochemical Sensors and Biosensors: Applications, New York, NY: Springer New York, pp. 719-728.
[38] Babuponnusami, A., Sinha, S., Ashokan, H., Veliyath, M.P., Hariharan, S.P., Jayaseelan, A., Panchamoorthy, G.K., Le, Q.H., Pugazhendhi, A., (2023), Advanced oxidation process (AOP) combined biological process for wastewater treatment: A review on advancements, feasibility and practicability of combined techniques. Environmental Research 116944.
[39] M'Arimi, M. M., Mecha, C.A., Kiprop, A.K., Ramkat, R., (2020), Recent trends in applications of advanced oxidation processes (AOPs) in bioenergy production. Renewable and Sustainable Energy Reviews, 121 109669.
[40] Bar-Niv, N., Azaizeh, H., Kuc, M.E., Azerrad, S., Haj-Zaroubi, M., Menashe, O., Kurzbaum, E., (2022), Advanced oxidation process UV-H_2O_2 combined with biological treatment for the removal and detoxification of phenol. Journal of Water Process Engineering 48, 102923.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

ALLELOPATHY AND ITS APPLICATION IN AGRICULTURE

ALELOPATIJA I NJENA PRIMENA U POLJOPRIVREDI

Bojan Konstantinović, Assoc. Prof., PhD[1]
Milena Popov, Assoc. Prof., PhD[1]
Nataša Samardžić, Assoc. Prof., PhD[1]
Tijana Stojanović, TA, MSc[1]

Abstract: *In recent years, in the world and in our country, there is an increasingly pronounced need for the production of the food which is safe for human consumption, by the application of the concept of the organic (ecological, biological) production, which promotes the reduction of the pesticides use, as well as the transition to various alternative methods in order to control the pests, diseases and the weeds. One of the potentially applicable alternative methods is allelopathy, i.e. the use of the allelopathic ability of some plant species in order to protect the crops.*

Key words: *bioherbicides, weed resistance, environmental protection*

Apstrakt: *Poslednjih godina, u svetu i kod nas, sve je izraženija potreba za proizvodnjom zdravstveno bezbedne hrane, primenom koncepta organske (ekološke, biološke) proizvodnje, koja propagira smanjenje primene hemijskih sredstava u zaštiti useva od štetočina, bolesti i korova, kao i prelazak na različite alternativne metode zaštite useva. Jedna od potencijalno primenjivih alternativnih metoda je alelopatija, tj. upotreba alelopatske sposobnosti nekih biljnih vrsta u cilju zaštite useva.*

Ključne reči: *bioherbicidi, rezistentnost korova, zaštita životne sredine*

1. INTRODUCTION

One of the biggest problems of the modern agriculture is the weed resistance, since the weeds are constantly present in the fields and plantations. The continuous use of herbicides with the same mode of action is considered as one of the main reasons for resistance development, while inappropriate herbicides selection and application led to their enhanced accumulation in the soil and even further stimulated the occurrence of the resistant biotypes [1]. To this day, 272 weed species have developed herbicide resistance, while the resistance was noted for 21 out of the total of 31 known herbicides modes of action, i.e. for 168 different herbicides [2].

The modern agriculture strives to reduce the use of pesticides, minimize soil erosion, and at the same time maintain a high level of production and yield [3]. The allelopathy-based strategies could help to achieve these goals.

Allelopathy presents the effect of one plant towards the other, either harmful or beneficial, by releasing the allelochemicals, which can affect the germination and the growth of the adjacent plants. The mentioned biochemicals are able to interact with the sensitive plants through the root

[1] University of Novi Sad, Faculty of Agriculture, Department of Environmental and Plant Protection, Trg Dositeja Obradovića 8, 21102. Novi Sad, Serbia,

exudates, leachates, decomposition of the residues, as well as the volatilization. Allelochemicals also have a great prospective in being used for the weed control [4]

Allelochemicals present the non-nutritional products of the secondary plant methabolism. Many of them are synthesized by the shikimate pathway and, depending on their properties and structure, they can be divided in 10 groups: ketones, aliphatic aldehydes, straight-chain alcohols and water-soluble organic acids; long-chain fatty acids and polyacetylenes; simple lactones; phenols; quinones; flavonoids; coumarins; steroids and terpenoids; tannins; cinnamic acid and its derivatives [1].
Allelochemicals reach the environment through the plant organs, where they obstruct the growth and germination of the adjacent plants by disturbing different physiological processes, mainly through the enzyme activity inhibition. When an allelochemical is able to negatively affect the germination and/or growth of the certain plant it is said that it has an "allelopathic (or phytotoxic) potential" [1].

Given the fact that allelochemicals can affect the composition of the weed flora, as well as the growth and yield of the crops [5], the study of the allelopathic relationships of plants leads to the conclusion that allelopathy could be of great importance for finding alternative methods in controlling weeds which would reduce the use of herbicides in agricultural production [6].

In recent years, the studies regarding the genes responsible for the production of allelopathic compounds in plants have become increasingly relevant. Such studies could lead to improving the allelopathic activities of crops through crossbreeding or genetic engineering strategies [7]. Some of the new tools which are promising for the synthesis of allelochemicals include suppressing or enhancing the expression of the genes, genetic transformations and metabolic engineering, with the aim to better understand synthesis of allelochemicals in terms of the metabolic pathways, genes encoding crucial enzymes, as well as the enzyme activities. Another important area of study within allelopathy is the development of new herbicides ("natural herbicides") through the isolation, identification and synthesis of allelochemicals [1].

The research on allelopathy should provide the perspective of reducing the use of herbicides if the application of allelochemicals from crops is included in the weed management. The cultivation of the crops that exhibit allelopathic activity could be especially important for the weed control in organic agriculture, where the application of herbicides is completely excluded [8]. Namely, the crops with allelopathic characteristics could be introduced into the crop rotation or applied as the green manure, their residues could be incorporated into the soil, the soil could be treated with their aqueous extracts, or they could be utilized for the production of the natural fertilizer with herbicidal activity [3]. Compared to the synthetic herbicides, the majority of allelochemicals is partially or completely soluble in water, their chemical structure is more environmentally friendly in terms of their half-life, accumulation in the environment, as well as the effects on the non-target organisms. On the other hand, their favourable chemical structure may pose a problem regarding their stability, reactivity and duration of their activity [1].

2. THE CROP STRATEGY

In order to obtain the allelochemicals able to suppress the weeds, a whole range of plant species such as sunflower, broomcorn and rice has been investigated [9]. Determining the varieties with high allelopathic potential is of great importance for the selection process. Crops such as sunflower, rye, oilseed rape and wheat, due to their allelopathic effect, reduce the application of herbicides by limiting the growth of the weeds [8]. There are many strategies for using these crops in weed control. These crops can be sown in the inter-row space of the perennial crops. The practice of agricultural producers in the USA has shown that sowing wheat in peaches led not only to a reduction of weeds but also of nematodes in the soil. The mentioned crops can be sown as an

accompanying crop of the main crop, but the possibility of their negative interaction must be taken into account. The research has shown that parallel sowing of rye and soybean negatively affects the soybean yield [10].

The rice-wheat crop rotation is the most widespread in the Asian countries. The introduction of allelopathic plants such as maize or sorghum into the crop rotation, after wheat and before transplanting rice, leads to a significant reduction of weeds in the rice crop. Forage crops such as oats and berseem clover (*Trifolium alexandrinum* L.) in wheat provide the natural weed control for the entire season [11].

Small radish is effective in controlling weeds in wheat and maize, while all *Brassicaceae* are effective in controlling rhizome *Sorghum halepense* in cotton [12]. Apart from *Sorghum halepense* , a study showed that *Raphanus sativus* L. extract completely reduced the germination of 10 weeds (shepherd's purse (*Capsella bursa-pastoris* (L.) Medic.), blackgrass (*Alopecurus myosuroides* Huds.), carrot (*Daucus carota* L.), dodder (*Cuscuta* sp.), camelthorns (*Alhagi* spp.), field bindweed (*Convolvulus arvensis* L.), shortpod mustard (*Hirschfeldia incana* L.), shortfruit hedgemustard (*Sisymbrium polyceratium* L.) and *Ochtodium aegyptiacum* (L.) DC.) and 4 crops (bean, lettuce, clover, tobacco). On the other hand, when residues of *R. sativus* were cut and incorporated into the growing medium they increased the maize yield and reduced the weed intensity [1].

Green manure allows the control of weeds, insects and pathogens. The plants used for green manure are: alfalfa, red clover, sorghum, field melitot (*Melilotus officinalis* (L.) Pall.), perennial ryegrass (*Lolium perenne* L.) and others. Due to the large amount of nutrients, alfalfa, in addition to its importance in livestock nutrition, is also used to improve soil quality. In Japan, some tested alfalfa cultivars inhibited total weed biomass by as much as 80%. Alfalfa, which was applied in the form of pellets in the amounts of 1-2 t/ha on young rice fields, reduced the biomass of the weeds such as: *Echinochloa crus-galli* (L.) P.Beauv., *Monochoria vaginalis* (Burm. f.) C Presl., *Cyperus difformis* L. and *Scirpus juncoides* (Roxb.) Lye [13]. The aqueous extract obtained from the upper leaves of alfalfa has a stronger allelopathic effect on seed germination of some weeds than the root extracts. In laboratory conditions, it was determined that alfalfa extract obtained from the plants in the reproductive phase shows a higher degree of inhibition compared to the extract taken from the plants in the vegetative phase of development [14].

When pea was used as a cover crop, the reduced growth and germination were noted for: common lambsquarters, smooth pigweed, smallflower galinsoga and lady's thumb (*Polygonum persicaria* L.) [1].

Buckwheat is an important crop because, in addition to improving the soil quality, it reduces the occurrence of the weeds, as well as the use of herbicides [13]. The tests conducted in Poland indicate that buckwheat inhibits the occurence of shepherd's purse, field pennycress (*Thlaspi arvense* L.) and couch grass (*Elymus repens* (L.) Gould to a large extent [15]. In the hilly areas, buckwheat, along with the couch grass, significantly suppressed the southern crabgrass (*Digitaria ciliaris* (Retz.) Koel.) and shaggy soldier (*Galinsoga ciliata* (Raf.) Blake). In rice fields, the application of buckwheat pellets in the amount of 2 t/ha reduces the weed occurrence by up to 80% [13].

The isothiocyanates found in *Brassica* sp. are negatively affecting the germination of the smooth pigweed (*Amaranthus hybridus* L.), blackgrass (*Alopecurus myosuroides* Huds.), sowthistle (*Sonchus asper* (L.) Hill), scentless mayweed (*Matricaria inodora* L.), barnyard grass (*Echinochloa cruss-galli* L.) and wheat. The radical length and germination of the wild oat (*Avena fatua* L.) were reduced by the black mustard (*Brassica nigra* L.) extract [1].

Rice plants release the allelochemicals through root exudates that prevent the development of some weeds, reducing their occurrence in rice fields by up to 35%. The Japanese scientists discovered that a mixture of rice hulls and bran in the amount of 1 t/ha reduces the weed occurrence by up to 50%, however, they also reduce the rice yield. In the combination with two alfalfa cultivars (Rasen and Yuba) weed reduction ranges from 53 to 88%, while the rice yield increases by 29-77% [16].

Crops that exhibit allelopathic properties such as: sorghum, alfalfa, wheat, barley, maize, asparagus, tea, coffee, tobacco and sunflower are powerful herbicides. The use of plant residues with proven allelopathic characteristics for fertilizing and mulching is one of the important weed control measures within the organic plant production [13].

Sorgaab, allelopathic water extract of *Sorghum bicolor* (L.) Moench, was highly effective when sprayed twice in 10% concentration for the weed control in wheat, soybean, rice and cotton, being the most effective in case of rice when it reduced the barnyard grass biomass for 40%, while increasing the yield for 18%. On the other hand, sunfaag, allelopathic water extract of sunflower, is predominantly used in wheat, where it reduced the occurrence of toothed dock (*Rumex dentatus* L.) and lambsquarters (*Chenopodium album* L.) by 97 and 70%, respectively, while improving wheat biomass by 7 to 8%. The pre-em application of 10% concentration extract, sunfaag led to high reduction of littleseed canarygrass (*Phalaris minor* Retz.), lesser swinecress (*Coronopus didymus* L.) and wild oat, while increasing the yield of the wheat by 7% [1].

3. PRODUCTS ON THE MARKET

The research on allelopathy led to the patenting of preparations for the weed control in some crops. For example, the herbicide based on the active substance mesotrione comes from the chemical compound leptospermone from the group of triketones, produced by the crimson bottlebrush (*Callistemon citrinus* Stapf.) and it gives good results in controlling weeds in the maize crops [17].

A natural product with herbicidal action that can be found on the market is the preparation „Bialaphos“. Bialaphos is a tripeptide isolated from the soil actinomycete *Streptomyces hygroscopicus* and is used as a herbicide for the control of annual and perennial weeds in grapevine, apple, mulberry, *Brassicaceae* and pumpkin plantations, as well as on uncultivated surfaces. Bialaphos becomes toxic only after metabolic transformation to the phytotoxin phosphinothricin which takes place in the target plants [18].

Natural plant growth inhibitors are a good choice for the production of herbicides with high efficiency and selectivity. A good example is the herbicide cinmethylin, a derivative of 1,4-cineole, produced by eucalyptus. Allelochemicals heliannuol A and B were isolated from sunflower plants, which could also be used as herbicides [19], as well as scopoletin, which is a product of cultivated *Avena* species [20].

Apart from the application of negative allelopathy in biological control of weeds, significant results have been achieved regarding the study and application of positive allelopathy. In our country, Gajić (1977) [21] examined the mutual relations of ecologically similar species: corncockle and wheat, as well as the relationships between the other crops (maize, sunflower, soybean) and corncockle. The phenomenon of stimulation of wheat by corncockle and inhibition of corncockle by wheat was determined. A number of active compounds (amino and organic acids and their derivatives) as well as inhibitors (derivatives of abscisic acid, saturated aliphatic hydrocarbons and cyclic inhibitor $C_8H_{29}N_3O_7$) were isolated from the corncockle. These substances are formulated as „Agrostemin“preparation, which is an ecological tool for plant nutrition. Allelochemicals of Agrostemin are stimulating cultivated plants to efficiently use available resources in the environment and enabling the optimization of the plant processes (respiration, assimilation, photosynthesis) in the plant's nutrition phase, which leads to better plant development and higher

yields. In addition to agrostemin, the growth of the wheat is positively influenced by gibberellins and allantoin from the corncockle [20].

The application of allelochemicals should have an advantage over herbicides in terms of environmental protection, due to their natural origin and biodegradability [22]. However, some scientists believe that, although most of the allelochemicals originate from natural sources, some of them have toxicological effects on unintended targets as well. Extensive ecotoxicological research is necessary to determine the unwanted effects of the wider use of allelopathic plants. For the possible development of genetically modified crops with pronounced allelopathic effects, ecological consequences must be taken into account, including the spread of allelopathic plants outside the agroecosystems and the spread of allelopathic traits to the other plants [23].

4. CONCLUSION

Allelopathy has the potential to be widely applied in the agriculture, especially in the field of weed control. Like synthetic herbicides, allelochemicals often exhibit selectivity, so their application is significant for ecological agricultural production, especially when allelopathic crops such as wheat, rye or sorghum participate in the crop rotation.

Nevertheless, the practical application of allelopathy is still limited due to the scarce knowledge of the mechanisms of allelopathic selectivity, physiological mechanisms of action, and genetic regulation of the allelochemicals biosynthesis.

Further studies of the characteristics and mechanisms of allelopathy would make it possible to increase the allelopathic potential of many crops through the cross-breeding and genetic engineering.

REFERENCES

[1] Soltys, D., Krasuska, U., Bogatek, R., Gniazdowska, A. (2013). Allelochemicals as bioherbicides – present and perspectives. – In: Price A., Kelton J. (eds.) Herbicides – current research and case studies in use, InTech, London, UK.

[2] https://www.weedscience.org/Home.aspx

[3] Farooq, M., Jabran, K., Cheema, Z. A., Wahid, A., Siddique, K. H. (2011). The role of allelopathy in agricultural pest management. Pest Management Science, 67, 493-506.

[4] Rajendra, M. P., Reddy, M. C., Podishetti, V., Reddy, B. V., Naveen, Y., Ravivarma, D., Ashwitha, B., Shakati, S., Bargavi, T. (2023). Influence of aqueous leaf extracts of *Eucalyptus tereticornis* Sm. on the expression of germination and growth of agricultural seeds. *International Journal of Environment and Climate Change*, 13(12), 896.

[5] Xuan, T. D., Anh, L. H., Khang, D. T., Tuyen, P. T., Minh, T. N., Khanh, T. D., Trung, K. H. (2016). Weed allelochemicals and possibility for pest management. International Letters of Natural Sciences, 56, 26.

[6] Khan, M. A., Afridi, R. A., Hashim, S., Khattak, A. M., Ahmad, Z., Wahid, F., Chauhan, B. S. (2016). Integrated effect of allelochemicals and herbicides on weed suppression and soil microbial activity in wheat (*Triticum aestivum* L.). Crop Protection, 90, 35.

[7] Aci, M. M., Sidari, R., Araniti, F., Lupini, A. (2022). Emerging trends in allelopathy: a genetic perspective for sustainable agriculture. Agronomy, 12, 2043.

[8] Jabran, K., Mahajan, G., Sardana, V., Chauhan, B. S. (2015). Allelopathy for weed control in agricultural systems. Crop Protection, 72, 57-59.

[9] Zeng, R. S., Mallik, A. U., Luo, S. (2008). Allelopathy in Sustainable Agriculture and Forestry, Springer, New York, USA.

[10] Einhellig, F. A. (1995). Allelopathy - Current Status and Future Goals. – In: Inderjit K.M., Dakshini M., Einhellig F.A. (eds.) Allelopathy: organisms, processes and applications, American Chemical Society, Washington, USA.
[11] Narwal, S. S. (2000). Weed management in rice: wheat rotation by allelopathy. Critical reviews in plant sciences, 19(3), 249-266.
[12] Ozcatalbas, O., Brumfield, R. (2010). Allelopathy as an agricultural innovation and improving allelopathy extension. Journal of Food, Agriculture and Environment, 8, 908-913.
[13] Khanh, T. D., Chung, M. I., Xuan, T. D., Tawata, S. (2005). The exploitation of crop allelopathy in sustainable agricultural production. Journal of Agronomy and Crop Science, 191, 172-184.
[14] Chon, S. U., Kim, Y. M., Lee, J. C. (2003). Herbicidal potential and quantification of causative allelochemicals from several *Compositae* weeds. Weed Research, 43, 444–450.
[15] Đikić, M., Gadžo, D., Gavrić, T., Muminović, Š. (2007). Alelopatski potencijal heljde. IV Simpozijum o zaštiti bilja u Bosni i Hercegovini, 11-13. decembar, Teslić, BiH.
[16] Xuan, T. D., Tsuzuki, E., Terao, H., Matsuo, M., Khanh, T. D. (2003). Alfalfa, rice by products, and their incorporation for weed control in rice. Weed Biology Management, 3, 137-144.
[17] Cornes, D. (2005). Callisto: a very successful maize herbicide inspired by allelochemistry. Fourth World Congress on Alleopathy, Wagga Wagga, NSW, Australia.
[18] Janjić, V., Stanković-Kalezić, R., Radivojević, L. (2008). Prirodni proizvodi sa alelopatskim, herbicidnim i toksičnim delovanjem. Acta biologica iugoslavica - serija G: Acta herbologica, 17, 1-22.
[19] Hirai, N. (2003). Application of allelochemicals to agriculture. Biological Sciences in Space, 17, 4-5.
[20] Khalid, S., Ahmad, T., Shad, R. A. (2002). Use of allelopathy in agriculture. Asian Journal of Plant Sciences, 1, 292-297.
[21] Gajić, D. (1977). Increase of free tryptophan content in wheat germ under the influence of allantoin and allelopathin. Fragmenta Herbologica Yugoslavica, 3, 5-9.
[22] Palanivel, H., Tilaye, G., Belliathan, S. K., Benor, S., Abera, S., Kamaraj, M. (2021). Allelochemicals as natural herbicides for sustainable agriculture to promote a cleaner environment. – In: Aravind J., Kamaraj M., Prashanthi D.M., Rajakumar S. (eds.) Strategies and tools for pollutant mitigation, Springer, Cham, Switzerland.
[23] Kruse, M., Strandberg, M., Strandberg, B. (2000). Ecological effects of allelopathic plants – a review. National Environmental Research Institute Technical Report, 315, 66.

