

BOOK OF PROCEEDINGS



*XIV International Scientific Agriculture Symposium
"Agrosym 2023"
Jahorina, October 05-08, 2023*



BOOK OF PROCEEDINGS

**XIV International Scientific Agriculture Symposium
“AGROSYM 2023”**



Jahorina, October 05 - 08, 2023

Impressum

XIV International Scientific Agriculture Symposium „AGROSYM 2023“

Book of Proceedings Published by

University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia
University of Belgrade, Faculty of Agriculture, Serbia
Mediterranean Agronomic Institute of Bari (CIHEAM - IAMB) Italy

International Society of Environment and Rural Development, Japan
Balkan Environmental Association (B.EN.A), Greece
Centre for Development Research, University of Natural Resources and Life Sciences
(BOKU), Austria
Perm State Agro-Technological University, Russia
Voronezh State Agricultural University named after Peter The Great, Russia
Tokyo University of Agriculture
Shinshu University, Japan
Faculty of Agriculture, University of Western Macedonia, Greece
Enterprise Europe Network (EEN)
Faculty of Agriculture, University of Akdeniz - Antalya, Turkey
Selçuk University, Turkey

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Slovak University of Agriculture in Nitra, Slovakia
Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
Valahia University of Targoviste, Romania
National Scientific Center „Institute of Agriculture of NAAS“, Kyiv, Ukraine
Saint Petersburg State Forest Technical University, Russia
University of Valencia, Spain
Faculty of Agriculture, Cairo University, Egypt
Tarbiat Modares University, Iran
Chapingo Autonomous University, Mexico

Department of Agricultural, Food and Environmental Sciences, University of Perugia, Italy
Higher Institute of Agronomy, Chott Mariem-Sousse, Tunisia
Watershed Management Society of Iran
Institute of Animal Science- Kostinbrod, Bulgaria
SEASN- South Eastern Advisory Service Network, Croatia
Faculty of Economics Brcko, University of East Sarajevo, Bosnia and Herzegovina
Biotechnical Faculty, University of Montenegro, Montenegro
Institute of Field and Vegetable Crops, Serbia
Institute of Lowland Forestry and Environment, Serbia
Institute for Science Application in Agriculture, Serbia
Agricultural Institute of Republic of Srpska - Banja Luka, Bosnia and Herzegovina
Maize Research Institute “Zemun Polje”, Serbia
Faculty of Agriculture, University of Novi Sad, Serbia
Institute for Animal Science, Ss. Cyril and Methodius University in Skopje, Macedonia
Academy of Engineering Sciences of Serbia, Serbia
Balkan Scientific Association of Agricultural Economics, Serbia
Institute of Agricultural Economics, Serbia

Editor in Chief

Dusan Kovacevic

Technical editors

Sinisa Berjan
Milan Jugovic
Rosanna Quagliariello

Website:

<http://agrosym.ues.rs.ba>

CIP - Каталогизacija u publikaciji
Nарodna и универзитетска библиотека
Републике Српске, Бања Лука

631(082)(0.034.2)

INTERNATIONAL Scientific Agriculture Symposium "AGROSYM"
(14 ; 2023 ; Jahorina)

Book of Proceedings [Електронски извор] / XIV International
Scientific Agriculture Symposium "AGROSYM 2023", Jahorina,
October 05 - 08, 2023 ; [editor in chief Dusan Kovacevic]. - Onlajn
izd. - El. zbornik. - East Sarajevo : Faculty of Agriculture, 2023. -
Ilustr.

Sistemski zahtjevi: Nisu navedeni. - Način pristupa (URL):
https://agrosym.ues.rs.ba/article/showpdf/BOOK_OF_PROCEEDINGS_2023_FINAL.pdf. - El. publikacija u PDF formatu opsega
1377 str. - Nasl. sa naslovnog ekrana. - Opis izvora dana 15.12.2023.
- Bibliografija uz svaki rad. - Registar.

ISBN 978-99976-816-1-4

COBISS.RS-ID 139524097

**XIV International Scientific Agricultural Symposium “Agrosym 2023”
Jahorina, October 05-08, 2023, Bosnia and Herzegovina**

HONORARY COMMITTEE

- Mr. Savo Minic**, Minister of Agriculture, Water Management and Forestry of Republic of Srpska, Bosnia and Herzegovina
- Dr. Zeljko Budimir**, Minister of Scientific-Technological Development, Higher Education and Information Society of Republic of Srpska, Bosnia and Herzegovina
- Prof. dr Mario T. Tabucanon**, President of the International Society of Environment and Rural Development, Japan
- Prof. dr Milan Kulic**, Rector of the University of East Sarajevo, Bosnia and Herzegovina
- Prof. dr Dusan Zivkovic**, Dean of the Faculty of Agriculture, University of Belgrade, Serbia
- Dr. Maurizio Raeli**, Director of the Mediterranean Agronomic Institute of Bari, Italy
- Prof. dr Metin Aksoy**, Rector of the Selcuk University, Turkey
- Prof. dr Aleksey Andreev**, Rector of the Perm State Agro-Technological University, Russia
- Prof. dr Alexey Yu. Popov**, Rector of the Voronezh State Agricultural University named after Peter The Great, Russia
- Prof. dr Barbara Hinterstoisser**, Vice-Rector of the University of Natural Resources and Life Sciences (BOKU), Austria
- Prof. dr Sorin Mihai Cimpeanu**, Rector of the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
- Doc. Ing. Klaudia Halászová**, Rector of the Slovak University of Agriculture in Nitra, Slovakia
- Prof. dr Calin D. Oros**, Rector of the Valahia University of Targoviste, Romania
- Prof. Dr Katerina Melfou**, Dean of the Faculty of Agriculture, University of Western Macedonia, Greece
- Prof. dr Amr Ahmed Mostafa**, Dean of the Faculty of Agriculture, Cairo University, Egypt
- Prof. dr José Sergio Barrales Domínguez**, Rector of the Chapingo Autonomous University, Mexico
- Prof. dr Davut Karayel**, Dean of Faculty of Agriculture, University of Akdeniz - Antalya, Turkey
- Prof. Dr EGUCHI Fumio**, Rector of the Tokyo University of Agriculture, Japan
- Prof Dr Sait Gezin**, Dean of Faculty of Agriculture, University of Selçuk- Konya, Turkey
- Dr Chokri Thabet**, the General Director of the High Agronomic Institute of Chott Mariem, Sousse, Tunisia
- Prof. dr Ivan Yanchev**, Director of the Institute of Animal Science- Kostinbrod, Bulgaria
- Prof. dr Seyed Hamidreza Sadeghi**, Professor at Tarbiat Modares University and the President of the Watershed Management Society of Iran, Iran
- Prof. dr Francesco Tei**, Director of the Department of Agricultural, Food and Environmental Sciences, University of Perugia, Italy
- Prof. dr Viktor Kaminskyi**, Director of National Scientific Center „Institute of Agriculture of NAAS“, Kyiv, Ukraine
- Dr. Igor Hrovatič**, President of South Eastern Advisory Service Network, Croatia
- Prof. dr Mirza Dautbasic**, Dean of the Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
- Prof. dr Bozidarka Markovic**, Dean of the Biotechnical Faculty, University of Podgorica, Montenegro
- Prof. dr Rade Jovanovic**, Director of the Institute for Science Application in Agriculture, Serbia
- Prof. dr Lazar Radovanovic**, Dean of the Faculty of Economics Brcko, University of East Sarajevo, Bosnia and Herzegovina
- Prof. dr Vojislav Trkulja**, Director of Agricultural Institute of Republic of Srpska - Banja Luka, Bosnia and Herzegovina
- Dr. Miodrag Tolimir**, Director of the Maize Research Institute “Zemun Polje”, Serbia
- Prof. Dr. Jegor Miladinović**, Director of the Institute of Field and Vegetable Crops, Serbia
- Prof. dr Nedeljko Tica**, Dean of the Faculty of Agriculture, University of Novi Sad, Serbia
- Prof. dr Rodne Nastova**, Director of the Institute for Animal Science, Skoplje, Macedonia
- Prof. dr Sasa Orlovic**, Director of the Institute of Lowland Forestry and Environment, Serbia
- Prof. dr Jonel Subic**, Director of the Institute of Agricultural Economics, Serbia
- Prof. dr Branko Kovacevic**, President of the Academy of Engineering Sciences of Serbia, Serbia
- Prof. dr Radovan Pejvanovic**, President of Balkan Scientific Association of Agricultural Economics, Serbia