ANALYSIS OF THE IMPACT OF FINANCIAL SUPPORT AND EDUCATION ON THE INTEREST OF YOUTH IN AGRIBUSINESS

ANALIZA UTICAJA FINANSIJSKE PODRŠKE I EDUKACIJE NA ZAINTERESOVANOST MLADIH ZA AGROBIZNIS

Slađana Vujičić, Associate Professor[1]
Oliver Momčilović, Full Professor[2]
Ljiljana Tomić, Full Professor[3]
Nina Pavićević, Assistant Professor[4]
Aleksandra Mesarović, Assistant Professor[5]

Abstract: *As a demographic group, youth possess the potential to bring innovations, energy, and new perspectives to every sector of society. Through active participation in agribusiness, young people contribute not only to the industry's growth but also to the overall economic development of their communities. The engagement of youth in agribusiness plays a crucial role in addressing unemployment issues, with financial and educational support recognized as factors that can empower young individuals to enter and succeed in the agribusiness sector. Adequate funding opportunities and access to relevant educational and training programs equip them with the necessary skills and knowledge for success in various aspects of agriculture. The paper analyzes the impact of financial support and education on the interest of youth in entering agribusiness.*

Key words: *Financial Support, Education, Youth, Agribusiness*

Apstrakt: *Kao demografska grupa, mladi poseduju potencijal da unesu inovacije, energiju i nove perspektive u svaki sektor društva. Aktivnim učešćem u agrobiznisu, mladi ne doprinose samo rastu industrije, već i ukupnom ekonomskom razvoju svojih zajednica. Angažovanje mladih u agrobiznisu igra ključnu ulogu u rešavanju problema nezaposlenosti tako da finansijska i edukativna podrška su prepoznati kao faktori koji mogu osnažiti mlade ljude da se uključe i uspeju u sektoru agrobiznisa. Adekvatne mogućnosti finansiranja i pristup relevantnim obrazovnim i obukama programima opremaju ih neophodnim veštinama i znanjem potrebnim za uspeh u različitim aspektima poljoprivrede. Rad anilizira uticaj finansijske podrške mladima i edukascija na interesovanje mladih za ulazak u agrobiznis.*

Ključne reči: *finansijska podrška, edukacija,mladi agrobiznis*

[1] Faculty of Business Economics and Entrepreneurship, Belgrade, Serbia,
e-mail: sladjanakonto@gmail.com
[2] Faculty of Applied Management, Economics and Finance Belgrade, University of Business Academy in Novi Sad, Serbia, e-mail: oliver.momcilovic@mef.edu.rs
[3] University Bijeljina, Faculty of Pharmacy,Bijeljina, Bosna and Hercegovina,
e-mail: ljiljanatomic1965@gmail.com
[4] University „Union Nikola Tesla“ Belgrade, Faculty of Applied Sciences in Nis, Serbia,
e-mail: nina.pavicevic007@gmail.com
[5] University Bijeljina, Faculty of Pharmacy, Bijeljina, Bosna and Hercegovina,
e-mail: krsmanovic.sandra88@gmail.com

1. INTRODUCTION

The regular Economic Report of the World Bank for the Western Balkans, it is stated that the Serbian economy experienced slower growth in the second half of 2022, and the same trend continued in the first half of 2023. Midway through 2023, the construction sector began to recover, and certain sectors of agriculture, particularly the production of grains and corn, recorded results better than expected.

Considering the available resources, rich tradition, and favorable geographical position, we can say that agriculture in Serbia represents a crucial potential in overall social and economic development. However, for agriculture in Serbia to develop, a greater workforce is needed, as indicated by World Bank data showing a dramatic decline in employment in agriculture (to only 26.76% of the workforce worldwide in 2019). The youth unemployment rate in Serbia has been steadily decreasing since 2015; however, it is still much higher compared to the rest of the population.

The Labor Force Survey by the Statistical Office of the Republic of Serbia (2023) shows that the young population in 2022 amounted to 685,000, which is 9,800 (1.4%) less than in 2021[1]. The employment rate of the young population in 2022 was 24.7%, representing a slight increase (0.2 p.p.) compared to 2021. Unemployment is a highly significant topic in many countries in recent years. Numerous authors have addressed issues related to unemployment and the factors influencing it in their works [2-8].

In Serbia, the youth are recognized as a solution to the shortage of labor. However, to attract young people to work in agriculture, it is necessary to make agriculture more dynamic and appealing compared to the current state. The Strategy for Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 (Official Gazette of RS, No. 85/2014)[9] lists the creation of favorable conditions for the life and work of young people, their retention in rural areas, and the provision of more attractive job opportunities and equal opportunities for their families as one of the basic goals of the policy aiming at achieving more balanced regional development of the Republic of Serbia.

Engaging young people in agribusiness can lead to the creation of new jobs, both directly and indirectly. By entering entrepreneurial ventures within the agricultural value chain, such as farming, agro-processing, or startups in agrotechnology, they generate employment not only for themselves but also for others in their communities.

In addition to economic benefits, the involvement of young people in agribusiness contributes to sustainable agricultural practices. Their enthusiasm for adopting modern technologies and sustainable farming methods can lead to increased productivity and environmental conservation.

Therefore, it is crucial to create an environment that encourages and supports the active participation of young people in agribusiness. This includes not only providing financial incentives and educational resources but also creating a supportive ecosystem that recognizes and celebrates the valuable contributions of the youth in shaping the future of agriculture and addressing the issue of unemployment.

2. MATERIAL AND METHODS

U order to investigate the impact of financial support and education on the interest of youth in agribusiness in the Republic of Serbia, an empirical study was conducted through a questionnaire survey with a sample of 387 respondents from June to November 2023. The research covered the territory of Serbia, and the questionnaires were distributed to respondents in a written electronic form.

The theoretical research model (Figure 1) consists of independent variables "A" and "B" - State financial support for youth (abbreviated as "A") and Entrepreneurial education programs for youth (abbreviated as "B"), and dependent variable "C" - Youth interest in agribusiness (abbreviated as "C"). The number of participants in the study was 387 respondents. The variables were analyzed using a questionnaire, and for each variable, 6 statements were formulated with 5 possible attitudes as responses (5-point Likert scale).

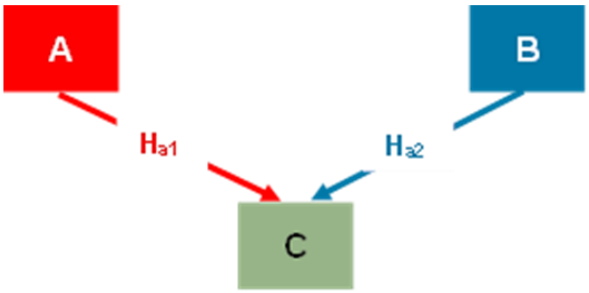


Figure 1. Theoretical Systemic Research Model
Source: Authors

Research objectives are:

To determine whether state financial support for youth affects the interest of young people in agribusiness.
To ascertain whether entrepreneurial education programs for youth influence the level of interest of young people in agribusiness.
To determine whether state financial support for youth and entrepreneurial education programs for youth jointly influence the interest of young people in agribusiness.

The research hypotheses are:
H01: State financial support for youth does not affect the interest of young people in agribusiness.
Ha1: State financial support for youth influences the interest of young people in agribusiness.
H02: Entrepreneurial education programs for youth do not affect the level of interest of young people in agribusiness.
Ha2: Entrepreneurial education programs for youth influence the level of interest of young people in agribusiness.
H0: State financial support for youth and entrepreneurial education programs for youth do not jointly influence the interest of young people in agribusiness.
Ha: State financial support for youth and entrepreneurial education programs for youth jointly influence the interest of young people in agribusiness.

3. RESULTS AND DISCUSSION

In (Table 1), cross-tabulated values are provided according to the respondents' profiles. There were more female respondents, 249 or 64.34%, compared to fewer male respondents, 138 or 35.66%, out of a total of 387 respondents. The majority of respondents were in the age group (21-26) years, accounting for 54.26%, followed by respondents in the age group (27-32) years, comprising 27.90%, and the fewest respondents in the age group (15-20) years, representing 17.82% of the total 387 respondents. More respondents had education levels of elementary school (OŠ) and secondary school (SSS), totaling 259 or 66.92%, while fewer had higher education (VŠ and VSS), amounting to 128 or 33.07% out of the total 387 respondents. The majority of female respondents were in the age group (21-26) years with education levels of elementary school (OŠ) or secondary school (SSS), accounting for 21.18%, while the fewest male respondents were in the age group (27-32) years with

education levels of higher education (VŠ) or higher specialized studies (VSS), constituting 3.10%, out of the total 387 respondents.

Table 1. Cross-tabulated descriptive values according to the respondents' profiles

Gender of respondents:	The age group of respondents																	
	(15-20) years:			(21-26) years						(27-32) years						All		
	Educational attainment of respondents:																	
	OŠ ili SSS			Elementary school (OŠ) and Secondary school (SSS):			Higher education (VŠ) and Higher specialized studies (VSS)			Elementary school (OŠ) and Secondary school (SSS):			Higher education (VŠ) and Higher specialized studies (VSS)					
	N	R%	C%	N	R%	C %	N	R%	C %	N	R%	C%	N	R%	C %	N	R%	C%
Male	20	14.49 %	28.99%	32	23.19 %	28.07%	43	31.16 %	44.79%	30	21.74 %	39.47%	13	9.42 %	40.63%	**138**	100.00 %	**35.66%**
Female	49	19.68 %	71.01%	82	32.93 %	71.93%	53	21.29 %	55.21%	46	18.47 %	60.53%	19	7.63 %	59.38%	**249**	100.00 %	**64.34%**
All	**69**	**17.83 %**	100.00 %	**114**	**29.46 %**	100.00 %	**96**	**24.81 %**	100.00 %	**76**	**19.64 %**	100.00 %	**32**	**8.27 %**	100.00 %	**387**	100.00 %	**100.00 %**

Source: Authors

3.1. CORRELATION ANALYSIS

In (Figure 2), Pearson correlation coefficients are presented. The smallest correlation coefficient is the relationship between the independent variables State financial support for youth and Entrepreneurial education programs for youth, which is 0.5024, indicating a relatively weak correlation. The highest correlation coefficient is the relationship between the independent variable Entrepreneurial education programs for youth and the dependent variable Youth interest in agribusiness, which is 0.7033, indicating a strong correlation.

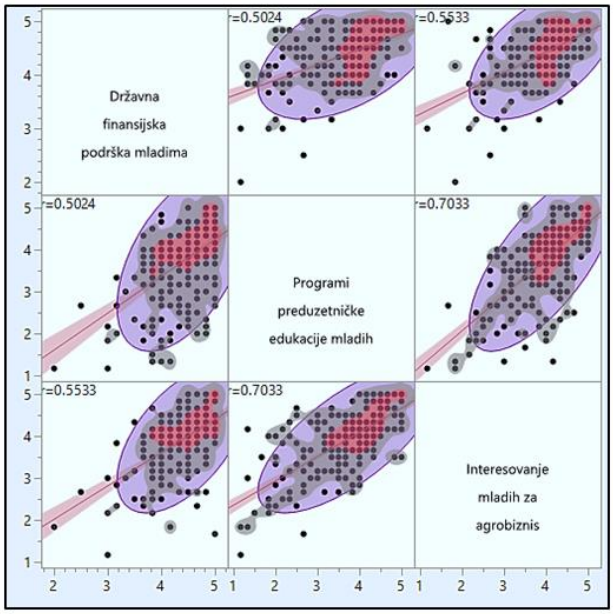


Figure 2. Correlation of the formed model
Source: Authors

3.2. REGRESSIONAL ANALYSIS OF VARIABLES A AND C

In (Table 2), a basic model evaluation has been conducted. The coefficient of determination is 0.306179, meaning that 30.61% of the variability in the dependent variable Youth interest in agribusiness can be explained by the independent variable State financial support for youth. The relationship between the variables is moderately strong.

Table 2. Model evaluation for variables A and C

RSquare	0.306179
RSquare Adj	0.304376
Root Mean Square Error	0.598112
Mean of Response	3.922481
Observations (or Sum Wgts)	387

Source: Authors

The assessment of statistical significance is provided in (Table 3.) and it is [F(1,385)=169.8979, p<0.0001].

Table 3. ANOVA for variables A and C

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Ratio**
Model	1	60.77883	60.7788	169.8979
Error	385	137.72892	0.3577	**Prob > F**
C. Total	386	198.50775		<.0001

Source: Authors

In (Table 4.), the contribution of the independent variable State financial support for youth to the dependent variable Youth interest in agribusiness is determined and it amounts to 0.553334. Based on these data, the alternative hypothesis Ha1: State financial support for youth influences the interest of youth in agribusiness can be confirmed.

Table 4. Contribution coefficients for variables A and C

Term	**Estimate**	**Std Error**	**t Ratio**	**Prob>|t|**	**Std Beta**	**VIF**
Intercept	0.4247933	0.270058	1.57	0.1165	0	.
State Financial Support for Youth	0.7959261	0.061063	13.03	<.0001	0.553334	1

Source: Authors

Based on the data from the previous table, a regression equation (Formula 1.) can be formulated as follows:

$$\boldsymbol{C} = 0.4247933 + 0.7959261 \cdot \boldsymbol{A} \tag{1}$$

Ili

$$\boldsymbol{Youth\ Interest\ in\ Agrobusiness} == 0.4247933 + 0.7959261 \cdot \textbf{State Financial Support for Youth} \tag{2}$$

On (Figure 3.), the Regression Equation Diagram for A and C is provided.

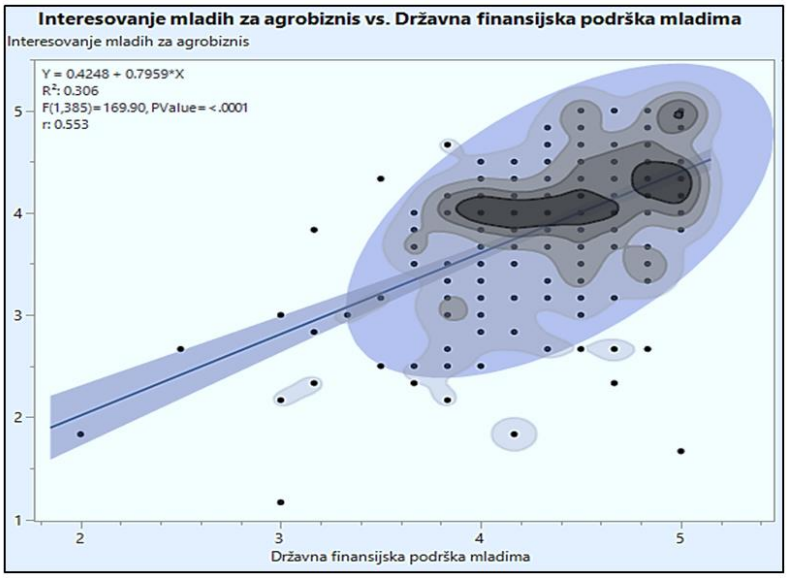


Figure 3. Regression Equation Diagram for Variables A and C
Source: Authors

3.3. REGRESSION ANALYSIS OF VARIABLES B AND C

In (Table 5.), a basic model evaluation has been conducted. The coefficient of determination is 0.494653, meaning that 49.46% of the variability in the dependent variable "Youth Interest in Agribusiness" can be explained by the independent variable "Entrepreneurial Education Programs for Youth." The relationship between the variables is moderately strong.

Table 5. Model Evaluation for Variables B and C

RSquare	0.494653
RSquare Adj	0.49334
Root Mean Square Error	0.51045
Mean of Response	3.922481
Observations (or Sum Wgts)	387

Source: Authors

The assessment of statistical significance is provided in (Table 6.) and it is [F(1,385)=376.8522, p<0.0001].

Table 6. ANOVA for Variables B and C

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Ratio**
Model	1	98.19238	98.1924	376.8522
Error	385	100.31537	0.2606	**Prob > F**
C. Total	386	198.50775		<.0001

Source: Authors

In (Table 7.), the contribution of the independent variable "Entrepreneurial Education Programs for Youth" to the dependent variable "Youth Interest in Agribusiness" is determined, and it amounts to 0.703315. Based on these data, the alternative hypothesis Ha2: Entrepreneurial Education Programs for Youth influence the interest of youth in agribusiness can be confirmed.

Table 7. Contribution coefficients for Variables B and C

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	1.7761541	0.113567	15.64	<.0001	0	.
Entrepreneurial Education Programs for Youth	0.5780965	0.029779	19.41	<.0001	0.703315	1

Source: Authors

Based on the data from the previous table, a regression equation (Formula 3 and 4) can be formulated as follows:

$$\boldsymbol{C} = 1.7761541 + 0.5780965 \cdot \boldsymbol{B} \tag{3}$$

or

$$\boldsymbol{Youth\ Interest\ in\ Agrobusiness} = \\ = 1.7761541 + 0.5780965 \\ \cdot \boldsymbol{Entrepreneurial\ Education\ Programs\ for\ Youth} \tag{4}$$

On (Figure 4.), there is a diagram of the regression equation for variables B and C.

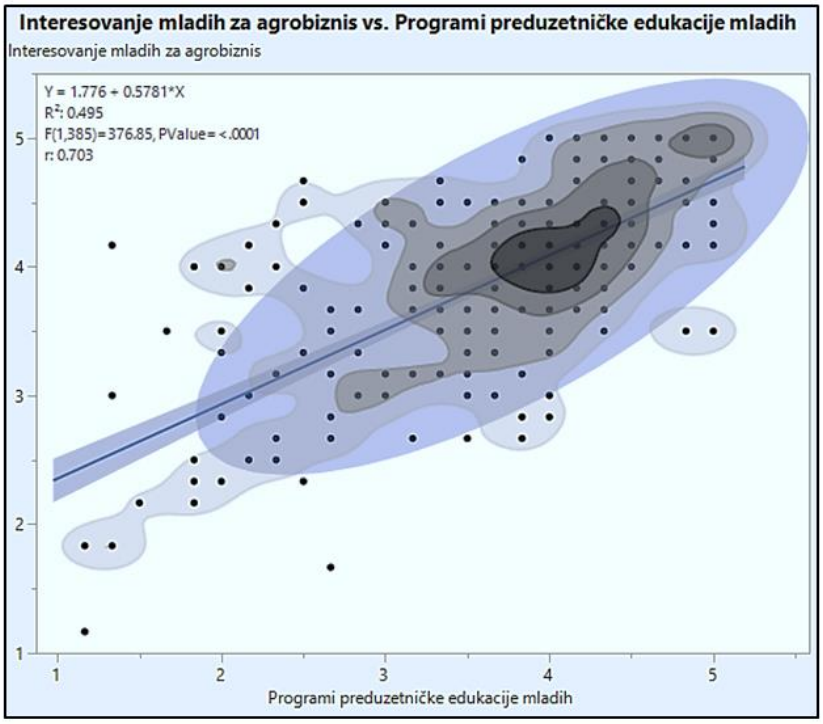


Figure 4: Regression Equation Diagram for Variables B and C
Source: Authors

3.4. MULTIPLE REGRESSION ANALYSIS FOR VARIABLES A, B, AND C

In (Table 8.), a basic model evaluation has been conducted. The multiple correlation coefficient is 0.548147, meaning that 54.81% of the variability in the dependent variable "Youth Interest in Agribusiness" can be explained by the independent variables "State Financial Support for Youth" and "Entrepreneurial Education Programs for Youth." The multiple correlation coefficient is moderately strong.

Table 8. Model Evaluation for Variables A, B, and C

RSquare	0.548147
RSquare Adj	0.545793
Root Mean Square Error	0.483306
Mean of Response	3.922481
Observations (or Sum Wgts)	387

Source: Authors

The assessment of statistical significance is provided in (Table 9.) and it is [F(2,384) = 232.9167, p < 0.0001].

Table 9. ANOVA for Variables A, B, and C

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	108.81137	54.4057	232.9167
Error	384	89.69639	0.2336	**Prob > F**
C. Total	386	198.50775		<.0001

Source: Authors

In (Table 10.), the contribution of independent variables to the dependent variable "Youth Interest in Agribusiness" is determined. The independent variable "Entrepreneurial Education Programs for Youth" has a higher contribution, amounting to 0.568919, while the independent variable "State Financial Support for Youth" has a lower contribution of 0.2675. Based on this data, the alternative hypothesis Ha can be confirmed: "State Financial Support for Youth" and "Entrepreneurial Education Programs for Youth" influence the interest of youth in agribusiness.

Table 10. Contribution Coefficients for Variables A, B, and C

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.4953952	0.218277	2.27	0.0238	0	.
State Financial Support for Youth	0.3847774	0.057068	6.74	<.0001	0.2675	1.3376518
Entrepreneurial Education Programs for Youth	0.4676283	0.03261	14.34	<.0001	0.568919	1.3376518

Source: Authors

Based on the data from the previous table, a multiple regression equation can be formulated (Formula 5 and 6), which is:

$$\boldsymbol{C} = 0.4953952 + 0.3847774 \cdot \boldsymbol{A} + 0.4676283 \cdot \boldsymbol{B} \quad (5)$$

or

$$\boldsymbol{Youth\ Interest\ in\ Agrobusiness} = \\ = 0.4953952 + 0.3847774 \cdot \textbf{State Financial Support for Youth} \\ + \\ +0.4676283 \cdot \boldsymbol{Entrepreneurial\ Education\ Programs\ for\ Youth} \quad (6)$$

On Figure 5. There is a diagram of the multiple regression equation for variables A, B, and C.