SCIENTIFIC COMMITTEE

- Chairman: Academician Prof. dr Dusan Kovacevic**, Faculty of Agriculture, University of Belgrade, Serbia
- Prof. dr Machito Mihara**, Tokyo University of Agriculture, Japan

Prof. dr John Brayden, Norwegian Agricultural Economics Research Institute (NILF), Norway
Prof. dr Steve Quarie, Visiting Professor, School of Biology, Newcastle University, United Kingdom
Prof. dr Andreas Melcher, CDR, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria
Prof. dr Dieter Trautz, University of Applied Science, Germany
Prof. dr Sergei Eliseev, Vice-Rector for Research and Innovations, Perm State Agro-Technological University, Russia
Prof. dr Dani Shtienberg, full professor, Department of Plant pathology and Weed Research, ARO, the Volcani Center, Bet Dagan, Israel
Prof. dr William Meyers, Howard Cowden Professor of Agricultural and Applied Economics, University of Missouri, USA
Prof. dr Markus Schermer, Department of Sociology, University of Innsbruck, Austria
Prof. dr Thomas G. Johnson, University of Missouri – Columbia, USA
Prof. dr Fokion Papathanasiou, School of Agricultural Sciences, University of Western Macedonia, Greece
Prof. dr Sabahudin Bajramovic, Faculty of Agriculture and Food Sciences, University of Sarajevo, Bosnia and Herzegovina
Prof. dr Hiromu Okazawa, Faculty of Regional Environment Science, Tokyo University of Agriculture, Japan
Prof. dr Tatiana Sivkova, Faculty for Veterinarian Medicine and Zootechny, Perm State Agro-Technological University, Russia
Prof. dr Aleksej Lukin, Voronezh State Agricultural University named after Peter The Great, Russia
Prof. dr Matteo Vittuari, Faculty of Agriculture, University of Bologna, Italy
Prof. dr Seyed Mohsen Hosseini, Faculty of Natural Resources, Tarbiat Modares University, Iran
Prof. dr Ardian Maci, Faculty of Agriculture and Environment, Agricultural University of Tirana, Albania
Prof. dr Regucivilla A. Pobar, Bohol Island State University, Philippines
Prof. dr Sudheer Kundukulangara Pulissery, Kerala Agricultural University, India
Prof. dr EPN Udayakumara, Faculty of Applied Sciences, Sabaragamuwa University, Sri Lanka
Prof. dr Vladimir Smutný, full professor, Mendel University, Faculty of agronomy, Czech Republic
Prof. dr Franc Bavec, full professor, Faculty of Agriculture and Life Sciences, Maribor, Slovenia
Prof. dr Jan Moudrý, full professor, Faculty of Agriculture, South Bohemia University, Czech Republic
Prof. dr Stefan Tyr, full professor, Faculty of Agro-biology and Food Resources, Slovakia
Prof. dr Natalija Bogdanov, Faculty of Agriculture, University of Belgrade, Serbia
Prof. dr Richard Barichello, Faculty of Land and Food Systems, University of British Columbia, Canada
Prof. dr Francesco Porcelli, University of Bari Aldo Moro, Italy
Prof. dr Vasilije Isajev, Faculty of Forestry, University of Belgrade, Serbia
Prof. dr Elazar Fallik, Agricultural Research Organization (ARO), Volcani, Israel
Prof. dr Junaid Alam Memon, Pakistan Institute of Development Economics, Pakistan
Prof. dr Jorge Batlle-Sales, Department of Biology, University of Valencia, Spain
Prof. dr Pandi Zdruli, Land and Water Resources Department; IAMB, Italy
Prof. dr Mladen Todorovic, Land and Water Resources Department; IAMB, Italy
Dr. Hamid El Bilali, Mediterranean Agronomic Institute of Bari, Italy
Prof. dr Maksym Melnychuk, National Academy of Agricultural Science of Ukraine, Ukraine
Prof. dr Borys Sorochynskyi, Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine
Dr. Lorenz Probst, CDR, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria
Prof. Dragana Sunjka, Faculty of Agriculture, University of Novi Sad, Serbia
Prof. dr Miodrag Dimitrijevic, Faculty of Agriculture, University of Novi Sad, Serbia
Prof. dr Mohsen Boubaker, High Institute of Agronomy of Chott Meriem, Sousse, Tunisia
Dr. Nouredin Driouech, Coordinator of MAIB Alumni Network (FTN), Mediterranean Agronomic Institute of Bari, Italy
Prof. dr Ion Viorel, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Prof. dr. Chuleemas Boonthai Iwai, Faculty of Agriculture, Khon Kaen University, Thailand
Prof. dr Wathuge T.P.S.K. Senarath, Department of Botany, University of Sri Jayewardenepura, Colombo, Sri Lanka
Dr. Hamada Abdelrahman, Soil Science Dept., Faculty of Agriculture, Cairo University, Egypt
Prof. dr Maya Ignatova, Agricultural Academy – Sofia, Bulgaria
Prof. dr Ioannis N. Xynias, School of Agricultural Technology & Food Technology and Nutrition, Western Macedonia University of Applied Sciences, Greece
PhD ing. Artur Rutkiewicz, Department of Forest Protection, Forest Research Institute - IBL, Poland
Prof. dr Mohammad Sadegh Allahyari, Islamic Azad University, Rasht Branch, Iran
Dr. Lalita Siri wattananon, Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi (RMUTT), Thailand
Prof. dr Konstantin Korlyakov, Perm Agricultural Research Institute, Russia