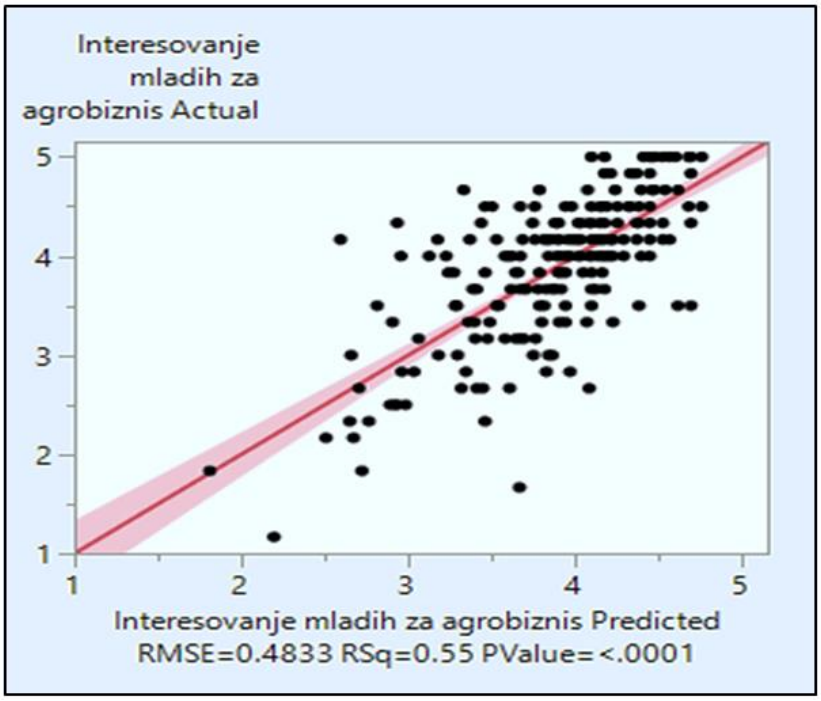


Figure 5. Diagram of the multiple regression equation for variables A, B, and C.
Source: Authors

In (Figures 6.a-g.), diagrams of multiple regression equations are presented for the variables "State Financial Support for Youth," "Entrepreneurial Education Programs for Youth," and "Youth Interest in Agribusiness" according to the profile of respondents, indicating:

Male respondents (Figure 6.a) perceive a higher contribution of the independent variables "State Financial Support for Youth" and "Entrepreneurial Education Programs for Youth" to the dependent variable "Youth Interest in Agribusiness" compared to female respondents (Figure 6.b).
Respondents aged (15-20) years (Figure 6.c) perceive a greater contribution of the independent variables "State Financial Support for Youth" and "Entrepreneurial Education Programs for Youth" to the dependent variable "Youth Interest in Agribusiness" compared to respondents aged (21-26) years (Figure 6.d) and respondents aged (27-32) years (Figure 6.e).

Respondents with education level primary or secondary school (Figure 6.f) perceive a greater contribution of the independent variables "State Financial Support for Youth" and "Entrepreneurial Education Programs for Youth" to the dependent variable "Youth Interest in Agribusiness" compared to respondents with education level higher or vocational school (Figure 6.g), while respondents with higher or vocational school education level perceive a smaller contribution.

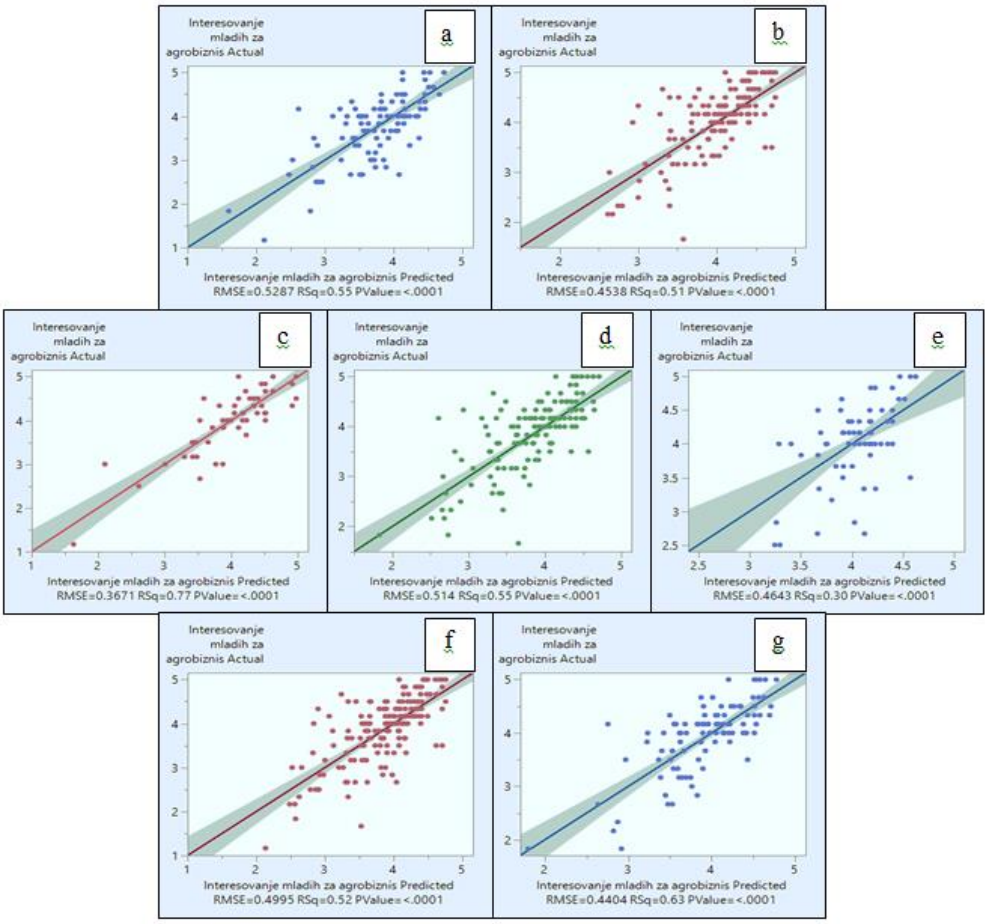


Figure 6. Diagram of multiple regression equations for variables A, B, and C according to the respondents' profile

Source: Authors

4. CONCLUSION

The research has provided insight into the complex dynamics of the impact of state financial support for youth and entrepreneurial education programs on their interest in agribusiness in the Republic of Serbia. The data analysis indicates a significant correlation between this financial support, education, and the interest of young people in agribusiness.

The results suggest that male respondents, younger respondents (aged 15-20), and those with primary or secondary education contribute more in perceiving the importance of state financial support and entrepreneurial education programs for the development of their interest in agribusiness. These findings provide relevant guidelines for the creation of targeted initiatives and policies that could increase the engagement of young people in agribusiness.

Furthermore, multiple regression analysis indicates that the combined effect of state financial support for youth and entrepreneurial education programs significantly reflects on their interest in agribusiness. This knowledge can serve as a basis for further shaping support strategies and programs aimed at encouraging active participation of youth in agribusiness.

Ultimately, this research offers valuable insights for making informed decisions in the fields of education, youth support, and agribusiness development, contributing to a better understanding of the factors influencing their interest in this crucial economic sector.

REFERENCES

[1] RZS (2023),Anketa o radnoj snazi u Republici Srbiji 2022

[2] Kovačević I., VujičićS.,Nikitović Z. (2015),,The influence of tourism on the unemployment in the Republic Serbia,, The Second International Conference "Higher Education in Function of Development of Tourism in Serbia and Western Balkans", that will be held within the SED 2015 Conference, is one of the results of the TEMPUS project No. 544543-TEMPUS-1-2013-1- RS-TEMPUS-JPCR entitled "Modernization and Harmonization of Tourism Study Programs in Serbia" (MHTSPS).

[3] Mirjana Radovic-Markovic,Slađana Vujicic, Zorica Medic (2021) „Strategic employee motivation and creating productive work.,, Tenth international scientific conference Employment, education and entrepreneurship, Belgrade,Serbia, October 21-23, 2021, p.126-130

[4] Nikitović,Vujičić (2021) Preduzetništvo, Visoka škola za poslovnu ekonomiju i preduzetnoštvo, Beograd, Statistical office of the republic of serbia (2021)Labor Force Survey in the Republic of Serbia

[5] Nziku, M. D.(2012) "Tanzanian Education and Entrepreneurial Influence among Females" Journal of Female Entrepreneurship and Education (JWE), no. 1- 2/2012: 52

[6] Radović-Marković M., Salamzadeh A., Vujičić S.(2019) Selection of organization models and creation of competences of the employed people for the sake of competitiveness growth in global business environment, International Review, No.1-2,p. 64-71

[7] Radovic-Markovic M., Vujicic S.,Medic Z.(2021) Strategic employee motivation and creating productive work, Tenth international scientific conference Employment, education and entrepreneurship, Belgrade,Serbia, October 21-23, 2021, p.126-130

[8] Klašnja, S. (2020): Osnovni pokazatelji položaja mladih u Srbiji, Ministarstvo omladine i sporta

[9] Official Gazette of RS, No. 85/2014)

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

CHEMICAL ANALYSIS OF THE LAND FOR THE GROWTH OF RASPBERRIES IN MACEDONIA

HEMIJSKA ANALIZA ZEMLJIŠTA ZA RAST MALINE U MAKEDONIJI

Jovica Momirceski, PhD student[1]
Julijana Tomovska, Full prof. dr[2]

Abstract: *In raspberry production technology, the choice of land is mostly important. Raspberry varieties are perennial herbs, in the form of a bush or semi-shrub, with several annual roots and annual or biennial shoots from the Rosaceae family. Raspberry irrigated with a drip system, through soil is rehabilitated and the appropriate fertilizers are added. Examination of the chemical composition of the soil was in three laboratories in deferent periods. Results obtained in the first period of examination shows that nitrogen is the element with greatest movement in the soil itself and its content is 0.08 - 0.14%. The pH value affects the content of calcium, which plays an important role in the hardness of the fruit, the sensitivity to physiological disorders, and it amounts to 1113.0-3745.0 ppm. Phosphorus is an important element for the properties of fruit during storage and it amounts to 14.77 – 40.36 P_2O_5 kg/da. Potassium plays a role in producing good yields and the amount is about 14.0 – 50.49.7 K_2O kg/da. Magnesium does not have the most important role which is 74.58 -220.9 ppm. The main role of magnesium is in the ratio of potassium (K / Mg) and should range from 2: 1 to 3: 1. From the data obtained of the soil analysis, in addition to the climatic conditions, the species and the structure, which are equally important for raspberry cultivation, we get a complete picture of soil processes and instructions for suitable conditions for growing raspberries*.

Key words*: soil, raspberry, planting, chemical elements, soil acidity*.

Apstrakt: *U tehnologiji proizvodnje maline najviše je važan izbor zemljišta. Sorte maline su višegodišnje začinsko bilje, u obliku žbuna ili polužbuna, sa nekoliko jednogodišnjih korena i jednogodišnjim ili dvogodišnjim izdancima iz porodice Rosaceae. Malina koja se navodnjava kap po kap, sanira se kroz zemljište i dodaje se odgovarajuća đubriva. Ispitivanje hemijskog sastava zemljišta vršeno je u tri laboratorije u različitim periodima. Rezultati dobijeni u prvom periodu ispitivanja pokazuju da je azot element sa najvećim kretanjem u samom zemljištu i njegov sadržaj iznosi 0,08 - 0,14%. pH vrednost utiče na sadržaj kalcijuma koji ima važnu ulogu u tvrdoći ploda, osetljivosti na fiziološke poremećaje i iznosi 1113,0-3745,0 ppm. Fosfor je važan element za svojstva voća tokom skladištenja i iznosi 14,77 – 40,36 P2O5 kg/da. Kalijum igra ulogu u stvaranju dobrih prinosa i količina je oko 14,0 – 50,49,7 K2O kg/da. Magnezijum nema najvažniju ulogu a to je 74,58 -220,9 ppm. Glavna uloga magnezijuma je u odnosu kalijuma (K/Mg) i trebalo bi da se kreće od 2:1 do 3:1. Iz podataka dobijenih analizom zemljišta, pored klimatskih uslova, vrste i strukture, koje su podjednako važne za gajenje maline dobijamo potpunu sliku zemljišnih procesa i uputstva za pogodne uslove za gajenje maline.*

Ključne reči: *zemljište, malina, sadnja, hemijski elementi, kiselost zemljišta.*

1. INTRODUCTION

Raspberries can be classified in the group of the most important and profitable types of berries in terms of quantity and value of production. Raspberries are very adaptable to different climatic and

[1,2] University,, St. Kliment Ohridski' – Bitola, Faculty of Biotechnical Sciences. Partizanska bb, Bitola 7000, Republic North Macedonia, e-mail: golemizvor@yahoo.com[1] , dzulitomovska@yahoo.com[2]

soil conditions. The specificities of the raspberry are multiple and are reflected primarily in its favorable biological properties, the agroecological growing conditions it requires, the market value of the production itself, the economic effects of the production, etc. Raspberries bear fruit in the first or second year after planting, and already in the third year they reach full fertility. Raspberry yields can be extremely high if a balance is established between favorable agro-ecological conditions for cultivation, the application of modern agro-technical measures and the use of certified seedlings [1]. Soil is one of the most important factors to consider before planting raspberries. Raspberries require well-drained soil. Most of the roots are located in the top 20 cm of soil and are easily damaged by overwatering. Before planting, organic matter should be added to improve soil drainage and nutrient holding capacity. In heavy soils, planting raised beds can also help improve water drainage from the top of the bed. A bed about 10 to 12 cm high is sufficient. Soil amendments can be made to help manage alkaline soils. Weed control before planting is critical [2]. Raspberries prefer environments with moderate summer temperatures lower than 30°C, but most cultivated varieties tolerate down to -30°C [3]. The optimal temperatures of the leaves are from 18°C to 22°C. Raspberries grow best in well-drained loam soil with organic matter greater than 3% and a pH of 5.5 to 6.5. Soil temperatures of 22° to 27°C are best for roots. Raspberry light requirements are a minimum of 6-8 hours of sunlight, the plants tolerate light shade, while high light intensity can result in sun damage to the plant [4]. General raspberry water requirements are approximately 2.5 cm of water per week per plant. This varies by cultivar, stage of growth, soil type, temperature and wind exposure. Raspberries need a period of dormancy and cooling on an annual basis [5].

A soil test is the first step in determining the needs of the planting site. Soil test results indicate what nutrients are available in the soil for the plant to receive and whether any changes or recommendations are needed to obtain the desired crop. Factors affecting nutrient availability are temperature, soil aeration, nutrient concentration, plant growth rate, and soil moisture. In contrast, plant tissue analysis is used to measure the nutrients that are taken up and found in different plant parts. Tissue analysis has the benefit of alerting the grower to nutrient levels approaching deficiency and if the fertilizer is more concentrated. Corrective action can be taken before plant symptoms are visible [6]. Primary macronutrients Nitrogen (N), Phosphorus (P) and Potassium (K) are the nutrients needed in the greatest quantity by raspberries. Secondary nutrients Calcium (Ca), magnesium (Mg) and sulfur (S) are primary nutrients. The requirements of raspberries for Ca and Mg are medium and the demand for S is low. Micronutrients Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn) are used in small amounts by the plant, but they still play an important role in plant development. B and Cu requirements are medium, Fe and Mn are high, and Mo and Zn requirements are low. It is important to have soil test results before applying these nutrients, as nutrient overload can be harmful to the plant and the environment. Nitrogen (N) is the most important nutrient required for plant growth and is generally required in large quantities. Nitrogen (N) is necessary for plant growth, formation of amino acids and is directly involved in photosynthesis [7, 8].

Excess N at planting can potentially lead to moderate vegetative growth of the plant and, consequently, root system suffering. Nitrogen (N) should be applied based on soil test recommendations and the amount of organic matter in the soil. Organic matter consists of living organisms, fresh and decomposed residues such as animal manure, cover crops and green manures. Animal manure adds organic matter and nutrients directly to the soil. Cover crops add organic matter and N to the soil, reduce soil erosion and provide habitat for beneficial insects. Green manures are cover crops that grow during winter and spring and are plowed in early spring. Fertilization refers to a method in which the fertilizer is applied 5 to 10 cm from the side of the plant. After application, the soil is easily broken down and fed. Direct contact with plant tissue may result in burn-related damage to plant tissue. Nitrogen (N) is mobile in the soil and soil levels will change depending on biological activity and soil conditions. Phosphorus (P) is a major component of plant DNA and plays a key role in numerous plant functions. P is critical for root development, plant growth and maturity, seed production, energy transfer, photosynthesis, sugar and starch

transformation, nutrient movement, and transmission of genetic traits. P is immobile in the soil and should be mixed into the top 4-6 inches of the soil. Potassium (K) is required for the activation of eighty or more enzymes in the plant and is responsible for increasing the efficiency of using water and converting sugars into starch. Adequate K levels improve fruit quality and increase stress tolerance. Potassium (K) is immobile in soil and should only be applied if a soil test indicates a low level. Recommended K rates for all crops are based on equation and soil test recommendations [9, 10].

2. MATERIAL AND METHODS

The test crop is a variety of raspberry. For this purpose, three soil tests were done in two different periods of time [11]. The tests are in the period of the 3rd month in 2023, they were done in laboratory (University "Cyril and Methodius", Faculty of agricultural sciences and Food - Skopje, Republic of North Macedonia, Laboratory for Soil and Fertilizer Analysis). Samples were taken at a depth of 30 to 60 cm in different places on the same plot to get a better picture of that land. The plant, in the case of raspberry species, was irrigated with a drip system. The samples were taken, packed in black nylon bags and taken to the accredited laboratory by own transport. First, the laboratory gave instructions: exactly how to take samples and how far the sampling should be from each other. Thus, within the period of 2 hours, the samples are transferred to the appropriate laboratory and left for further examination.

During this test, 5 soil samples were taken from the entire surface at a location of their own choosing, but of course the established distance between all samples was taken into account. It was also pointed out that the samples were not taken from a water surface or covered mud per 1 kg soil sample [12, 13].

Appropriate accredited methods were used for each examined element from the respective laboratory, which are described in detail in the following table (Table 1).

Table 1. Method / instrument used for soil analyses

Parameters	**Laboratory 1 /** Methods	**Laboratory 2 /** Methods
Soil preparation		MKC ISO 11464:2015
Hummus		* Determination of organic C and humus according to the method of Tyurin, modified
pH	TS ISO 10390/Sature ortamda (H_2O)	MKC ISO 10390:2015
Calcium carbonate ($CaCO_3$) / %	TS 8335 ISO 10693 / Kalsimetrik	Volumetrically ISO 10693
EC / (ds m^{-1})	TS ISO 11265 / Sature ortamda	
Salt (NaCl) / %		
Saturation (Texture)	TS 8333/ Saturasyon	
Organic substances	TS 8336/ Walkley Black	
Total Nitrogenium (N) / %	TS 8337 ISO 11261 / Kjeldahl	ISO -11261
Apsorbed Phosphorus (P) / P_2O_5 kg/da	TS 834 Olsen / Spektrofotometrik	AL Method Validated on FZNH-Skopje

Apsorbed Potasium (K) as K_2O / kg da $^{-1}$	TS 8341 / 1N Amo. ASE / 1CP – 0ES	AL Method Validated on FZNH-Skopje
Apsorbed Calcium (Ca) / ppm	TS 8341 / N Amo. ASE / ICP	
Absorbed Magnesium (Mg) / ppm	TS 8341 / N Amo. ASE / ICP	
Absorbed iron (Fe) / ppm	TS ISO 14870 DTPA / ICP – 0ES	
Apsorbed Manganese (Mn) / ppm	TS ISO 14870 DTPA / ICP	
Apsorbed Zink (Zn) / ppm	TS ISO 14870 DTPA / ICP	
Apsorbed Cooper (Cu) / ppm	TS ISO 14870 DTPA / ICP	

3. RESULTS AND DISCUSSION

3.1 FIRST EXPERIMENTAL TRIALS IN LABORATORY 1

The initial chemical analysis was done in laboratory 1 (PROANALİZ Laboratory) in four soil samples with three repetitions each in 2018. The obtained results were calculated and their average value is shown in Table 2.

Table 2. First Soil analyses results in Laboratory 1

Parameters	Sample 1		Sample 2		Sample 3		Sample 4	
	Results	Conclusion	Results	Conclusion	Results	Conclusion	Results	Conclusion
pH	7,7	Slightly alkaline	6,28	Slightly acidic	6,35	Slightly acidic	6,11	Slightly acidic
Calcium carbonate ($CaCO_3$) / %	1,0	Calcareous	1,3	Calcareous	1,6	Calcareous	2,1	Calcareous
EC / (ds m^{-1})	0,287 (21,7^{0}C)	Without salt	0,237 (20,7^{0}C)	Without salt	0,215 (21,16^{0}C)	Without salt	0,225 (21,1^{0}C)	Without salt
Salt (NaCl) / %	0,01	Without salt	0,007	Without salt	0,006	Without salt	0,009	Without salt
Saturation (Texture)	71,5	Sandy land	51,04	Clayey rocky	53,9	Clayey rocky a	55,44	Clayey rocky
Organic substances	2,05	Middle	2,80	Middle	1,64	A little	1,24	A little
Total Nitrogenium (N) / %	0,10	Enough	0,14	Enough	0,08	A little	0,06	A little
Apsorbed Phosphorus (P) / P_2O_5 / kg da^{-1}	16,03	Very high	40,36	Very high	24,7	Very high	14,77	Very high
Apsorbed Potasium (K) as K_2O / kg da^{-1}	17,1	Very little	49,7	Enough	23,6	A little	14,0	Very high
Apsorbed Calcium (Ca) / ppm	3745,0	High	1235,0	Enough	2170,0	Enough	1113,0	A little
Absorbed Magnesium (Mg) / ppm	74,58	A little	138,7	A little	220,9	Enough	184,7	Enough

Absorbed iron (Fe) / ppm	1,163	Middle	81,92	Enough	157,8	Enough	76,20	Enough
Apsorbed Manganese (Mn) / ppm	1,283	A little	21,00	Enough	24,25	Enough	12,12	A little
Apsorbed Zink (Zn) / ppm	1,031	Enough	5,473	High	2,570	High	1,848	Enough
Apsorbed Cooper (Cu) / ppm	3,309	Enough	4,655	Enough	4,322	Enough	2,822	Enough

Source: Jovica Momirchevski, own research (2018).

After several (four) years, a subsequent inspection of the quality of the soil follows, so that in 2023 the same soil was examined.

3.2 SECOND EXPERIMENTAL TRIALS IN LABORATORY 2

Following the first examination and chemical analysis of the soil performed in four soil samples, the data of which are presented in Table 2, in 2023, in the period from March 13 to 20, soil testing was carried out in another laboratory (Laboratory for Soil and Fertilizer Analysis at the University "St. Cyril and Methodius" - Skopje, at the Faculty of Agricultural Sciences and Food). Within this test, 11 samples were taken for testing, 10 of which are soil at a depth of 15-25 cm, while the last number 11 corresponds to the refrigerator label, on which a physical and chemical test was performed in order to determine the suitability of the soil for raspberry planting. The data obtained from the trials are shown in Table 3.

Table 3. Second Soil analyses results in Laboratory 2

Parameters/ Sample	Humus / %	N (Total Nitrogenium) / %	$CaCO_3$ / %	pH во H_2O /	P_2O_5 / ($mg100g^{-1}$)	K_2O/ ($mg100g^{-1}$)
1	1,98	0,104	0,00	5,76	26,08	37,45
2	2,01	0,112	0,11	5,55	24,25	45,76
3	1,90	0,118	0,00	6,04	38,56	48,30
4	1,76	0,106	0,00	6,09	21,05	37,69
5	1,74	0,096	0,00	5,55	21,23	31,16
6	1,68	0,108	0,00	6,31	19,10	36,13
7	1,68	0,091	0,00	5,58	10,15	29,52
8	1,59	0,084	0,00	5,83	11,86	27,31
9	1,42	0,085	0,00	6,10	9,21	30,28
10	1,67	0,092	0,00	5,97	10,66	29,44
11	2,05	0,117	0,00	6,26	25,64	26,27

Source: Jovica Momirchevski, own research (2023).

In the results from the First Laboratory we can see that **organic substances** in soil samples under serial number 3 and 4 have a low content of organic substances, while samples with serial number 1 and 2 have a medium content of organic substances. It is recommended to carry out composting with 20 - 30 t ha^{-1} of burnt barnyard manure or compost that contains about: 0.3% N, 0.1% P, 0.3% K and about 2 – 3% CaO. **In terms of soil acidification** it is necessary to perform it only for the surface from which sample number 1 was taken, where the pH value is 7.7 (slightly alkaline). From the results obtained **saturation – texture of soil** it can be seen that only in the first sample a higher value of 71.51% was obtained compared to other samples whose value ranges from 51.04% to 55.44% so the first sample is a surface with deposits of sand or sandy soil, while the

other three samples are clayey rocky soil. For **Electrical conductivity of the soil** / (ds m^{-1}) of the ions of the elements of the sample present with a suitable temperature of 20.70 C - 21.70 C and without salt (NaCl) are in the normal range, which is the result of the absence or minimal presence of salt in the soil. The percentage of NaCl is from 0.009 to 0.07% and corresponds to the requirements for planting raspberries. About **calcification** which independent from contents of pH value, shows the content of calcium in the soil. A minimal addition of calcium to this surface is recommended, all in order to bring the calcium to the ideal content required by the raspberry plantation. Further calcification can be carried out every 3 years, to replenish the carbonate evaporated or removed from the soil by natural processes. Regarding the **presence of Elements,** it can be seen that **Nitrogen (N)**, with the application of a fertilizer, the soil from which sample number 1 was taken, the nitrogen content will increase, and in the sample number 2, the nitrogen content is sufficient, and in the samples number 3 and 4, ammonium nitrate will be added. to achieve the desired nitrogen content. **Phosphorus (P)** is important for the properties of fruits during their storage. The representation of phosphorus in all samples is high, and it is especially the highest in the sample under number 2. Due to such a high representation of phosphorus in the soil, it is recommended that further fertilization be performed with fertilizers where there is no representation of phosphorus in them or that the representation is minimal. **Potassium (K)** is the main element and plays a major role in obtaining a good yield. In sample number 2, the content of K is good, and the content in the remaining samples 1, 3, 4 is insufficient. Fertilizing with potassium chloride (60%) is recommended for these samples. When **Magnesium (Mg)** is mentioned, its role is not the most important. The main role for magnesium is played by the relationship with K (K/Mg), which should be in the ratio 2:1 to 3:1. This relationship in all the samples taken is not favorable. Therefore, in this case, individual fertilizers are used, and not multiple components. Due to the unfavorable ratio of K/Mg, fertilizing with Mg is not recommended [14, 15, 16].

From the Results of Second laboratory several conclusions can be drawn which are presented in the next few passages. In view of each of the examined parameters **pH** in water. The samples that have been examined vary from weakly acidic in samples 6, 9 and 11 to moderately acidic in samples 1, 3, 4, 8 and 10 to strongly acidic in samples 2, 5 and 7. According to the **Humus** content of the soils subject to this analysis, it can be concluded that the values of each sample range from 1.42% as the lowest to 2.05% as the highest limit, placing the samples in a soil with a low humus content. Regarding the **total Nitrogen (N)** level from the process of examining the amount of total nitrogen in the samples and taking into account the classification of soils according to the content of total nitrogen and according to the results of the analysis, it can be said that the samples numbered 5, 8, 8, 9 and 10 belong to soils soil which is moderately provided for growing plants, while the samples numbered 1, 2, 3, 4, 6 and 11 belong to soil that is well provided for growing plants. In terms of **Calcification - $CaCO_3$** the analysis of the soils from these samples according to the content of $CaCO_3$ shows that all the samples that were taken and examined are classified in soil without carbonates with the exception of sample number 2 which can be said to be classified in low carbonate soils although the values it has are minimal that is, only 0.11. About **Macronutrients in soil** during the analyzes performed in terms of P_2O_5, from the obtained results it can be said that five of the samples, i.e. 1,2, 4, 5 and 11, are in the group of soils with a very high level of phosphorus, which according to the classification includes soils where this level of provision is 20-30 $mg100g^{-1}$ of soil, while sample number 3 also exceeds these limits with 38.56 $mg100g^{-1}$ of soil, which can be said to have too high levels of phosphorus. Sample number 6 belongs to the group of high level of security, while the other samples 7, 8, 9 and 10 have a medium level of phosphorus security. Regarding **K_2O**, according to the data obtained from the tests, it is concluded that samples 1, 4, 5 and 6 are soils with a very high level of potassium provided, which according to the classification includes soils where this level of provision is 35-45 $mg100g^{-1}$of soil. while sample number 2 and 3 also come out of these limits with 45.76 and 48.30 $mg100g^{-1}$of soil, which can be said to have too high levels of potassium. Sample number 9 belongs to soils with a high level of provision, so that samples under ordinal number 7, 8, 10 and 11 belong to soils with an intermediate level of potassium provision.

4. CONCLUSION

Our country occupies a central place on the Balkan Peninsula in terms of raspberry production possibilities. Because the elements are most needed for quality production, raspberries are in good proportion and well contained in the soil, it is safe to say that this land is good for raising a new raspberry plantation. From the results you can also get the recommendations that are the conclusions of this research.

- The choice of land for raising long-term raspberry plantations is mostly used deep soils with good permeability, humus content is 3-5%, pH value is in the range of 5.5 - 6.5 (slightly acidic) and medium heavy soil (about 50% clay).
- The method of irrigation case is important, because through that system the land can be restored by adding appropriate crystalline enzymes, to achieve a better quality of the soil composition and, if possible, to reach the requirements of raspberries for the soil composition to raise an appropriate plantation.
- Nitrogen (N) is the element with the highest mobility in the soil, which can be a significant problem from an environmental point of view. The uncontrolled application of fertilizers can lead to a series of unwanted consequences that are manifested through various forms of disadvantages, deposition of various foods, unevenness of the elements in the soil, but also in the plant itself.
- The most important elements that should be included in the soil to raise the raspberry plantation: phosphorus (P_2O_5) in amounts of 10mg and potassium (K_2O) in an amount of 40mg per 100g of soil. Values that the soil should contain for raising a raspberry plantation: pH value 5.5 – 6.5; K_2O (light soils) 20 – 25 mg / 100g; K_2O (heavy soils) 25 – 30 mg / 100g; P_2O_5 > 12 – 15 mg; MgO > 10 mg (best K/Mg ratio 2:1 to 3:1).

The values obtained from the soil analysis represent a direction to aim for, but equally important are the climatic conditions, the type and structure of the soil where the respective plantation will be raised.

REFERENCES

[1] Petrović S., Leposavić A. (2016): Raspberry - new cultivation, protection and processing technologies (amended and supplemented edition). Scientific fruit growing society of Serbia, Čačak, 1−265

[2] Nathan, M., J. Stecker, E. Erwin, J. Dunn, M. Warmund, D. Trinklein, R. Rothenberger, P. Schraf, and T. Lee. (1999). Soil Test Interpretations and Recommendation Guide Commercial Fruits, Vegetables and Turf. University of Missouri Extension

[3] Warmund, M. (2009). Fruit Production. University of Missouri Extension. Bul. MG6

[4] Carew, J. G., K. Mahmood, J. Darby, P. Hadley and N. H. Battey. 2001. The effect of low temperature on the vegetative growth and flowering of the primocane fruiting raspberry 'Autumn Bliss'. J. Hort. Sci. Biotech., 76: 264-270

[5] Hall, H., Hummer, K.E., Jamieson, A., Jennings, S., & Weber, C. (2009). Raspberry Breeding and Genetics. Plant Breeding Reviews

[6] Sheavly, M., L. Brewer, F. Doherty. 2011. Getting the Most out of Your Raspberry Soil Test Report. Cornell University, Garden Based Learning. Retrieved from http://blogs.cornell.edu/horticulture/files/2011/11/Raspberry-Info-Sheet-xeyvut.pdf

[7] Mukaetov D., (2013). Soil fertility, UKIM, Agricultural Institute – Skopje

[8] Rulebook on analysis of inorganic fertilizers, Government of the Republic of Macedonia, 2009.

[9] Ball, J. (2001). Mind Your P's and K's. Ag News and Reviews Soils and Crops. Retrieved from http://www.noble.org/ag/soils/psandks/

[10] Sonsteby, A. and O. M. Heide. 2008. Environmental control of growth and flowering of Rubus idaeus. Sci. Hort., 117: 249-256

[11] Pritts, M., C. Heidenreich. (2012). Leaf and Soil Analysis Special Edition. New York Berry News. Cornell University College of Agriculture and Life Sciences. Vol. 11(8b)

[12] Momirchevski J., Tomovska J., Blazhekovikj Dimovska D., (2019) Soil Exemination and Recommendations for Creating Better Conditions of Raspberries rasing. Food and Environment Safety. Journal of Faculty of Food Enginering, Stefan cel Mare University of Sacueva, Romania. Volume XVIII, ISSUE 2, pp: 105-110
[13] Momirceski J., Tomovska J., (2019). Soil assessment for raspberry cultivation. The Eleventh Conference of Agronomy Students with international participation by the Faculty of Agronomy in Čačak, Serbia, Vol. 11, Issue 11. pp: 423-429. ISSN 2334-9883.
[14] Trajkova F., Zlatkovski V., (2017). Guide for soil samples from agricultural land-Guidelines for proper soil soil sampling for agrochemical analysis of soil; Publisher: University "Goce Delcev" - Shtip, Faculty of Agriculture, March, 2017.
[15] Plaster, E., (1984) Soil Science and Management (5th Edition), Delmar Cengage Learning, 2008, New York.
[16] Rubin Gulabovski (2013). Agrochemistry and Plant Nutrition, UGD, Faculty of Agriculture - Stip, 2013.

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

TREND ANALYSIS OF CADMIUM IN FEEDSTUFF

ANALIZA TRENDA KADMIJUMA U HRANI ZA ŽIVOTINJE

Boris Pisinov, research associate[1]*
Sanja Đurović, research associate [2]
Zoran Sekulić, PhD - environmental protection engineer [3]
Tijana Dudić, BSc - biochemistry [4]
Tanja Keškić, research associate [5]
Maja Petričević, research associate [6]
Tamara Stamenić, research assistant [7]

Abstract: *Heavy metals are potent metabolic inhibitors. Cadmium is considered a non-essential element and has high emissions in the biosphere due to anthropogenic activities. The aim is to indicate the importance of cadmium in feedstuff as a potential contamination source. Microwave digestion and graphite furnace atomic absorption spectrometry were used to examine 298 feedstuff samples. A high amount of cadmium above permitted is present in 0.67% of samples. Continuous cadmium monitoring is necessary to prevent its uncontrolled entry into the food chain.*

Key words: *cadmium, pollution, feed, GFAAS, regulations*

Apstrakt: *Teški metali su snažni metabolički inhibitori. Kadmijum se smatra neesencijalnim elementom i ima visoke emisije u biosferi usled antropogenih aktivnosti. Cilj je da se ukaže na važnost kadmijuma u hrani za životinje kao potencijalnom izvoru zagađenja. Mikrotalasna digestija i grafitna peć atomska apsorpciona spektrometrija su korišćeni za ispitivanje 298 uzoraka hrane za životinje. Visoka količina kadmijuma iznad dozvoljene je prisutna u 0.67% uzoraka. Neophodan je stalan nadzor kadmijuma da bi se sprečio njegov nekontrolisani ulaz u lanac ishrane.*

Ključne reči: *kadmijum, zagađenje, štočna hrana, GFAAS, propisi*

1. INTRODUCTION

Under intensive urbanization and industrialization conditions, there are also negative consequences, primarily to large-scale pollution and environmental destruction. Pollutants of anthropogenic origin,

[1] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia, e-mail: boriss752002@yahoo.com (*Corresponding author)
[2] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia, e-mail: stojakovicsm@yahoo.com
[3] Institute of Public Health of Belgrade, Bulevar Despota Stefana 54a, 11108 Belgrade, Serbia, e-mail: zoran.sekulic@zdravlje.org.rs
[4] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia, e-mail: tijanadudic44@gmail.com
[5] Institute for Animal Husbandry, Autoput Belgrade-Zagreb 16, 11080 Belgrade-Zemun, Serbia, e-mail: tanjakeskic@gmail.com
[6] Institute for Animal Husbandry, Autoput Belgrade-Zagreb 16, 11080 Belgrade-Zemun, Serbia, e-mail: majanovakovic@live.com
[7] Institute for Animal Husbandry, Autoput Belgrade-Zagreb 16, 11080 Belgrade-Zemun, Serbia, e-mail: tstamenic169@gmail.com

including heavy metals and their compounds and alloys, in the chemical, automotive, textile, and electronics industries, agriculture, metallurgy and mining, and wastewater from heavy industry lead water, land, and air pollution. Heavy metals and their salts represent a very important group of environmental pollutants since they are potent metabolic inhibitors. The inherent toxicity of a metal depends upon its capacity to disturb the dynamic life processes in biological systems by combining with cell organelles, macromolecules, and metabolites.

Cadmium (Cd), as a heavy metal, can damage the structure of the natural ecosystem, so it is built into the food chain, creating the need to establish criteria of health safety food not only of plant and animal origin but also the various nutrients used in animal feed. In the 1950s and 1960s, industrial pollution with cadmium was high. Still, when the toxic effects of cadmium became apparent, the boundaries of the industrial release were reduced in most industrialized countries, with the approval of further reduction. Considering that there is a possibility of accumulation of heavy metals, therefore also cadmium, from the environment in the food and living organisms, as well as the fact that the least amount of heavy metals can affect the metabolism of plants, animals, and people, there is a need for determining the content of cadmium in various materials (water, soil, etc.). The buildup of cadmium levels in the water, air, and soil has been occurring, particularly in industrial areas.

Food is another source of cadmium. Plants may only contain small or moderate amounts in non-industrial areas, but high levels may be found in the liver and kidneys of adult animals [1]. Environmental exposure to cadmium has been particularly problematic in Japan, where rice consumed was grown in irrigation water contaminated with cadmium, causing Itai-Itai disease in humans, which was recognized in 1968th as the first illness caused by pollution of the environment [2]. Cadmium from various sources (water, air, food, dust) slowly accumulates in the body during the 50-60 years, and the biological half-life is 10-30 years [3].

Some phosphate sources in fertilizer contain cadmium in amounts of up to 100 mg kg^{-1}, which can lead to an increase in cadmium concentration in soil [4-5]. Cadmium is found in low concentrations in rocks, coal, and oil and is often naturally found in groundwater rather than surface water. Soft water of low pH value can contain multiple values of the concentrations of cadmium. In surface waters, cadmium can run in discharging unrefined wastewater, released from the soil where sewage sludge is added or applying pharmaceutical products for stock breeding, with the waste from farms uncontrolled distributed on agricultural land [6].

Cadmium is a serious, lethal occupational and environmental toxin known for its high toxicity, which may affect living systems in various ways. Therefore, it has been ranked seventh among the top 20 hazardous substances [7]. The International Agency for Research on Cancer (IARC) has classified cadmium as a group 1 human carcinogen of the prostate and lung [8].

The maximum permitted concentrations (MPC) in water, soil, food, and animal feed define the cadmium content. It occurs naturally in almost all agricultural soils, and the average concentration in Earth's crust is 0.1-0.5 mg kg^{-1}; therefore, the European Union (EU) sets a limit on the concentration of sewage sludge used on agricultural land as 20-40 mg kg^{-1} dry matter, and 1-3 mg kg^{-1} Cd when sewage sludge is used on agricultural soil [9-10]. In Serbia, MPC for cadmium in soil is 0.8 mg kg^{-1} dry matter, for sediment is 6.4 mg kg^{-1}, while for tap and bottled water are 0.003 mg l^{-1} and 0.005 mg l^{-1}, respectively [11,12,13]. Depending on the type of food, national and EU legislation prescribe cadmium MPC values from 0.020 to 1.20 mg kg^{-1} [14]. According to the national Regulation on the quality of animal feed, MPCs for cadmium, depending on the categorized group, are in the intervals 1 to 10 mg kg^{-1} for feed and 0.5 to 7.5 mg kg^{-1} for mixtures, while 15 mg kg^{-1} is for premixes [15].

In order to determine the potential risk of contamination with cadmium and its entering into the food chain system as a bioaccumulation toxin, in terms of the tendency of getting safe food, tests were carried out on samples of animal feed (feedstuffs, premixtures, and mixtures).

2. MATERIAL AND METHODS

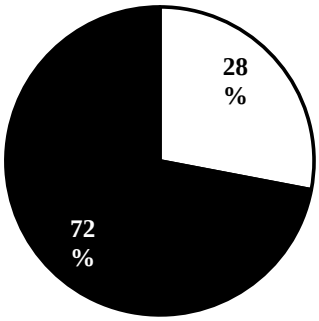
The tests were performed on 298 samples received to the laboratory over two years period, of which 130 feed samples (75 samples of mineral feed, 55 samples of animal origin feed), 112 samples of premixes (97 samples of vitamin-mineral premix, 15 samples of mineral premixes), 56 samples of the mixture.

Sample preparation and cadmium analyses were performed according to EN 15550 [16] using an advanced MARS 6 iWave microwave digestion system (CEM Corporation, Charlotte, NC, USA) and PinAAcle 900T graphite furnace atomic absorption spectrometer (GFAAS) equipped with furnace autosampler AS 900, electrodeless discharge lamps (EDL) and hydride generation FIAS 100 System (Perkin-Elmer Inc., Shelton, CT, USA). Ground test samples up to 0.5 g were digested in 9 ml of concentrated nitric acid (≥ 65%) and 2 ml of hydrogen peroxide (≥ 30%) by microwave heating in the microwave system. The temperature profile was specified to start at 16 ± 4 °C, reach 165–170 °C within 10 min, and hold for 10 min to complete reactions. After cooling for at least 30 min, the samples were filtered and analyzed. The operating conditions of GFAAS for cadmium determination were set as follows: power supply 10.1 kW, element-specific analytical wavelength of 228.8 nm, slit width 0.7 nm, pyrolysis and atomization temperature of 900 °C and 1600 °C, output pressure of argon (purity ≥ 99.996%) gas stream at 350-400 kPa with maximum flow rate of 0.7 l min^{-1}, autosampler injection volume of 10 µl. A temperature program for the graphite furnace consists of four steps: drying, pyrolysis, atomization, and cleaning. Palladium nitrate/magnesium nitrate matrix modifier (Perkin-Elmer Inc., Shelton, CT, USA), Zeeman's effect background correction, and blank solution were used to eliminate interferences and obtain reliable results. Cadmium was quantified in the samples by subtracting the analyte concentration of the blank solution and using an external calibration curve. Individual commercial standard (AccuStandard Inc., New Haven, CT, USA) was used to prepare standard calibration solutions. Working (calibration) standard solutions were prepared at the concentration range of 0.0, 0.1, 0.2, 1.0, and 2.0 mg l^{-1}.

3. RESULTS AND DISCUSSION

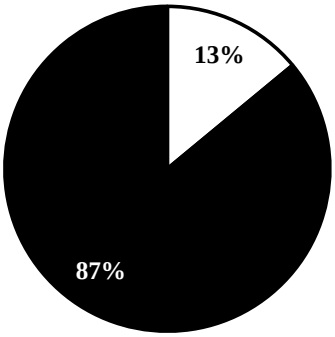
In the period of two years, were obtained in the feed samples (mineral feed, animal origin feed), premix (vitamin-mineral premixtures, mineral premixtures) mixture following results we have shown in Graphs 1, 2, 3, 4.

In mineral feeds, cadmium was detected in 54 samples (72% of the total surveyed samples of mineral feed) (Graph 1). Of these, in 52 samples (69%), its concentration was below 10 mg kg^{-1}, the maximum permitted concentration specified in the Regulation on the quality of animal feed [15]. In only two samples (3%), cadmium was proven to be above MPC (10 mg kg^{-1}). Similar to our research, Sigarini et al. [17] investigated eleven mineral feeds with Cd concentrations ranging from lower than the limit of quantification to 6.1 mg kg^{-1}. It was found that 60% of samples showed values above the recommended by the EU (1.0 mg kg^{-1}), but regarding Brazilian national legislation, all values were below the maximum recommended (10 mg kg^{-1}). The wide result variations can be attributed to inhomogeneous impurity levels of used batches of phosphate rocks.