Dr. Mohammad Farooque Hassan, Shaheed Benazir Bhutto University of Veterinary & Animal Sciences Sakrand, Sindh, Pakistan

Dr. Larysa Prysiashniuk, Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine

Prof. dr Oksana Kliachenko, National University of Life and Environmental Science of Ukraine, Ukraine

Prof. dr Ivan Simunic, Department of amelioration, Faculty of agriculture, University of Zagreb, Croatia

Dr. Abid Hussain, International Centre for Integrated Mountain Development (ICIMOD), Nepal

Dr. Amrita Ghatak, Gujarat Institute of Development Research (GIDR), India

Prof. dr Naser Sabaghnia, University of Maragheh, Iran

Dr. Karol Wajszczuk, Poznan University of Life Sciences, Poland

Prof. dr Penka Moneva, Institute of Animal Science - Kostinbrod, Bulgaria

Prof. dr Mostafa K. Nassar, Animal husbandry Dept., Faculty of Agriculture, Cairo University, Egypt

Prof. dr Márta Birkás, full professor, St. Istvan University, Godollo - Hungary

Prof. dr Andrzej Kowalski, Director of the Institute for Agricultural and Food Economy, Warszawa-Poland

Prof. dr Yalcin Kaya, The Director of the Plant Breeding Research Center, University of Trakya, Turkey

Prof. dr Sanja Radonjic, Biotechnical Faculty, University of Montenegro, Montenegro

Prof. dr Ionela Dobrin, Department for Plant Protection, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

Prof. dr Inocencio Buot Jr., Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Banos, Philippines

Prof. dr Monica Paula Marin, Department for Animal Husbandry, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

Prof. dr Nedeljka Nikolova, Institute for Animal Science, Ss. Cyril and Methodius University in Skopje, Republic of Macedonia

Prof. dr Mohammad Al-Mamun, Department of Animal Nutrition, Bangladesh Agricultural University, Bangladesh

Prof. dr Anucha Wittayakorn-Puripunpinyoo, School of Agriculture and Co-operatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand

Dr. Redouane Choukr-Allah, International Center for Biosaline Agriculture (ICBA), United Arab Emirates

Prof. dr Ignacio J. Díaz-Maroto, High School Polytechnic, University of Santiago de Compostela, Spain

Prof. dr Nidal Shaban, University of Forestry Sofia, Bulgaria

Prof. dr Mehdi Shafaghati, Faculty of Geography, Tarbiat Moalem (kharazmi) University, Iran

Prof. dr Youssif Sassine, Lebanese University Beirut, Lebanon

Prof. dr Cafer Topaloglu, Faculty of Tourism, Mugla Sitki Kocman University, Turkey