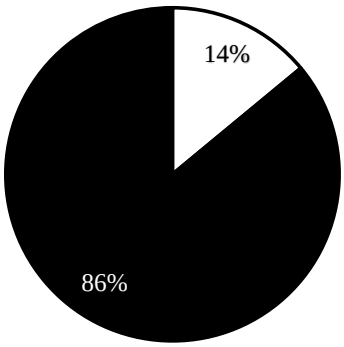
Graph 1. Total percentage of samples where cadmium was measured (dark field).

In the animal-origin feed, cadmium was determined in 48 samples (87% of the total surveyed samples of animal-origin feed) (Graph 2). In samples containing cadmium, its concentration was below 2 mg kg^{-1}, the maximum permitted concentration defined in the Regulation on the quality of animal feed [15]. All 48 samples where cadmium was quantified were fish meal, in other animal-origin feed samples its amount was below the limit of quantification. The findings of Adamse et al. [18] were partly in agreement with ours, where was stated in the period 2000-2013, of the 401 analyzed animal origin feed samples, 249 (62%) had values above the limit of quantification (> 0.02 mg kg^{-1}) but four samples (1%) exceeded recommended MPC (2 mg kg^{-1}) of EU Regulation [19].



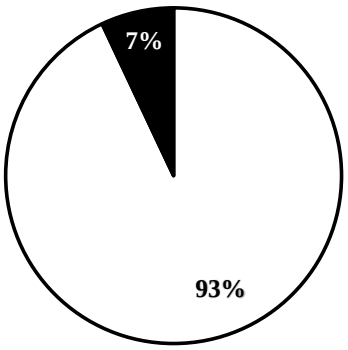
Graph 2. Total percentage of samples where cadmium was measured (dark field).

In premixtures, 96 samples contained cadmium (86% of the total number of tested premixes samples) (Graph 3). However, for premixes, 15 mg kg^{-1} is the maximum permitted concentration of cadmium according to the Regulation on the quality of animal feed [15]. Further, obtained results for cadmium content in premix samples indicate that neither of them had concentrations greater than prescribed for premixes. The findings of Adamse et al. [18] were in agreement with ours, who stated in the period between 2000 and 2013, of the 734 analyzed premixture samples, 577 (79%) had values above the limit of quantification (> 0.02 mg kg-1), but neither exceeded recommended MPC (15 mg kg^{-1}) of EU Regulation [19].



Graph 3. Total percentage of samples where cadmium was measured (dark field).

In the mixtures, cadmium was determined in four samples (7% of the total number of samples in the tested mixture) (Graph 4). The cadmium content did not exceed the maximum permitted concentration of 1 mg kg^{-1}, prescribed in the Regulation on the quality of animal feed [15].



Graph 4. Total percentage of samples where cadmium was measured (dark field).

Our findings contradicted the findings of Marçal et al. [20], who examined 37 mixture samples and in 33 samples (89%) found cadmium concentrations greater than 0.5 mg kg^{-1} (ranged < 0.5 to 11.2 mg kg^{-1}), which is the maximum concentration recommended by the Brazilian national legislation. The sufficient content of cadmium may cause toxicity in animals.

4. CONCLUSION

Based on the obtained results, it can be concluded that the content of cadmium was mainly below the maximum permitted concentration in animal feedstuff and that it complies with the legislation's requirements on the quality of animal feed in part related to the harmful substance.

However, according to the presented information on the toxicity of cadmium and all possibilities for it to enter the food chain, in order to obtain safe food, it is necessary to continue monitoring toxic elements for preventive reasons and also for locating possible contamination at any part of the system water-soil-plant-animal-human.

REFERENCES

[1] Järup, L., Berglund, M., Elinder, C. G., Nordberg, G., Vahter, M. (1998). Health effects of cadmium exposure a review of the literature and a risk estimate, Scand. J. Work. Environ., Health, 24, 11–51.

[2] Anonymus (1968). The view of the Ministry of Health and Welfare of Japan, 8th May.
[3] Bernard, A., Lauwerys, R. (1986). Cadmium in human population, Experientia Suppl., 50, 114-123.
[4] Syers, J. K., Mackay, A. D., Brown, M. W., Currie, C. D. (1986). Chemical and physical characteristics of phosphate rock materials of varying reactivity, J Sci Food Agric, 37, 1057–1064.
[5] Trueman, N. A. (1965). The phosphate, volcanic and carbonate rocks of Christmas Island (Indian Ocean), J Geol Soc Aust, 12, 261–286.
[6] Veljković, N., Vidojević, D., Jovičić, M. (2010). Uticaji zagađujućih materija iz urbanih otpadnih voda na životnu sredinu i zdravlje, Zbornik referata međunarodne konferencije "Otpadne vode, komunalni čvrsti otpad i opasan otpad", Udruženje za tehnologiju vode i sanitarno inženjerstvo, Subotica.
[7] Ostrowski, S. R., Wilbur, S., Chou, C. H., Pohl, H. R., Stevens, Y. W., Allred, P. M., Roney, N., Fay, M., Tylenda, C. A. (1999). Agency for Toxic Substances and Disease Registry's 1997 priority list of hazardous substances, Latent effects-carcinogenesis, neurotoxicology, and developmental deficits in humans and animals, Toxicol. Ind. Health., 15, 602-644.
[8] Abdulaziz, Al-Khedhairy A., Salman, Al-Rokayan A., Fahad, Al-Misned A. (2001). Cadmium Toxicity and Cell Stress Response, Pak J Biol Sci, 4 (8), 1046-1049.
[9] Council Directive 86/278/EEC, Appendix 1A, Appendix 1B (1986). The protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, Brussels.
[10] Ballabio, C., Jones, A., Montanarella, L., Toth, G. (2023). Cadmium in the Soils of the EU: Analysis of LUCAS Soils data for the review of Fertilizer Directive, Publications Office of the European Union, Luxembourg, doi:10.2760/635857, JRC106056.
[11] Regulations on limit values of polluting, harmful and dangerous substances in the soil, Official Gazette of RS (30/2018, 64/2019), Belgrade, pp. 1-8.
[12] Regulations on limit values of polluting substances in surface and underground waters and sediment and time limits for reaching them, Official Gazette of RS (50/2012), Belgrade, pp. 1-12.
[13] Regulation on the hygienic health of drinking water, Official Gazette of SRJ (42/98, 44/99) and Official Gazette of RS (28/2019), Belgrade, pp. 1-18.
[14] Regulation on maximum levels for certain contaminants in foodstaffs, Official Gazette of RS (81/2019, 126/2020, 90/2021, 118/2021, 127/2022, 110/2023), Belgrade, pp. 1-32.
[15] Regulation on the quality of animal feed, Official Gazette of RS (4/2010, 113/2012, 27/2014, 25/2015, 39/2016, 54/2017), Belgrade, pp. 1-65.
[16] EN 15550:2017, Animal feeding stuffs: Methods of sampling and analysis - Determination of cadmium and lead by graphite furnace atomic absorption spectrometry (GF-AAS) after pressure digestion, European Committee for Standardization, Brussels.
[17] Sigarini, K. d. S., de Oliveira, A. P., Martins, D. L., Brasil, A. S., de Oliveira, K. C., Villa, R. D. (2017). Determination of the Lead, Cadmium, and Chromium Concentration in Mineral Feeds and Supplements for Cattle Produced in the Mato Grosso State, Brazil, Biol Trace Elem Res, 177 (1), 209-214, doi.org/10.1007/s12011-016-0869-y.
[18] Adamse, P., van der Fels-Klerx, H. J., de Jong, J. (2017). Arsenic, lead, cadmium and mercury in animal feed and feed materials; Trend analysis of monitoring results collected in the Netherlands, RIKILT report 2017.006, RIKILT Wageningen University & Research, Wageningen, 1-124.
[19] Council Directive 2002/32/EC, Undesirable substances in animal feed, Brussels.
[20] Marçal, W. S., Gaste, L., do Nascimento, M. R. L., Liboni, M., Gomes, G. P., Hisasi, C. S. (2003). Cadmium concentration in mineral salt mixtures used as supplementation in beef cattle food, Vet Arhiv, 73 (1), 47-53.

IMPACT OF CLIMATE CHANGES ON THE PRODUCTION OF AGRICULTURAL CROPS - ASSESSMENT OF THE WORLD BANK

UTICAJ KLIMATSKIH PROMENA NA PROIZVODNJU POLJOPRIVREDNIH USEVA - PROCENA SVETSKE BANKE

Sonja Ketin, vanredni profesor[1]
Boban Kostić, vanredni profesor[2]
Rade Biocanin, redovni profesor[3]

Abstract: *The paper presents the World Bank's risk assessment for Serbia. Based on these scenarios and forecasts, investment risk factors for the Serbian region in agriculture are formed. The results for the period from 2020 to 2039 are shown for the following indicators: risk categorization, population in accordance with temperature rise, display of complex risk on the map.*

Key words: *Agriculture, Climate change, World bank, Risk*

Apstrakt: *Rad prikazuje procenu rizika Svetske banke za Srbiju. Na osnovu ovih scenarija i prognoza formiraju se faktori rizika ulaganja za oblast Srbije u poljoprivredi. Prikazani su rezultati za period 2020 do 2039 za sledece pokazatelje: категоризацију ризика, популацију у складиса порастом температуре, приказ сложеног ризика на карти.*

Ključne reči: *Пољопривреда, Климатске промене, Светска банка, Ризик*

1. UVOD

Climate change refers to long-term changes in temperatures and weather patterns. Such changes can be natural, due to changes in the activity of the sun or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas. Burning fossil fuels generates greenhouse gas emissions that act like a greenhouse wrapped around the Earth, trapping the sun's heat and raising the temperature. The main greenhouse gases that cause climate change are carbon dioxide and methane. They come from using gasoline to drive a car or coal to heat a building, for example. Land clearing and deforestation can also release carbon dioxide. Agriculture, oil and gas production are the main sources of methane emissions. Energy, industry, transport, buildings, agriculture and land use are among the main sectors that cause greenhouse gases [2,3,6].
Climate scientists have shown that humans are responsible for almost all of the global warming of the last 200 years. Human activities such as those mentioned above are causing greenhouse gases to warm the world faster than at any time in at least the last two thousand years.[4,5,7,8,9]
The Earth's average surface temperature is now about 1.1°C warmer than it was in the late 1800s (before the Industrial Revolution) and warmer than at any time in the last 100,000 years. The last

[1] Istraživačko-razvojni institut Tamiš d.o.o. Pančevo, e-mail: ketin@institut-tamis.rs
[2] Univerzitet Privredna akademija, FIMEK, Novi Sad, e-mail: bobankosticbk@gmail.com
[3] University of Travnik, Bosna and Herzegovina, e-mail: Rb.biocanin@gmail.com

decade (2011-2020) was the warmest on record, and each of the last four decades was warmer than any previous decade since 1850.

Many people think that climate change generally means warmer temperatures. But rising temperatures are only the beginning of the story. Because the Earth is a system, where everything is connected, changes in one area can affect changes in all others.

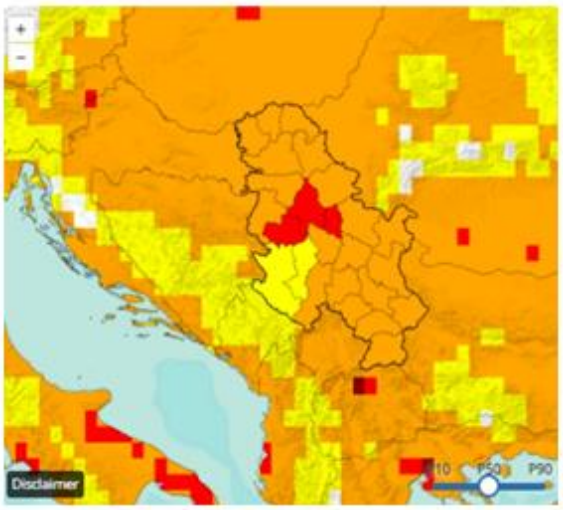
2. MATERIAL AND METHODS

Climate data, current and projected, can be downloaded from the World Bank website. Current climate data from 1901 to 2021 is obtained, as well as projected, i.e. predicted data until 2099.

This section presents a complex risk categorization (0-4) of heat + population based on temperature or heat + population based on temperature and humidity, allowing users to understand where and when risks may occur. The complex risk presentation can be explored spatially via the map (which shows the maximum heat risk categorization during the year). Investigations of specific seasonality of risk based on monthly categorizations are shown through a pie chart. Note how the seasonality of the highest heat risks may extend later, especially for higher emission pathways. The individual elements that contribute to compound risk (ie, thermal conditions and population) are presented separately in the following sections.

3. REZULTATI I DISKUSIJA

3.1. Graphic representation of the basic measured values from which the risk factor and risk categorization can be seen depending on the temperature.

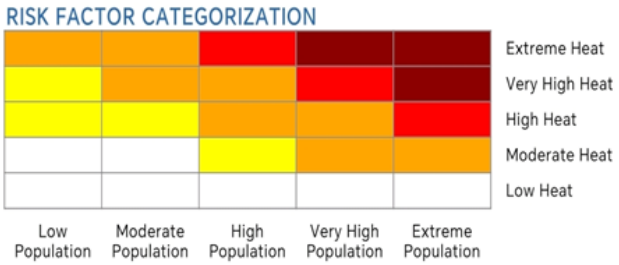


Graph 1. Categorization of Temperature-BASED Heat+Population Risk Categorization for 2020-2039, Serbia (Ref.Period: 1995-2014=, SSPS-8,5, 50th percentile)[1]

Graph 2. Temperature - BASED
Heat+Population Risk Categorization by month, for 2080-2099, Serbia, SSPS-8.5, 50th [1]

Table 1. National Population Below Poverty Threshold – Serbia, %[1]

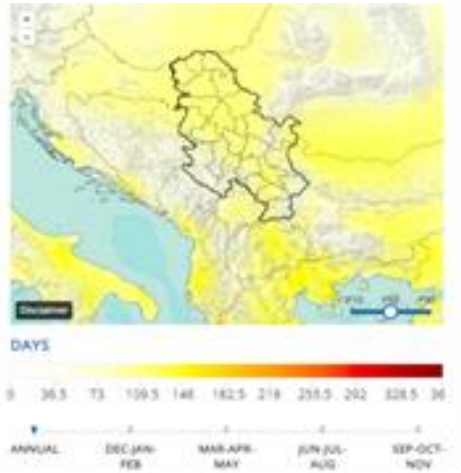
$1.90	0
$3.20	0
$5.50	0
Identified Age Vulnerabilities - Serbia	
Very young, 0-4yrs	M: 53.79 Thousand F: 58.08 Thousand
Age Group 65+	M: 2.61 Million F: 2.3 Million



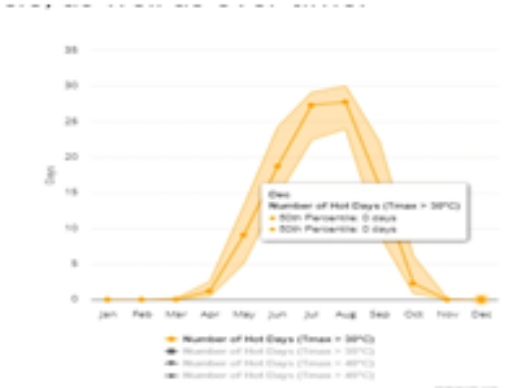
Graph 3. Risk factor categorization [1]

3.2 Understanding 'heat risk' comprehensively requires looking at the range of temperature and humidity conditions that may occur over a 24-hour period, season or year. We present multi-threshold metrics for daytime maximum temperatures, nighttime minimum temperatures, and a combined heat index (a measure of air temperature and humidity) as a basis for assessing changes and intensification of heat risk conditions for an area. It is crucial to understand where extreme heat

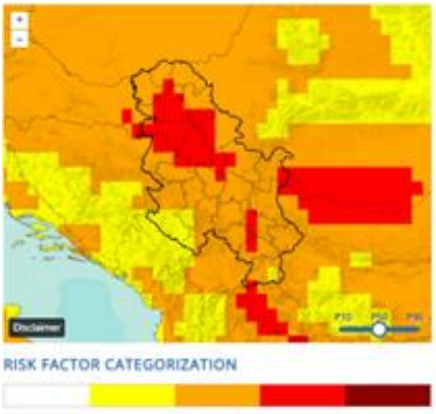
conditions are more likely to occur and when higher heat conditions are expected in the seasonal cycle, as well as over time.



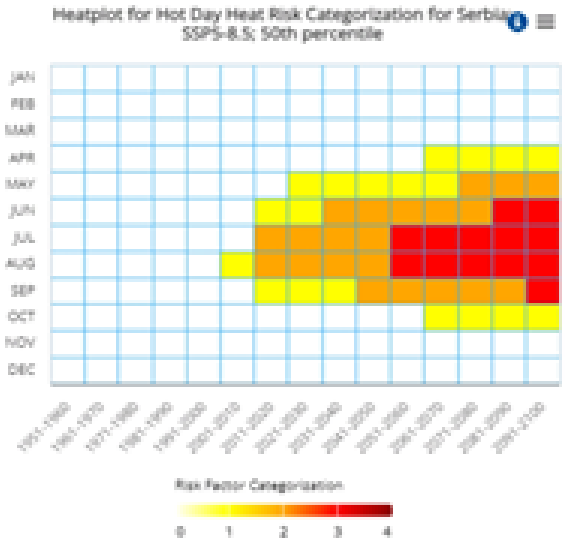
Graph 4. Projected Number of Hot Days (Tmax>300C) for 2080-2099(Annual) [1].



Graph. 5. Projected Seasonal Cycle of Daytime Temperatures; 2080-2099, ssps-8,5, Serbia [1].



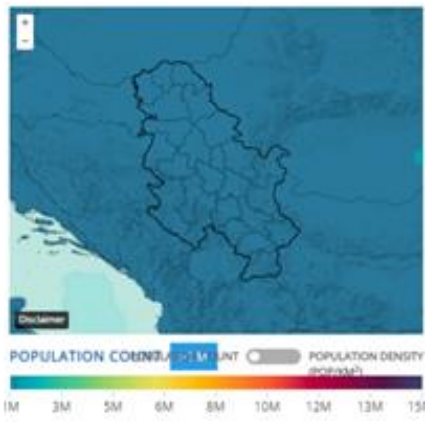
Graph. 6. Heat Categorization: Hot Day Heat Risk CATEGORIZATION FOR 2020-2039 (Annual); Serbia, SSPS-8,5; 50 th percentile [1].



Graph. 7. Heatplot for Hot Day heat Risk Categorization for Serbia, SSPS-8,5; 50th percentile [1].

3.3. This section explores the socio-economic background against which heat risks should subsequently be assessed. The following are presented: population (density: persons/km2 and number) and poverty classification. Understanding where the population is and what their relative poverty level is (using the percentage of the population below the poverty classification at the thresholds: $1.90, $3.20, $5.50 of income per day) can help decision makers identify key areas of need

Population and poverty data from the past to the present largely reflect the results of censuses and surveys (roughly up to 2010 in the presentations here). Future projections are made in collaboration with the formulation of the narrative of social development within the framework of the Common Socioeconomic Pathways (SSP). The goal of SSP is to describe a series of possible social futures where different technological, political and life trajectories are described. Within each of these stories, a trajectory of demographic change is generated, which then, based on technology assumptions, leads to likely emissions patterns that reflect that trajectory. From these emission lines, a set of the most representative likely radiation levels at the end of the 21st century is then selected to provide input to climate models. The SSPs reflect the most advanced iteration of socioeconomic narratives offered to date. They take into account social factors such as demography, human development, economic growth, inequality, governance, technological change and political orientations. While most factors are given as narratives outlining broad patterns of change globally and for major world regions, a subset (population1, GDP, urbanization and educational attainment) are given as country-specific quantitative projections. These variables were chosen based on their common use as inputs to emission or impact models and their interrelationships. See O'Neill et al. 2017 for more information on scripts and script development. The data presented below describe the population growth, poverty scale, age and gender classifications for each SSP.



Graph. 8. Projected Population Count for 2020-2039; Serbia; SSPS-8,5 [1].

Graph. 9. Current (2020) Poverty Scale for Percentage of Population below, $1,90/day, Serbia [1].

Graph. 10. Projected Population by SSP, for Serbia [1].

Graph. 11. Projected % National Population below Poverty Thresholds Serbia[1]

Graph. 12. Population pyramid for Serbia, 2020-2039, SSPS-8,5 [1].

4. CONCLUSION

Assessments that include forecasts and climate changes are needed and will be considered more and more in the future, due to the impact on the population, risk increase and other important factors for human life. Agriculture is considered here from the point of view of the amount of production of agricultural products, the capacity of water resources and the investments that will be realized in the coming period.

REFERENCES

[1] https://climateknowledgeportal.worldbank.org/country/serbia/heat-risk
[2] Kostic, B., Stevanovic, G., Lutovac, M., Lutovac, B., Ketin, S., Biocanin, E. (2020). Animal manure and environment,Fresenius Environmental Bulletin, Volume 29 , No. 03, p. 1289-1296
[3] Djelic, A. T., Neskovic, S., Ketin, S., Lutovac, M., Popovic, Z., Mirkovic, M., Secerov, P. (2019) Economic and environmental context of organic agriculture and farms in Serbia :case study, Fresenius environmental bulletin, vol. 28, no. 1, p. 87-92
[4] Ketin, S., Šinik, V., Biocanin, R (2019). Special techniques for prediction pollutants in the environmental safety, Industrial engineering and environmental protection IIZS 2019, p. 324-330
[5] Stanic, S., Šinik, V.,Ketin, S.(2019). Special method for investigation of geochemical parameters in studies of environmental protection, hydrological and mineralogical studies, Industrial engineering and environmantal protection IIZS 2019, p. 331-337
[6] Bojic, B., Lutovac, M., Ketin, S., Biocanin, R (2016). Agricultural sustainability strategy to implementation animal biofuels and „Green chemictry“, 6th International Conference Economics and Management-Based on New Technologies EMoNT 2016, p.472-487, Vrnjačka Banja, Serbia

[7] Sacirovic, S., Ketin, S., Vignjevic- Djordjevic, N.(2019). Eco-industrial zones in the context of sustainability development of urban areas. Environmental Science and Pollution Research, vol. 25, p. 1-11
[8] Matkovic, Stojsin, M., Zečević, V., Bošković, J., Perišić, V., Urošević, D., Roljević Nikolić, S., Knežević, D., (2023), The impact of environmental factors on yield components of winter and spring durum wheat, Zbornik radova : Nacionalni naučni skup sa međunarodnim učešćem Biotehnologija i savremeni pristup u gajenju i oplemenjivanju bilja, Smederevska Palanka, str. 106-115
[9] Nikolić, Roljević, S., Ćurčić, N., Matković, Stojšin, M., Stefanović, Mickovski, V.(2023) Variability of crop yield under the inflience of climate factors, X Simpozijum Društva selekcionera i semenara Republike Srbije i VII Simpozijum sekcije za oplemenjivanje organizama Društva genetičara Srbije, str. 79-80

THE IMPORTANCE AND BENEFITS OF IMPLEMENTING AN AGRICULTURAL INFORMATION SYSTEM

ZNAČAJ I KORISTI IMPLEMENTACIJE POLJOPRIVREDNOG INFORMACIONOG SISTEMA

Blagojche Najdovski, Asst. Prof. Ph.D[1]
Gordana Dimitrovska, Prof. Ph.D[2]
Elena Joshevska, Prof. Ph.D[3]
Darko Veljanovski, Asst. Prof. Ph.D[4]

Abstract: *The paper includes theories and literature starting with the development and implementation of agricultural information system, which is importance of agriculture information systems, the importance of their use, as well as analysis of the work agricultural information system. The purpose is to identify the components that are necessary for promotion, initiation, and use od information system in the field of agricultural. Also the paper presents advantages, importance and significance of agricultural information system and how they can be stimulated to improve and accelerate the growth and development of argo-production. The paper also presents the importance of the development and implementation of agricultural information system as which steps should be implemented..*

Key words: *Information, Information system, agriculture information system.*

Apstrakt: *Трудот опфаќа теории и литература почнувајќи од развојот и имплементацијата на земјоделскиот информациски систем, што е важноста на земјоделските информациски системи, важноста на нивната употреба, како и анализа на работата на земјоделскиот информациски систем. Целта е да се идентификуваат компонентите кои се неопходни за промоција, иницирање и користење на информацискиот систем во областа на земјоделството. Исто така во трудот се претставени предностите, важноста и значењето на земјоделскиот информациски систем и како тие можат да се стимулираат за подобрување и забрзување на растот и развојот на арго-производството. Трудот, исто така, ја прикажува важноста на развојот и имплементацијата на земјоделскиот информациски систем како чекори што треба да се спроведат.*

Ključne reči: *Информации, Информациски систем, земјоделски информациски систем.*

1. INTRODUCTION

The term information system can be accepted as a system that manages and processes information. Information systems are the place where you can find the necessary information to solve the problems. Their application is quite large. With the availability of information from Information systems are emerging and new opportunities.
With the help of information systems, users have access to a large amount of information, where they are enabled to share information and solve a variety of problems on a daily basis. Information

[1] Faculty of Biotechnical Sciences, Bitola, e-mail: blagojce.najdovski@uklo.edu.mk
[2] Faculty of Biotechnical Sciences, Bitola, e-mail: gordana.dimitrovska@uklo.edu.mk
[3] Faculty of Biotechnical Sciences, Bitola, e-mail: elena.joshevska@uklo.edu.mk
[4] Faculty of Biotechnical Sciences, Bitola, e-mail: darko.veljanovski@uklo.edu.mk

obtained from the agricultural sector is a very important factor for both domestic users and external users that can interact with other production factors. The productivity and functionality of other factors such as land, capital, labor and knowledge can be improved by using relevant and useful data.

It is necessary to understand the functioning of agricultural information systems in order to be able to manage them and use them as needed. The new agricultural technologies used are generated by research institutions, universities, private companies. Agricultural information systems together with knowledge sharing services, along with new technologies enable end users to connect and exchange information.

The main role of information retrieval is to obtain highly accurate, relevant and accurate data for end users. The purpose of this connection is to assist customers in their decision-making and to provide appropriate knowledge in order to obtain the best results.

2. MATERIAL AND METHODS

Agricultural information systems from different countries

Agricultural information systems are one of the new innovations in the agricultural sector. The use and implementation of agricultural information systems is different for each country, depending on the extent of the population engaged in agriculture and the need to implement an agricultural information system. Figure 1 shows a list of countries where agricultural information systems have been implemented and put into use.

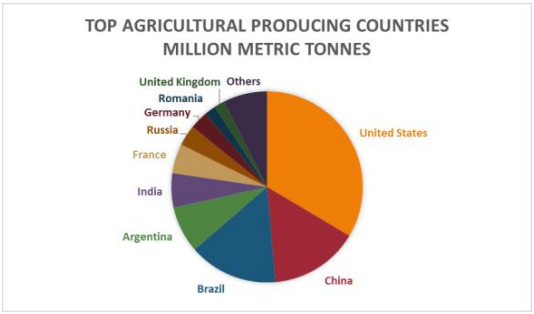


Figure 1: List of countries where agricultural information systems have been implemented and put into use.
Source:(https://www.google.com/search?q=top+10+agricultural+countries+in+the+world&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwjLwN37cHTAhXMthQKHeFJBA8Q_AUIBygC&biw=1440&bih=794#imgrc=LgmLZwCPSszuLM)

According to Figure 1, the country that has the greatest support for working with agricultural information systems is China and United States.

China - China has 7% of the arable land and with that; they feed 22% of the world's population. In the 20th century, China struggled to feed its large population. After that, upgrading farming policies and technologies made china big-time self-sufficiency and growth. China's top economic planning body alert that this would be difficult to keep. Agricultural information systems in China are of strategic importance, and they have major implications for GDP in their own country. China globally uses different information systems for different areas. Currently China is ranked as the second country in crop production thanks to agricultural information systems. Despite advances in

cereal, China great progress with the use of agricultural information systems has in the area of cattle farming.

United States - The United States is known for its agriculture science and provides some advanced agriculture technology in the world. It proves a role model for many countries in the agriculture sector, and the United States agriculture is developing continually with increasing rates. Developing here refers to scientific soil, crop analysis, more innovative machinery, and increased use of computers. In short, we can say that the United States is the best country in agriculture technology. The main culprits for the creation of agricultural information system in United States are three target groups, namely: The first target group refers to institutional customers who have quite a large benefit from this system. The benefit applies to that you can view different data involving agriculture internationally, or locally which applies for the country internally. The second target group are users who are concerned with agriculture, as a group where such benefits include advice and experience from different breeders and producers of agricultural production. The third target group refers to students, where the benefit is that they can explore and access information that they need. With the help of agricultural information systems this country significantly is improved regarding communication and support in the field of agriculture.

3. RESULTS AND DISCUSSION

The need and benefits of implementing an agricultural information system in Macedonia

Information systems are a place where information can be filled, transformed, processed and transferred and back, in order to enable cooperation and collection of information from different profiles depending on the type and purpose of the information system. Therefore, like any information system, the agricultural information system consists of interrelated processes such as: search, transfer and processing of information, as well as search mechanisms and certain operational services. Agricultural information systems are essential for agriculture in the process of education and gathering advice and entering certain comments. When analyzing the information system, one should look at the source of the information, the content of the information, the exchange of information, the degree of access to the information. An agricultural information system can be of great importance to users primarily in land planning, labor, capital and management. Considering the fact that the Republic of Macedonia is an agricultural country, the implementation of this type of information systems is of great importance.

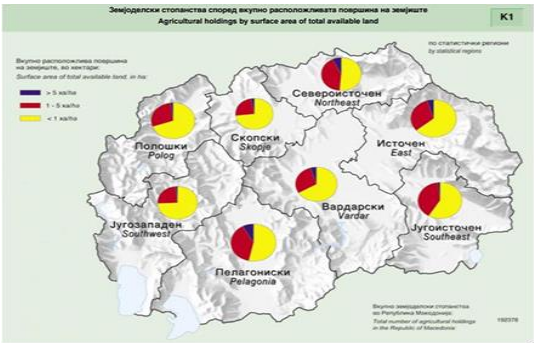


Figure 2: View of the population which is engaged in agriculture and availability of agricultural land in the Macedonia

Source:(http://www.stat.gov.mk/OblastOpsto.aspx?id=33)

Figure 2, according to the State Statistics Office, shows the population engaged in agriculture in different regions of Macedonia. According to the figure below with number 4, a part of the graph that is colored in yellow refers to a population that cultivates more than 1 ha/ha of land for all

regions of Macedonia. The red color refers to a population that cultivates more than 1-5 ha/ha of land and dominates the Pelagonian region, the northeastern, eastern, and southeastern regions, while the blue color corresponds to a population that cultivates less than 5 ha/ha of land, and so settled in mainly in the Pelagonian region, the eastern and northeastern regions.

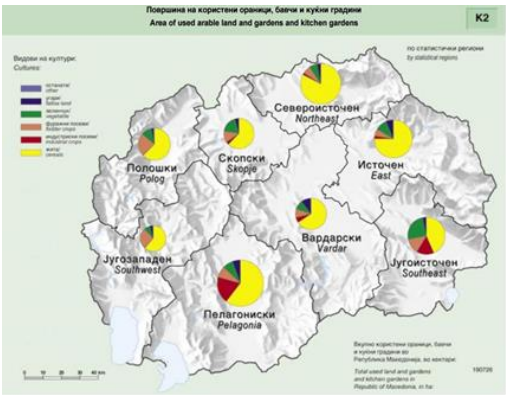


Figure 3: View the active use of agricultural land and crops processed
Source: (http://www.stat.gov.mk/OblastOpsto.aspx?id=33)

Figure 3, according to the State Statistics Office, shows the active cultivation of land and processing of agricultural products. According to Figure 3, a part of the graph that is colored in yellow refers to a population that is mainly engaged in the cultivation of cereal crops and has the highest percentage in Eastern and Northeastern Pelagonia. The red color refers to the population that grows cereal crops, which are most prevalent in the Pelagonian and Southeast regions. The green color refers to the inhabitants who grow vegetables and fruits in all regions of Macedonia, but the most widespread in the Southeast and Skopje, while the orange color refers to the products for animal feed from the population that are mainly grown in all regions of Macedonia and is most represented in Poloshko . The blue color corresponds to the population growing other crops.

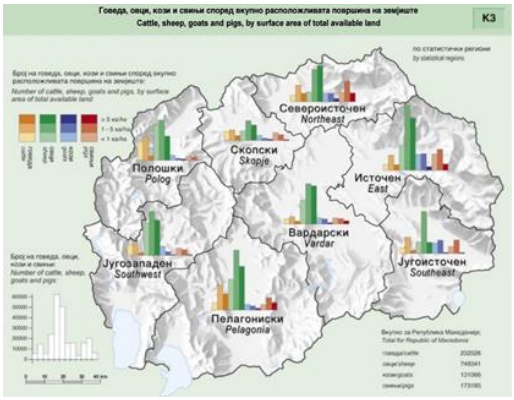


Figure 4: View the number of animals based on all available area of land in Macedonia by region
Source: (http://www.stat.gov.mk/OblastOpsto.aspx?id=33)

Figure 4, according to the State Statistics Office, shows the number of livestock based on all available land in Macedonia by region. The graph that is colored green in Figure 4 (dark and light) is the population that mainly deals with sheep with the highest percentage in the Pelagonian, Polognian and Eastern regions. The orange (dark and light) color indicates that the population is

growing and the goods are standing in all regions of Macedonia, mostly in relation to the Pelagonian and Pologne regions. The blue (light and dark) color refers to a goat-breeding population, but is most prevalent in the southeastern and eastern regions, while the red (light and dark) color refers to a pig-breeding population, but is most prevalent in the northeastern and Pelagonian regions.

As one of the advantages that follow with the implementation of agricultural information systems in this sector are: Productivity - increased economic contribution, profitability, potential and maintenance, environmental safety, energy saving, availability of information in real time, availability of content from different agricultural commodities, Integrated, flexible work, Ability to process large amounts of data.

Over the years, Macedonia has seen great progress and an increase in the use of information and communication services, which are not a big problem for the operation and management of agricultural information systems.

4. CONCLUSION

In the era of information and communication technology, for the successful execution of various needs in the field of agriculture it is necessary to have access to a large amount of information. However, in some rural areas of the country where the population is engaged in agriculture, there is a lack of adequate access to information, so that agricultural information systems are of great importance for access to information from domestic and foreign sources and their practical application. To improve the work of agricultural information systems, it is recommended to use communication between farmers, coordinators, agricultural experts. Information should be based on the needs of the users, while the Internet can be used as an advanced way to transmit information in the community. As well as with the help of the analysis of agricultural information systems, a conclusion can be reached about its components. It allows users to realize the benefits of agricultural information systems. In addition, the exchange of information is very important to find solutions to problems. The paper presents the results in different parts of the business where the population is engaged in agriculture. Based on these results, it can be concluded that the implementation of information systems for Macedonia is of great importance.

REFERENCES

[1] Adebayo, E. L. (2007). Awareness, access and usage of information and communication technologies between female researchers and extensionists. International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2007, Vol. 3, Issue 1. pp. 85-93.

[2] Aggelidis, V.P., Chatzoglou, P.D. (2012). Hospital information systems: measuring end user computing satisfaction (EUCS). J Biomed Inform. pp. 76

[3] Arokoyo, T. (2005). ICTs application in agricultural extension service delivery. In S.F. Adedoyin (Ed.), Agricultural extension in Nigeria (pp. 32–40). Ilorin, Nigeria: Agricultural Extension Society of Nigeria.

[4] Byerlee, D., de Janvry, A., Sadoulet, E., (2010). Agriculture for development – revisited. Lessons learned from the University of California at Berkeley conference. *In Paper Presented at the Conference Agriculture for Development Revisited*, University of California at Berkeley, CA, October 1–2.

[5] Chatterjee, S., Chakraborty, S., Sarker, S., Sarker,. S, Lau, F.Y. (2009). Examining the success factors for mobile work in healthcare: a deductive study. *Decis Support Syst*. pp. 620-633

[6] Vázquez-Cruz, M.A., Torres-Pacheco, I., Miranda-Lopez, R., Cornejo-Perez, O., Osornio-Rios, A.R., Romero-Troncoso, R., Guevara-Gonzalez, R.G. (2010). Potential of mathematical modeling in fruit quality, Afr J Biotechnol. pp. 260–267

[7] Warren, M. F. (2002). Adoption of ICT in agricultural management in the United Kingdom:The intra rural digital divide. Agricultural Economics, 48 (1), pp.1–8.
[8] West, G.B., Brown, J.H., Enquist, B.J. (1997). A general model for the origin of allometric scaling laws in biology. Sci 276. pp. 122–126
[9] https://www.tractorjunction.com/blog/top-10-agricultural-producing-countries-in-the-world/

11. JEEP MEĐUNARODNA NAUČNA AGROBIZNIS KONFERENCIJA – MAK 2024.
11th International Scientific Agribusiness Conference – MAK 2024.
"HRANA ZA BUDUĆNOST-VIZIJA SRBIJE, REGIONA I JI EVROPE"
"FOOD FOR THE FUTURE-VISION OF SERBIA, REGION AND SE EUROPE"
KOPAONIK, 02. - 04. februar 2024.

THE STATE AND THE PERSPECTIVE OF ORGANIC AGRICULTURE IN REPUBLIC OF NORTH MACEDONIA

ДРЖАВАТА И ПЕРСПЕКТИВАТА НА ОРГАНСКОТО ЗЕМЈОДЕЛСТВО ВО РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА

Kristina Tomska, Msc Bs[1]
Milena Magerovska,[2]

Abstract: *Modern organic agriculture has been developed as a response to the environmental damage caused by the use of chemical pesticides and synthetic fertilizers in conventional agriculture and has numerous ecological advantages. According to the data of the Ministry of Agriculture, Forestry and Water Management of the Republic of North Macedonia on the total arable land in 2022 year, a total of 4,815 ha were registered under plant organic agricultural production. Cereal crops with 36%, fruit plantations with 23%, fodder crops with 22%, vine plantations with 3%, industrial/aromatic/medicinal plants with 13% and horticultural crops with 2% have the largest share in plant organic production. In livestock organic production, the leading branch is sheep farming with 89% of the total organic livestock production. Cattle breeding accounts for 7% and goat breeding for 4% in the total animal husbandry. In beekeeping organic production, the total number of bee families is 10,072 in 2022. Our country has ideal conditions for their cultivation, and therefore the increased production of organic food is of particular interest to all of us, both as a country and as farmers and as consumers.*

Key words: *organic, agriculture, pesticides, ecology, certification*

Apstract: *Современото органско земјоделство е развиено како одговор на еколошката штета предизвикана од употребата на хемиски пестициди и синтетички ѓубрива во конвенционалното земјоделство и има бројни еколошки предности. Според податоците на Министерството за земјоделство, шумарство и водостопанство на Република Северна Македонија на вкупното обработливо земјиште во 2022 година, под растително органско земјоделско производство се регистрирани вкупно 4.815 хектари. Најголемо учество во растителното органско производство имаат житните култури со 36%, овошните со 23%, фуражните со 22%, лозовите насади со 3%, индустриските/ароматичните/лековитите со 13% и градинарските култури со 2%. Во сточарското органско производство водечка гранка е овчарството со 89% од вкупното органско сточарско производство. Во вкупното сточарство сточарството учествува со 7%, а козарството со 4%. Во пчеларското органско производство вкупниот број на пчелни семејства е 10.072 во 2022 година. Нашата земја има идеални услови за нивно одгледување и затоа зголеменото производство на органска храна е од особен интерес за сите нас, и како држава и како земјоделци и како потрошувачи.*

Key words: *органски, земјоделство, пестициди, екологија, сертификација*

1. INTRODUCTION

Organic farming is a method of agricultural production that excludes the use of synthetic substances, such as pesticides, synthetic drugs or fertilizers, and genetically modified organisms.

[1,2] University "St. Kliment Ohridski" – Bitola, Faculty of Biotechnical Sciences – Bitola, e-mail: kristina_velkova@hotmail.com

Modern organic agriculture was developed in response to the environmental damage caused by the use of chemical pesticides and synthetic fertilizers in conventional agriculture and has numerous environmental advantages.

Organic farming reduces the use of non-renewable energy by reducing agrochemical needs (they require large amounts of fossil fuels for production). Organic farming contributes to mitigating the greenhouse effect and global warming through its ability to sequester carbon in the soil.
Apart from the ecological moment, there is also the social element, i.e. the loss of traditional values, the loss of villages and the emigration of the able-bodied population to larger cities and outside the country.

Today, as technology evolves, social expectations evolve in parallel. There is a consensus for more sustainable agriculture, with a double challenge – to produce enough food, while additionally protecting nature and protecting our biodiversity. Organic agriculture enables permanent production of primary agricultural products, without the use of chemicals that have a harmful impact on the environment and human health. Agrochemicals (plant protection products and mineral fertilizers) are not used in cultivation operations, as they degrade the soil and pollute the environment, in order to protect the biodiversity and integrity of humans and other organisms that live there.

The creation and maintenance of organic matter in the soil, that is, the maintenance of the soil and seeing it as a living organism is the basic principle of organic production.
Regardless of which cultivation system is used (conventional or organic), farmers will always encounter the problem of pests, for which they spend considerable time and money. However, in organic agriculture, diseases and pests are seen as indicators of how much the ecosystem in which production takes place is disturbed compared to the one whose imitation is sought (the undisturbed natural system). The greater and more frequent their presence, it is a sign of a greater disruption of the ecosystem. Today, it is considered that pesticides are one of the causes of the loss of balance of ecosystems, which is why the use of permitted (natural) pesticides is resorted to, and only as a last resort.

Integrated plant protection reduces economic, health and life risks. By using all available plant protection measures, the use of plant protection products is reduced, and thus their potentially negative effects on consumer health and the environment;

The rotation of agricultural crops protects the anthropogenic soil from negative abiotic factors, and the protective crops and intercrops inserted in the rotation of agricultural crops, as well as the residues of agricultural crops play a special role because they suppress weeds, control erosion, increase the content of nutrients substances and improve the structure of the soil;

Protective crops, intercrops and harvest residues protect the soil from adverse abiotic factors, control erosion and suppression of weeds, thus influencing the improvement of the structure and the increase of the nutrient content of the soil.

In organic production, fertilization consists in the application of domestic manures, stable manures, and leguminous siderations in order not to use factory fertilizers with nitrogen. The trees and bushes of the farm are also the safest protection against strong winds; The European Green Deal, the Farm to Fork Strategy, the Biodiversity Strategy and the Zero Pollution Action Plan – set very ambitious targets that will significantly influence farming practices in the years to come in the quest for a more sustainable agriculture in Europe.