Prof. dr Seyed Hamidreza Sadeghi, Faculty of Natural Resources, Tarbiat Modares University, Iran

Prof. dr Mohsen Mohseni Saravi, University of Teheran and Member of WMSI Management Board, Iran

Prof. dr Branislav Draskovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina

Prof. dr Mahmood Arabkhedri, Soil Conservation and Watershed Management Research Institute and Member of WMSI Management Board, Iran

Prof. dr Ataollah Kavian, Sari Agricultural Science and Natural Resources University and Member of WMSI Management Board, Iran

Prof. dr Tugay Ayasan, Department of Organic Farming Business Management, Osmaniye, Applied Science School of Kadirli, Osmaniye Korkut Ata University, Turkey

Prof. dr Sakine Özpınar, Department of Farm Machinery and Technologies Engineering, Faculty of Agriculture, Çanakkale Onsekiz Mart University, Çanakkale, Turkey

Prof. dr Sherein Saeide Abdelgayed, Faculty of Veterinary Medicine, Cairo University, Cairo, Egypt

Prof. dr Zohreh Mashak, Islamic Azad University, Karaj Branch, Iran

Dr. Khalid Azim, National Institute of Agriculture Research, Morocco

Dr. Mario Licata, Department of Agricultural, Food and Forest Sciences, University of Palermo, Italy

Prof. dr Srdjan Lalic, University of East Sarajevo, Bosnia and Herzegovina

Prof. dr Muhammad Ovais Omer, Faculty of Bio-Sciences, University of Veterinary & Animal Sciences, Lahore, Pakistan

Dr. Edouard Musabanganji, School of Economics/CBE, University of Rwanda, Rwanda

Prof. dr Kubilay Baştaş, Department of Plant Protection, Faculty of Agriculture, Selçuk University, Turkey

Dr. Branka Kresovic, Director of the Maize Research Institute “Zemun Polje”, Serbia

Dr. Nenad Delic, Maize Research Institute “Zemun Polje”, Serbia

Dr. Milan Stevanovic, Maize Research Institute “Zemun Polje”, Serbia

Prof. Violeta Babic, Faculty of Forestry, University of Belgrade, Serbia

Dr. Svetlana Balesevic-Tubic, Institute of Field and Vegetable Crops Novi Sad, Serbia

Dr. Ana Marjanovic Jeromela, Institute of Field and Vegetable Crops Novi Sad, Serbia

Prof. dr Tatjana Krajisnik, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina

Prof. dr Aleksandra Govedarica-Lucic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Desimir Knezevic, University of Pristina, Faculty of Agriculture, Kosovska Mitrovica - Lesak, Kosovo i Metohija, Serbia
Dr. Snezana Mladenovic-Drinic, Maize Research Institute “Zemun Polje”, Serbia
Prof. dr Nebojsa Momirovic, Faculty of Agriculture, University of Belgrade, Serbia
Prof. dr Osman Mujezinovic, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
Prof. dr Dalibor Ballian, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
Prof. dr Zoran Jovovic, Biotechnical Faculty, University of Montenegro, Montenegro
Prof. dr Danijel Jug, Faculty of Agriculture, University of Osijek, Croatia
Prof. dr Milan Markovic, Biotechnical Faculty, University of Montenegro, Montenegro
Prof. dr Dejana Stanic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Zeljko Dolijanovic, Faculty of Agriculture, University of Belgrade, Serbia
Prof. Mirjana Jovovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. Goran Marinkovic, Faculty of Technical Sciences, University of Novi Sad, Serbia
Dr Dejan Stojanovic, Institute of Lowland Forestry and Environment, Serbia
Dr Dobrivoj Postic, Institute for plant protection and environment, Belgrade, Serbia
Dr Srdjan Stojnic, Institute of Lowland Forestry and Environment, Serbia
Dunja Demirović Bajrami, Research Associate, Geographical Institute “Jovan Cvijić,” Serbian Academy of Sciences and Arts, Belgrade, Serbia

ORGANIZING COMMITTEE

Chairperson: Prof. dr Vesna Milic, Dean of the Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr Marko Gutalj, Vice rector of the University of East Sarajevo, Bosnia and Herzegovina
Dr Jelena Kronic, Vice rector of the University of East Sarajevo, Bosnia and Herzegovina
Dr. Maroun El Moujabber, Mediterranean Agronomic Institute of Bari, Italy
Mrs. Rosanna Quagliariello, Mediterranean Agronomic Institute of Bari, Italy
Dr. Nouredin Driouech, Coordinator of MAIB Alumni Network (FTN), Mediterranean Agronomic Institute of Bari, Italy
Dr Milic Curovic, The journal “Agriculture and Forestry”, Biotechnical Faculty Podgorica, University of Montenegro, Montenegro
Dr. Tatiana Lysak, International Relations Office, Voronezh State Agricultural University named after Peter The Great, Russia
Dr. Oksana Fotina, International Relations Center, Perm State Agro-Technological University, Russia
Prof. dr Fokion Papathanasiou, School of Agricultural Sciences, University of Western Macedonia, Greece
Dr Ana Marjanović Jeromela, Institute of Field and Vegetable Crops, Serbia
Dr. Anastasija Novikova, Faculty of Bioeconomy Development, Vytautas Magnus University, Lithuania
Prof. dr Engr. Teodora Popova, Institute of Animal Science - Kostinbrod, Bulgaria
Prof. dr Mehmet Musa Ozcan, Faculty of Agriculture, Selçuk University, Turkey
Dr. Abdulvahed Khaledi Darvishan, Faculty of Natural Resources, Tarbiat Modares University, Iran
Prof. dr Nikola Pacinovski, Institute for Animal Science, Ss. Cyril and Methodius University in Skopje, N. Macedonia
MSc. Erasmo Velázquez Cigarroa, Department of Rural Sociology, Chapingo Autonomous University, Mexico
Dr. Ecaterina Stefan, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Dr. Jeeranuch Sakkhamduang, The International Society of Environmental and Rural Development, Japan
Dr. Raoudha Khanfir Ben Jenana, High Institute of Agronomy of Chott Meriem, Sousse, Tunisia
Dr. Hamada Abdelrahman, Soil Science Dept., Faculty of Agriculture, Cairo University, Egypt
Prof. Dragana Sunjka, Faculty of Agriculture, University of Novi Sad, Serbia
Dr. Antonije Zunic, Faculty of Agriculture, University of Novi Sad, Serbia
Dr. Vedran Tomic, Institute for Science Application in Agriculture, Serbia
MSc. Vojin Cvijanovic, Institute for Science Application in Agriculture, Serbia
MSc. Mladen Petrovic, Institute for Science Application in Agriculture, Serbia
Dr. Milan Stevanovic, Maize Research Institute “Zemun Polje”, Serbia
Dr. Andrej Pilipovic, Institute of Lowland Forestry and Environment, Serbia
Dr. Sc. Morteza Behzadfar, Tarbiat Modares University, Tehran, Iran
Dr. Larysa Prysiazniuk, Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine
Doc. dr Sead Ivojevic, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina

Dr. Nenad Markovic, Enterprise E. N. (EEN) Coordinator, University of East Sarajevo, Bosnia and Herzegovina
Domagoj Group, SEASN - South Eastern Advisory Service Network, Croatia
Prof. dr Zeljko Lakic, Agricultural Institute of Republic of Srpska - Banja Luka, Bosnia and Herzegovina
Doc. dr Zoran Maletic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Dejana Stanic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Milan Jugovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Sinisa Berjan, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Milena Stankovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr. Stefan Stjepanovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Stefan Bojic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr. Tanja Jakisic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr. Boban Miletic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Todor Djorem, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Selena Cevriz, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr. Igor Djurdjic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina, **General Secretary**

NEWLY CREATED ČAČAK’S SOUR CHERRY VARIETIES AS A RAW MATERIAL FOR SPIRIT PRODUCTION

Branko POPOVIĆ^{1*}, Sanja RADIČEVIĆ¹, Olga MITROVIĆ¹, Aleksandra KORIĆANAC¹,
Ninoslav NIKIĆEVIĆ², Vele TEŠEVIĆ³, Ivan UROŠEVIĆ⁴

¹Fruit Research Institute, Čačak, Serbia

²Faculty of