2. CERTIFICATION

Organic certification allows a farm or processing plant to sell, label and represent its products as organic. A control/certification body is an independent legal entity to which the competent authority gives the authority to perform control and certification in organic agricultural production, in accordance with the

provisions of this law. Certification control is a procedure carried out by the control/certification body for the first time in the process of issuing a certificate for organic production. Certification provides written confirmation that the product, process or service complies with the specific requirements for organic agricultural production.

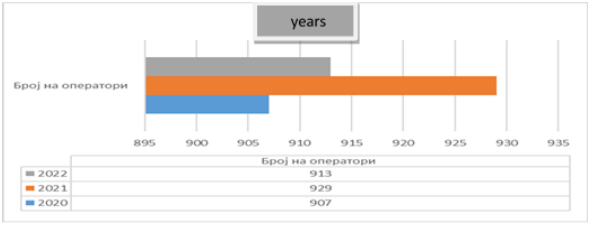
Producers should thoroughly study all the rules and norms, to be able to assess whether their farm can pass the strict filter, before proceeding to the certification process. After obtaining a certificate, which is renewed every year. the producer can start selling his products under the name "organic product", as well as put symbols on them that will reflect the character of that production.

1. The process of control and certification of organic production begins with a conversation with a representative from the certification house and with familiarization with
the conditions and rules that must be observed in the organic production method.
2. After receiving the necessary information and meeting all the prerequisites (whether the location is suitable, distance from road/polluter, when and how the land was used before, whether there are surrounding farms that treat with pesticides, etc.), it is necessary to fill out an application (a form that will be given to you by the control and certification body) for the control and certification of the planned organic production, which is then submitted to the certifier.
3. Based on the submitted application, the control and certification body will provide you with an offer with specified costs and conditions for performing the control and certification.
4. If the manufacturer decides to continue with the control and certification process, it is necessary to provide the control and certification body with more detailed information about the planned production, after which a contract for control and certification is signed. With the signing of the contract, the control and certification procedure officially begins
5. The control and certification body has the right at any time to perform unannounced controls in the production process and adherence to the principles of organic production.
6. If the control shows that the producer does not comply with the principles of organic production, the control and certification body has the right to impose appropriate punitive measures, as well as to revoke the acquired certificate.
7. Within the Ministry of Agriculture, there is an inspector for organic production who, after a report of irregularity, should go for inspection and visit. He controls indirectly both the certifier himself and the manufacturer.

3. THE STATE WITH ORGANIC PRODUCTION IN THE REPUBLIC OF NORTH MACEDONIA

The development of organic agricultural production in the Republic of North Macedonia continues and is maintained in accordance with the measures established in the support policies established in the National Strategy for Agriculture and Rural Development for the period 2021-2027 and the Program for Organic Agricultural Production for 2022. ("Official Gazette of the Republic of North Macedonia" no. 111/22), required for the realization of the planned activities.
In the last three years, there has been a variation in the number of organic operators (entities) in organic production.

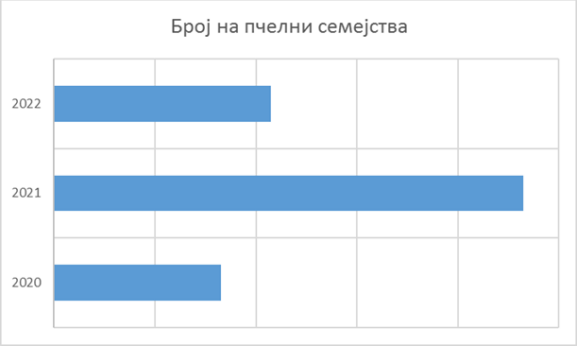
Exhibit 1: Number of organic operators, 2020-2022.



According to the state of the total arable land in 2022, a total of 4,815 ha were recorded under plant organic agricultural production. Cereal crops with 36%, fruit crops with 23%, fodder crops with 22%,

vineyards with 3%, industrial/aromatic/medicinal plants with 13% and horticultural crops with the largest share in organic plant production have 2%. In livestock organic production, the leading branch is sheep farming with 89% of the total organic livestock production. Cattle breeding accounts for 7% and goat breeding for 4% in the total animal husbandry. In beekeeping organic production, the total number of bee families in the period from 2020 is 9,826 families in 2021 to 11,325 bee families and 10,072 bee families in 2022.

Exhibit 2: Number of bee colonies, 2020-2022



According to the National Strategy for Agriculture and Rural Development for the period 2021-2027, the financial support of organic production continues in 2022. Support for

organic production in 2022 is 30% higher than the amount of direct payments for conventional production for fodder crops, 50% for arable crops, livestock and beekeeping production, 70% for fruit growing and viticulture and 100% for horticultural production, as well as covering 50% of the costs for certification of organic production and covering 70% of the costs for agrochemical, pedological or analyzes of pesticide residues, heavy metals, etc. substances on soil and in organic products.

The support for the processing of organic products and organic products in transition from domestic origin (including for the finishing and packaging of wild species of organic origin is 10% of the value of the produced and sold products, but not more than 150,000.00 denars per operator. The support for trade or export of fresh and processed organic products and organic products in transition from domestic origin is 5% of the value of sold/exported products, but not more than 150,000 denars per operator.

4. THE STATE WITH ORGANIC PRODUCTION IN THE BITOLA REGION

In the Single Register for Agricultural Economy of the Ministry of Agriculture, Forestry and Water Management - PE Bitola, there are about 30 producers of certified organic production. The largest part of them are registered breeders of bee families. Two cattle breeders. A producer of aromatic and spicy plants. Five producers of nuts - hazelnut and walnut.

5. PERSPECTIVES OF ORGANIC AGRICULTURE IN THE REPUBLIC OF MACEDONIA

About 1,000 entities are certified in the country, some for crop production, but there are also livestock farmers, beekeepers, processors, traders and others. They encounter various problems in everyday life, small producers face problems with placement, they are not available to the buyer, or they are not sufficiently informed about which protective means can be used to protect certain products.
Organic production is an alternative to the negative environmental consequences that come from the use of chemical fertilizers as well as from various means of protection that are used in conventional

agriculture. Our country has ideal conditions for their cultivation and therefore to all of us as a country and as farmers and as As consumers, the increased production of organic food is of particular interest to us.

Organic farming allows small farms to be more competitive with an emphasis on quality rather than quantity. According to research conducted by the International Fund for

Agricultural Development (IFAD), small farmers in developing countries can benefit significantly from organic farming.

Organic production can offer a solution to existential problems, given that organic products are sold at higher prices, and production itself becomes economically viable. The greater demand for organic products will increase the choice and reduce the price of organic products.

REFERENCES

[1] Annual agricultural report for 2022 of the Ministry of Agriculture, Forestry and Water Management, Republic of North Macedonia
[2] IFOAM (International Federation of Organic Agriculture Movements), Basel, Switzerland (2000), "Basic Standards for Organic production and processing"
[3] M.H. Malais and W.J. Ravensberg (2004): "Main pasts of greenhouse criops and their natural enemies"
[4] Law on Organic Production, Ministry of Agriculture, Forestry and Water Management, Republic of North Macedonia
[5] Berry, P., Ogilvy, S. and Gardener, S. (2004) Integrated farming and biodiversity (English Nature Research Report 634). Peterborough.
[6] Single Register for Agricultural Economy- PE Bitola

SUSTAINABLE PLANT AND ANIMAL WASTE MANAGEMENT STRATEGIES IN THE REPUBLIC OF NORTH MACEDONIA: A COMPREHENSIVE ANALYSIS

СТРАТЕГИИ ЗА ОДРЖЛИВ МЕНАЏМЕНТ СО РАСТИТЕЛЕН И ЖИВОТИНСКИ ОТПАД ВО РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА: СЕОПФАТНА АНАЛИЗА

Viktorija Stojkovski, Assistant Professor [1]
Katerina Bojkovska, Professor [2]
Nikolche Jankulovski, Professor [3]
Daniel Simakoski, Assistant [4]

Abstract: *Plant and animal waste, often generated in significant quantities through agricultural and livestock activities, represents a complex and multifaceted challenge with profound implications for environmental sustainability. As global populations grow, so does the demand for food production, intensifying the impact of waste generated from plant residues, crop processing, and animal husbandry.*
The effective management of this waste is imperative not only to mitigate environmental degradation but also to harness its potential benefits in promoting sustainable agricultural practices. This descriptive scientific paper examines the current state of plant and animal waste management strategies in North Macedonia, with a focus on sustainable and environmentally friendly practices. The paper explores various approaches and technologies employed to manage waste generated by agricultural and livestock activities, emphasizing the need for efficient waste utilization to minimize environmental impact.
This paper aims to present the current situation in the Republic of North Macedonia using statistical data and propose strategies for improving the management of plant and animal waste. Furthermore, by presenting a comprehensive overview of successful waste management strategies in North Macedonia, this paper aims to contribute to the ongoing efforts to create a more sustainable and environmentally conscious agricultural and livestock sector in the country.

Key words: *plant and animal waste management, sustainable agriculture, green management strategies*

Апстракт: *Растителниот и животинскиот отпад, често генериран во значителни количини преку земјоделски и сточарски активности, претставува комплексен и повеќеслоен предизвик со длабоки импликации за одржливоста на животната средина. Како што расте глобалното население, така расте и побарувачката за производство на храна, интензивирајќи го влијанието на отпадот што се создава од растителните остатоци, преработката на културите и сточарството.*

[1] University „St.Kliment Ohridski"- Faculty of Biotechnical Sciences, Bitola,
e-mail: viktorija.stojkovski@uklo.edu.mk
[2] University „St.Kliment Ohridski"- Faculty of Biotechnical Sciences, Bitola,
e-mail: katerina.bojkovska@uklo.edu.mk
[3] University „St.Kliment Ohridski"- Faculty of Biotechnical Sciences, Bitola,
e-mail: nikolce.jankulovski@uklo.edu.mk
[4] University „St.Kliment Ohridski"- Faculty of Biotechnical Sciences, Bitola,
e-mail: daniel.simakoski@uklo.edu.mk

Ефективното управување со овој отпад е императив не само за да се ублажи деградацијата на животната средина, туку и да се искористат неговите потенцијални придобивки во промовирањето одржливи земјоделски практики. Овој описен научен труд ја испитува моменталната состојба на стратегиите за управување со растителен и животински отпад во Северна Македонија, со фокус на одржливи и еколошки практики. Трудот истражува различни пристапи и технологии употребени за управување со отпадот создаден од земјоделски и сточарски активности, нагласувајќи ја потребата за ефикасно искористување на отпадот за да се минимизира влијанието врз животната средина.
Овој труд има за цел да ја прикаже моменталната состојба во Република Северна Македонија користејќи статистички податоци и да предложи стратегии за подобрување на управувањето со растителниот и животинскиот отпад. Понатаму, со презентирање на сеопфатен преглед на успешните стратегии за управување со отпад во Северна Македонија, овој труд има за цел да придонесе кон тековните напори за создавање поодржлив и поеколошки свесен земјоделски и сточарски сектор во земјата.

Ključne reči: *управување со растителен и животински отпад, одржливо земјоделство, стратегии за зелено управување*

THE INFLUENCE OF THE HEALTH CONDITION OF THE SEED MATERIAL ON THE PRODUCTIVITY OF THE OLD VARIETY "RUSKA KRTOLA"

UTICAJ ZDRAVSTVENOG STANJA SJEMENSKOG MATERIJALA NA PRODUKTIVNOST STARE SORTE „RUSKA KRTOLA“

Milica Bućković, MSc students.[1]
Zoran Jovović, Full professor [2]
Ana Velimirović, PhD [3]
Adreja Komnenić, PhD student [4]

Abstract: *'Ruska krtola' is an old potato variety that has been cultivated in Montenegro for more than 200 years. During that long growing period, the tuber completely degenerated, so planting such material results in very low yields.*

This paper presents the results of the influence of the health status of seed tubers on the most important productivity parameters of the dominantly cultivated local variety 'Ruska krtola'. The experiment was set up as a two-factorial experiment: factor A - tuber health condition and factor B - year. Tubers of different health conditions were used for planting: virus-free planting material and tubers 100% infected with viruses. In the experiments, seed tubers of the fraction 35-55 mm were used.
In the plots where virus-free seed tubers were planted, a significantly higher average number of tubers per plant was found (13.5 in 2020 and 11.5 in 2021) compared to the variants where degenerate planting material was used for planting (9.9 in 2020 and 9.5 in 2021). Average tuber mass was significantly higher in plants emerging from virus-free seed tubers (61.3 g in 2020 and 64.1 g in 2021). For these reasons, the highest total tuber yield was measured on these variants (33.7 tha^{-1} in 2020 and 30.1 tha^{-1} in 2021). Compared to the yields achieved in plots using virus-infected planting material (23.7 tha^{-1} in 2020 and 22.1 tha^{-1} in 2021) they were marked as very significant. On the variants with the use of virus-free planting material (29.9 tha^{-1} in 2020 and 25.7 tha^{-1} in 2021), a significant increase in the yield of marketable tubers was also determined, compared to the variants on which degenerated seed tubers were used for planting (20.0 tha^{-1} in 2020 and 18.3 tha^{-1} in 2021).

Key words: *potato, old varieties, 'ruska krtola', productivity*

[1] Ministry of Agriculture, Forestry and Water Management of Montenegro, Rimski trg 46, 81000 Podgorica, Montenegro, e-mail: milica.buckovic@mpsv.gov.me
[2] University of Montenegro, Biotechnical Faculty, Mihaila Lalića 15, 81000 Podgorica, Montenegro, e-mail: zoran.jovovic.btf@gmail.com
[3] University of Montenegro, Biotechnical Faculty, Mihaila Lalića 15, 81000 Podgorica, Montenegro, e-mail: ana.velimirovic@hotmail.com
[4] University of Montenegro, Biotechnical Faculty, Mihaila Lalića 15, 81000 Podgorica, Montenegro, e-mail: andrea.komnenic@gmail.com

Apstrakt: *„Ruska krtola“ je stara sorta krompira koja se u Crnoj Gori gaji više od 200 godina. Tokom tog dugog perioda gajenja došlo je do potpune degeneracije krtola, tako da se sadnjom takvog materijala dobijaju veoma niski prinosi.*

U ovom radu predstavljeni su rezultati uticaja zdravstvenog stanja sjemenskih krtola na najvažnije parametre produktivnosti dominantno gajene lokalne sorte „ruska krtola“. Ogled je postavljen kao dvofaktorijalni: faktor A - zdravstveno stanje krtola i faktor B – godina. Za sadnju su korišćene krtole različitog zdravstvenog stanja: bezvirsuni sadni materijal (virus free) i krtole stoprocentno zaražene visrusima. U ogledima su korišćene sjemenske krtole frakcije 35-55 mm.

Na parcelama na kojima su sađene bezvirusne sjemenske krtole utvrđen je značajno veći prosječan broj krtola po biljci (13,5 u 2020. i 11,5 krtola/biljci u 2021.) u poređenju sa varijantama na kojima je za sadnju korišćen degenerisani sadni materijal (9,9 u 2020. i 9,5 krtola/biljci u 2021.). Prosječna masa krtola bila je značajno veća kod biljaka izniklih iz bezvirusnih sjemenskih krtola - 61,3 g u 2020. i 64,1 g u 2021. god. Iz tih razloga na ovim varijantama izmjereni su i najveći ukupni prinosi krtola (33,7 tha^{-1} u 2020. i 30,1 tha^{-1} u 2021.). U poređenju sa prinosima ostvarenim na parcelama sa upotrebom virusom zaraženog sadnog materijala (23,7 tha^{-1} u 2020. i 22,1 tha^{-1} u 2021.) oni su označeni kao veoma značajni. Na varijantama sa upotrebom bezvirusnog sadnog materijala (29,9 tha^{-1} u 2020. i 25,7 tha^{-1} u 2021.) utvrđeno je i značajno povećanje prinosa tržišnih krtola u poređenju sa varijantama na kojima su za sadnju korišćene degenerisane sjemenske krtole (20,0 tha^{-1} u 2020. i 18,3 tha^{-1} u 2021.).

Ključne riječi: *krompir, stare sorte, „ruska krtola“, produktivnost*

Appendix B: AUTHORS' INDEX

	A	
1.	Andjušić Ljiljana	ljiljana.andjusic@pr.ac.rs
2.	Anđelković Ana	ana.andjelkovic21@gmail.com
3.	Abdulhameed M Isam	isambayati@uoanbar.edu.iq
	B	
4.	Bataveljić Dragan	bataveljic@jura.kg.ac.rs
5.	Božić Dragana	dbozic@agrif.bg.ac.rs
6.	Biočanin Rade	rb.biocanin@gmail.com
7.	Beskorovajni Radmila	rbeskorovajni@ipn.co.rs
8.	Bojkovska Katerina	katerina.bojkovska@uklo.edu.mk
9.	Bućković Milica	milica.buckovic@mpsv.gov.me
	V	
10.	Vojvodić Anka	anka.vojvodic@vzsvisan.com
11.	Vojvodić Marko	marko.vojvodic@vzsvisan.com
12.	Vujić Danijela	danijela.76@outlook.com
13.	Vrbničanin Sava	sava@agrif.bg.ac.rs;
14.	Vujičić Slađana	sladjanakonto@gmail.com
15.	Veljanovski Darko	darko.veljanovski@uklo.edu.mk
16.	Vasilievna Agarkova Natalya	
17.	Velimirović Ana	ana.velimirovic@hotmail.com
	G	
18.	Gantner Vesna	vgantner@fazos.hr
19.	Gantner Ranko	rgantner@fazos.hr
20.	Gjorgovska Natasha	natasha.gjorgovska@istoc.ukim.mk
21.	Grčak Dragan	dragangrcak@gmail.com
22.	Grčak Milosav	milosavgrcak@gmail.com
23.	Grujičić Ivana	grujicic43@gmil.com
	D	
24.	Dudić Tijana	tijanadudic44@gmail.com
25.	Delić Nikola	ndelic@istocar.bg.ac.rs
26.	Dimitrovska Gordana	gordana.dimitrovska@uklo.edu.mk
	Đ	
27.	Đurović Sanja	stojakovicsm@yahoo.com
	Z	
28.	Zečević Veselinka	vzecevic@institut-palanka.rs
	I	
29.	Ivanović Tatjana	tatjana.ivanovic@pr.ac.rs
30.	Ivetić, Aleksandra	aivetic@ipn.bg.ac.rs
	J	
31.	Jovanović Larisa	larisa.jovanovic@alfa.edu.rs
32.	Jovanović Jovana	jovanaj90@yahoo.com
33.	Janković Snežana	sjankovic@ipn.bg.ac.rs
34.	Joshevska Elena	elena.joshevska@uklo.edu.mk
35.	Jankulovski Nikolche	nikolce.jankulovski@uklo.edu.mk

36.	Jovović Zoran	zoran.jovovic.btf@gmail.com
	K	
37.	Knežević Desimir	deskoa@ptt.rs
38.	Ketin Sonja	ketin@institut-tamis.rs
39.	Kostić Boban	bobankosticbk@gmail.com
40.	Kuterovac Krešimir	kresimir.kuterovac@gmail.com
41.	Keškić Tanja	tanjakeskic@gmail.com
42.	Kondić Danijela	danijela.kondic@agro.unibl.org
43.	Keškić Tanja	tkeskic@istocar.bg.ac.rs
44.	Konstantinović Bojan	
45.	Komnenić Adreja	andrea.komnenic@gmail.com
	L	
46.	Levkov Vesna	vesna.levkov.1@istoc.ukim.mk
47.	Laze Ariona	alaze@ubt.edu.al
	M	
48.	Milanović Tijana	tijana.milanovic@akademijanis.edu.rs
49.	Menkovska Mirjana	menkovska06@yahoo.com
50.	Momčilović Oliver	oliver.momcilovic@mef.edu.rs
51.	Mesarović Aleksandra	krsmanovic.sandra88@gmail.com
52.	Matejić Biljana	biljanamatejicns@gmail.com
53.	Mićanović Danica	danica.micanovic@pks.rs
54.	Matković Stojšin Mirela	mirelam89@gmail.com
55.	Milošević Božidar	bozidar.milosevic@pr.ac.rs
56.	Maslovarić Marijana	mmaslovaric@ipn.bg.ac.rs
57.	Milošević Georgiev Andrijana	andrijana.milosevic@pharmacy.bg.ac.rs
58.	Mandić Violeta	vmandic@istocar.bg.ac.rs
59.	Momirceski Jovica	golemizvor@yahoo.com
60.	Magerovska Milena	
61.	Magerovska Milena	
62.	Musafah Seddiq Mohamed Ahmed El	
	N	
63.	Nazari Simin Hagh	haghnazari.simin@znu.ac.ir
64.	Najdovski Blagojche	blagojce.najdovski@uklo.edu.mk
	P	
65.	Pacinovski Nikola	nikola.pacinovski@istoc.ukim.mk
66.	Pisinov Boris	boriss752002@yahoo.com
67.	Petričević Maja	mpetricevic@istocar.bg.ac.rs
68.	Pavićević Nina	nina.pavicevic007@gmail.com
96.	Popović Nikola	npopovic@ipn.co.rs
70.	Popov Milena	
	S	
71.	Stepanov Saša	sasa.stepanov@gmail.com
72.	Stepanov Nemanja	nemanja.stepanov@gmail.com
73.	Stojanović Bojan	arcturas@agrif.bg.ac.rs
74.	Sekulić Zoran	zoran.sekulic@zdravlje.org.rs
75.	Stamenić Tamara	tstamenic169@gmail.com

76.	Simović Stanko	
77.	Stamenić Tamara	tstamenic@istocar.bg.ac.rs
78.	Savić Slađana	bonita.sladja@gmail.com
79.	Ivan S. Stević, S. Ivan	istevovic@mas.bg.ac.rs
80.	Stojkov, Pavlović Aleksandra	aleksandra.stojkov.pavlovic@alfa.edu.rs
81.	Samolovac Ljiljana	ljsamolovac@istocar.bg.ac.rs
82.	Samardžić, Nataša	
83.	Stanković Sladjan	
84.	Stojanović Tijana	
85.	Simić Divna	
86.	Skamarokhova Alexandra Sergeevna	rskamarokhov@mail.ru
87.	Stojkovski Viktorija	viktorija.stojkovski@uklo.edu.mk
87.	Simakoski Daniel	daniel.simakoski@uklo.edu.mk
	T	
89.	Tutkun Muhittin	muhittin.tutkun@dicle.edu.tr
90.	Tomić Ljiljana	ljiljanatomic1965@gmail.com
91.	Trkulja Nenad	trkulja_nenad@yahoo.com
92.	Tomić Darinka	dtomic@uwo.ca
93.	Tomovska Julijana	dzulitomovska@yahoo.com
94.	Tomska Kristina	kristina_velkova@hotmail.com
	Ć	
94.	Ćosić Milivoje	micko.cosic@gmail.com
	Š	
96.	Šikuljak Danijela	dulekaca@yahoo.com
	Y	
97.	Yaman Nese	nuzen@dicle.edu.tr

11. JEEP INTERNATIONAL SCIENTIFIC AGRIBUSINESS CONFERENCE MAK 2024 – KOPAONIK

"FOOD FOR THE FUTURE - VISION OF SERBIA, REGION AND SOUTHEAST EUROPE"
02-04. February 2024, KOPAONIK, GRAND HOTEL, CONGRESS CENTER

AGENDA

THURSDAY, February 1st, 2024	
16:00 - 18:00	**REGISTRTION OF PARTICIPANTS (HOTEL JAT APARTMENTS)**
18:00 - 19:00	**WELCOME COCTAIL (HOTEL JAT APARTMENTS)**
FRIDAY February 2nd, 2024	
09:00 – 18:00	**REGISTRTION OF PARTICIPANTS**
11:00 – 11:30	**WELCOME COCTAIL (Congress hall, Hotel Grand)** **Sponsor: Čoka Winery, Ohrid Winery, Rakija Gegula, BIO TEA**
11:30 - 12:20	**CONFERENCE OPENING CEREMONY AND WELCOME WORD** General sponsor: NIKOM CARS, Kragujevac **Marija Jovičić,** President of BM Sci. Business Center WORLD, Organizer **Zoran Jelenković,** President Union of Micological Societies of Serbia, Belgrade, **Zvonko Tufegdžić,** Director of Regional Chamber of Commerce of Kraljevo **Prof.dr Saša Stepanov,** President of the Scientific Committee MAK 2024 **Nenad Krstić,** President of Municipality Trgovište **Danica Ilić,** Municipality Lopare, Republic of Srpska **Nemanja Popović,** President of Municipality Raška **Dr Nenad Trkulja,** Director of Institute for Plant Protection and Environment, Belgrade **Siniša Dagary**, Director, Sl. Group, Ljubljana, Slovenija **Aleksandar Bogunović,** Serbian Chamber of Commerce & Industry, Belgrade **Boban Ilić,** General secretary of the permanent working group for regional rural development (SWG), Skopje, North Macedonia **Danilo Savić,** Director of the State Data Center, Kragujevac **Damir Baralić,** Deputy director of the Administration for Agrarian Payments, Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia **Dr Predrag Terzić**, Mayor of Kraljevo
12:20 – 13:00	**AWARDS CEREMONY**

	"DIPLOMA OF THE VALLEY OF KINGS, CENTURIES AND SYRINGA" **Sponsors: CITY OF KRALJEVO, SERBIAN CHAMBER OF COMMERCE, BELGRADE**
13:00 – 13:45	**CEREMONY COCKTAIL WITH LUNCH** Kongress centar (Hall); GRAND Hotel Sponzors: **ČOKA WINERY, RAKIJA GEGULA, BIO TEA**
13:45 - 14:55	**Plenary session: GLOBAL CHANGES AND SUSTAINABLE FOOD PRODUCTION** **Chairpersons: dr Slađana Savić, dr Danijela Šikuljak, prof dr Zoran Jovović**
13:45 – 14:05	**CLIMATE CHANGE CHALLENGES IN IRRIGATION AND AGRICULTURE IN ARID AND SEMI ARID REGIONS** **Nese Yaman,** Isam M. Abdulhameed, **Plenary Presentation**
14:05 – 14:25	**LIMITATION AND POTENTIAL OF WHEAT GROWING FOR FOOD SECURITY** Laze, A., **Knežević Desimir**, Mićanović, D., Ivanović, T., Menkovska, M., Nazari, S.H., Matković Stojšin, M., Zečević, V., **Plenary Presentation**
14:25 – 14:45	**MANAGEMENT OF USING SALINE WATER IN IRRIGATION** **Isam M. Abdulhameed,** Nese Yaman **Plenary Presentation-** zoom presentation
14:45 - 14:55	**STRUCTURE OF THE ALFALFA YIELD DEPENDING ON PRE-SOWING TREATMENT OF SEEDS WITH GRIVLAG GROWTH SUBSTANCE (GVG)** Skamarokhova Alexandra Sergeevna, Vasilievna, A. N., Stepanov, N. (zoom presentation)
14:55 – 15:05	Discussion
15:05 - 15:30	**Prezentation: AgAR-UNIVERSAL AUTONOMOUS AGRICULTURAL ROBOTIC PLATFORM** **Moderator: Company COMING**
15:30 - 15:50	Coffee Break (Sponsor: BIO TEA)
15:50 - 17:20	**Panel Discussion:** **APPLICATION OF INFORMATION TECHNOLOGIES IN AGRICULTURE: YESTERDAY, TODAY AND TOMORROW** Sponsors: Check Point, SERBIAN CHAMBER OF COMMERCE & INDUSTRY, BELGRADE, MUNICIPALITY LOPARE REPUBLIC OF SRPSKA **Moderator: MSc Nenad Nikolin,** Fractal group, Belgrade **Panelists:** **Danilo Savić,** Director of the State Data Center, Kragujevac **Damir Baralić,** Deputy director of the Administration for Agrarian Payments, Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia **Ivan Mladenović,** Sales director, Check Point **Zoran Ružić,** Information Technology Sector, RF PIO, Serbia **Niko Slavnić,** IEDC, Bled, Slovenija
17:20 - 18:45	**Session: RESPONSIBILITY IN THE PRODUCTION AND USE OF FOOD** **Chairpersons: dr Desimir Knežević, dr Danica Mićanović, prof dr Nese Yaman**
17:20 - 17:35	**FOOD LOSS AND WASTE PREVENTION AND REDUCTION – STATE OF PLAY IN SERBIA** **Snežana Savčić Petrić**, Plant Protection Directorate, Ministry of Agriculture, Forestry and Water Management, Beograd (**Invited speaker**)
17:35 – 17:50	**THE RIGHT TO FOOD AS AN INTANGIBLE RIGHT ESTABLISHED IN THE UNITED NATIONS INTERNATIONAL HUMAN RIGHTS – LACKING CLARITY** **Darinka Tomić** Seneca Polytechnic, School of Legal, Public and Office Administration, Canada**,** (zoom prezentation) (**Invited speaker**)

17:50 - 18:05	**APPLICATION OF BLOCKCHAIN TECHNOLOGY IN INCREASING THE FOOD SECURITY** **Vesna Gantner**, Krešimir Kuterovac, University of Osijek (**Invited speaker**)
18:05 - 18:20	**THE MODERN TRENDS FOR THE IMPROVEMENT OF SAFETY DAIRY PRODUCTION** **Aleksandra Ivetić,** Stojanović, B., Ćosić, M., Milošević, B., Beskorovajni, R., Maslovarić, M., Popović, N., Grujičić, I. (**Invited speaker**)
18:20 - 18:35	**ORGANIC AGRICULTURE PERSPECTIVES AND CERTIFICATION IN WESTERN BALKANS** **Aleksandra Stojkov Pavlović**, Larisa Jovanović
18:35 - 18:45	Discussion
21:00 - 00:00	**GALA DINNER -** restaurant BOING, hotel JAT APARTMENTS live music -Bend from Raška **General Sponsors**: **ČOKA WINERY, OHRID WINERY, RAKIJA GEGULA**
SATURDAY February 3rd, 2024	
10:00 - 11:00	**Session: MODERN TRENDS AND HEALTHY FOOD** **Chairpersons: dr Vesna Gantner, prof dr Snežana Janković, dr Nenad Trkulja**
10:00 - 10:15	**EFFECT OF FERTILIZERS ON HEAVY METAL RESIDUES IN AGRICULTURAL SOILS** Elahmar M.A, Anđelković, A., Trkulja, N., Đurović, S., Janković, S., **Slađana Savić**, Šikuljak, D.
10:15 - 10:30	**THE IMPORTANCE OF FOOD SYSTEMS FOR CEREAL APPLICATION IN HUMAN AND ANIMAL NUTRITION** **Mirjana Menkovska**, Gjorgovska, N., Lekov, V., Knežević, D., Pacinovski, N. (**Invited speaker**)
10:30 - 10:45	**ANTICANCER POTENTIAL OF SHORT-CHAIN SATURATED FATTY ACIDS IN MILK AND DAIRY PRODUCTS** **Vesna Gantner**, Ćosić, M., Kuterovac, K., Popović, V., Gantner, R.
10:45 - 11:00	Discussion
11:00 - 11:20	Coffee Break (Sponsor: BIO TEA)
11:20 - 12:35	**Panel discussion: HEALTHY DIET – THE MEDICINE OF THE FUTURE** **Sponsors:** BIO TEA, BIOSIL **Moderators**: **dr Jovana Vunduk**, Institute of general and physical chemistry, Belgrade **Zoran Jelenković**, Mycological and mushroom growing association of Serbia **Panelists:** **Aleksandar Bogunović**, Association for Plant Production and Food Industry, Serbian Chamber of Agriculture **Boban Ilić**, General Secretary of the Permanent Working Group for Regional Rural Development (SWG) **Zoran Roksandić,** Sales director, WELLAN GERMANY-SRBIJA **Nataša Milanović**, Director, Biosil, Ugrinovci **Biljana Matejić**, Director, Azertrade, Novi Sad
12:35 - 13:45	**Panel diskussion: Modern way of business - BIZZ.io transformation** **Sponsors:** Sl group, Investra Enterprises, Bizz.io **Moderators**: **Siniša Dagary**, CEO Sl. group, Europe **Tamara Fišter**, Director Bizz.io, Slovenija

	Panelists: **Niko Slavnić,** IEDC, Bled, Slovenia **Zvonko Tugegdžić**, Director, RPKK, PKS **Danijela Vujić,** VMA, Belgrade **Prof. dr Mitar Lutovac**, Balkan Scientific Center, Russian Academy of Natural Sciences, Belgrade **Doc. dr Srećko Bačevac,** Belgrade Banking Academy, Beograd
13:45 – 14:30	**PAUSE**
14:30 - 15:55	**Session: AGRO TOURISM AND FOOD IN AGRICULTURE** **Chairpersons: dr Aleksandra Ivetić, prof dr Milivoje Ćosić, dr Slađana Savić**
14:30 - 14:45	**INVESTMENT IN THE DEVELOPMENT OF AGRO-TOURISM AND THE PRODUCTION OF ETHNO FOOD AND DRINKS - GREAT CHANCE FOR THE ECONOMIC RECOVERY OF THE REPUBLIC OF SERBIA** **Dr Dragan Bataveljić,** University of Kragujevac
14:45 - 15:00	**ENERGY EFICIENCY WITHIN GREEN SOLUTIONS FOR MANAGEMENT OFWATER-ENERGY-FOOD-ENVIRONMENT NEXUS** **Ivan S. Stević**, Jovana Jovanović (**Invited speaker**)
15:00 - 15:15	**SUSTAINABLE BUSINESS PRACTICES THROUGH THE IMPLEMENTATION OF GREEN PUBLIC PROCUREMENT** **Danijela Vujić,** Military medical Academy, Belgrade **(Invited speaker)**
15:15 - 15:30	**COLOSTRUM, THE IMPORTANCE OF COLOSTRUM IN FEEDING CALVES** **Zvonimir Steiner**, Babić, I., Gantner, R., Gantner, V.
15:30 – 15:45	**PRODUCTION OF FOOD IN ACCORDANCE WITH NATURE,** Biljana Matejić, Saša Stepanov (**Invited speaker**)
15:45 - 15:55	Discussion
15:55 - 17:00	**ROUNDTABLE:** **COOPERATIVE – A MODERN FORM OF ENTERPRISE AND ENTREPRENEURSHIP** **Moderator: Jelena Antić**, Director, Center for Education and Vocational Training, Jagodina **Sponsors**: ORGANIKA NOVA, Skopje, North Macedonia **Panelists:** **Dragan Cvetković,** Director Adut GVN, Kumanovo, North Macedonia **Prof. dr Saša Stepanov,** CINEP, Belgrade **Blagica Cvetković**, Protection Through Research, Education and Biodiversity Maintenance "Life", Kumanovo, North Macedonia **Svetlana Anđelić**, President of Municipality Knić, Knić **Prof. dr Dragan Bataveljić,** Faculty of Law, University of Kragujevac
17:00 - 18:00	**10. JEEP TEST DRIVE (**Night driving in Jeeps**)** **Sponsor: NIKOM AUTO, Kragujevac**
20:00 - 00:00	**ENTERTAINMENT EVENING**
SUNDAY **February 4th, 2024**	
10:00 - 11:00	**CLOSING CEREMONY, CONCLUSIONS AND NEW PLANS** **Sponsors: Check Point, Coming**

POSTER SESSION

18:45 – 19:15 FRIDAY, February 2nd, 2024
9:30 – 10:00 SATURDAY, February 3rd, 2024

Congress hall, Hotel Grand, (Posters will be presented in e-version)

FRIDAY, February 2nd, 2024

18:45 – 19:15
Moderators: dr Saša Stepanov, dr Rade Biočanin, dr Anka Vojvodić

P 1	**METHANE MITIGATION STRATEIGIES IN RUMINANTS,** Muhittin Tutkun
P 2	**IMPACT OF CLIMATE CHANGES ON THE PRODUCTION OF AGRICULTURAL CROPS – ASSESSMENT OF THE WORLD ECONOMIC BANK,** Sonja Ketin, Boban Kostić, Rade Biočanin
P 3	**INTEGRATED WEED MANAGEMENT IN THE FUNCTION OF PRODUCTION OF HEALTHY AND SAFE FOOD,** Sava Vrbničanin, Dragana Božić, Danijela Šikuljak
P 4	**TREND ANALYSIS OF CADMIUM IN FEEDSTUFF**, Boris Pisinov, Sanja Đurović, Zoran Sekulić, Tijana Dudić, Tanja Keškić, Maja Petričević, Tamara Stamenić,
P 5	**ANALYSIS OF THE IMPACT OF FINANCIAL SUPPORT AND EDUCATION ON THE INTEREST OF YOUTH IN AGRIBUSINESS**, Slađana Vujičić, Oliver Momčilović, Ljiljana Tomić, Nina Pavićević, Aleksandra Mesarović
P 6	**EFFECT OF INSECTICIDES ON VARIATION OF MAIZE STEM DAMAGE CAUSED BY FEEDING OF LARVAE Ostrinia nubilalis Hbn**., Dragan Grčak, Desimir Knežević, Milosav Grčak, Snežana Gošić Dondo, Željko D. Popović, Miroljub Aksić, Ljiljana Andjušić, Danijela Kondić
P 7	**THE IMPORTANCE OF INNOVATIVE BIOGEOCHEMICAL TECHNOLOGIES IN THE SOIL REMEDIATION,** Larisa Jovanović, Vadim Ermakov
P 8	**ALLELOPATHY AND ITS APPLICATION IN AGRICULTURE,** Bojan Konstantinović, Milena Popov, Nataša Samardžić, Tijana Stojanović
P 9	**MARKET TRENDS IN MEAT AND MEAT PRODUCT PRICES ANALYZING THE COST PRICE OF ENERGY VALUE IN MEAT PRODUCTS,** Tamara Stamenić, Maja Petričević, Tanja Keškić, Boris Pisinov, Ljiljana Samolovac, Zoran Sekulić, Andrijana Milošević Georgiev
P 10	**AGRO PROCESSING INDUSTRY ADVANCED TECHNOLOGIES FOR MEAT INDUSTRY WASTEWATER TREATMENT: A REVIEW**, Tanja Keškić, Maja Petričević, Tamara Stamenić, Violeta Mandić, Nikola Delić, Boris Pisinov, Sanja Đurović
P 11	**CHEMICAL ANALYSIS OF THE LAND FOR THE GROWTH OF RASPBERRIES IN MACEDONIA,** Jovica Momirceski, Julijana Tomovska

SATURDAY, February 3rd, 2024
09:30 – 10:00
Moderators: dr Saša Stepanov, dr Rade Biočanin, dr Anka Vojvodić

P 1	**THE IMPORTANCE AND BENEFITS OF IMPLEMENTING AN AGRICULTURAL INFORMATION SYSTEM,** Blagojche Najdovski, Gordana Dimitrovska, Elena Joshevska, Darko Veljanovski
P 2	**SUSTAINABLE PLANT AND ANIMAL WASTE MANAGEMENT STRATEGIES IN THE REPUBLIC OF NORTH MACEDONIA: A COMPREHENSIVE ANALYSIS,** Viktorija Stojkovski, Katerina Bojkovska, Nikolche Jankulovski, Daniel Simakoski
P 3	**THE INFLUENCE OF THE HEALTH CONDITION OF THE SEED MATERIAL ON THE PRODUCTIVITY OF THE OLD VARIETY "RUSKA KRTOLA,** Milica Bućković, Zoran Jovović, Ana Velimirović, Adreja Komnenić
P 4	**PLANT PRODUCTION, IMPORTANCE AND PROTECTION OF PLANT GENETIC RESOURCES**, Ljubica Šarčević-Todosijević, Kristina Vojvodić, Marija Perić, Nikola Đorđević
P 5	**EFFECTIVENESS OF REDUCED DOSES OF FLUMIOXAZIN AT WEED CONTROL IN SUNFLOWER**, Ljiljana Radivojević, Jelena Gajić Umiljendić, Marija Sarić Krsmanović, Ljiljana Šantrić
P 6	**CORPORATE SOCIAL RESPONSIBILITY IN ECO-PROTECTION OF FOOD AND DRINKING WATER IN EMERGENCY SITUATIONS,** Rade Biočanin, Žaklina Rakiić
P 7	**AGRICULTURAL DEVELOPMENT IN GORAZDEVAC AND ITS IMPACT ON THE SOCIAL PRODUCT,** Milo Stevanović, Milosav Maksić
P 8	**FINANCING SOURCES OF AGRICULTURAL AND RURAL ENTREPRENEURSHIP IN SERBIA,** Marija Stevanović, Violeta Jovanović
P 9	**REQUIREMENTS AND TRENDS IN THE SPHERE OF SUSTAINABILITY REPORTING IN THE RACING HORSE INDUSTRY,** Ljubica Peković, Milorad Damjanović, Nemanja Damjanović, Kosana Vićentijević
P 10	**FACTORS FOR IMPROVING THE AGRICULTURAL SECTOR IN THE REPUBLIC OF SERBIA,** Dragan Miletić, Jovana Simić
P 11	**RAISING AWARENESS AMONG STUDENTS ABOUT THE IMPORTANCE OF USING HEALTHY RAW MATERIALS IN THE PREPARATION OF QUALITY FOOD AND PRESERVING HUMAN HEALTH,** Jelena Marković, Tijana Milanović

CIP - Каталогизација у публикацији Народна библиотека Србије, Београд

631(082)
338.43(082)
338.1:502.131.1(082)
330.341.1(082)
33(082)

JEEP INTERNATIONAL scientific agribusiness conference (11 ; 2024 ; Kopaonik)
Food for the future - vision of Serbia, region and Southeast Europe = Hrana za budućnost - vizija Srbije, regiona i Jugoistočne Evrope : proceedings = zbornik radova / 11th JEEP International scientific agribusiness conference MAK 2022, Kopaonik, Serbia, 02.- 04. February 2024. = 11. JEEP međunarodna naučna agrobiznis konferencija MAK 2024, Kopaonik ; editor Milan Jovičić. - Kraljevo : Naučno poslovni centar WORLD = Science and business center WORLD ; Beograd : Centar za istraživanje, nauku, edukaciju i posredovanje [i. e.] CINEP = Center for Research, Science, Education and Mediation [i. e.] CINEP : Institut za zaštitu bilja i životnu sredinu : Institute for plant protection and environment, 2024 (Kraljevo : Kvark). - 297 str. : ilustr. ; 30 cm. - (Edicija Evropski put = Edition The European road)

Tiraž 50. - Str. 10: Foreword / Milan Jovičić. - Napomene i bibliografske reference uz tekst. - Bibliografija uz svaki rad. - Rezimei.

ISBN 978-86-80510-12-5 (NPCW)

a) Пољопривредна производња -- Зборници b) Привредни развој -- Одрживи развој -- Зборници v) Економија -- Зборници g) Технолошки развој -- Зборници

COBISS.SR-ID 136334089
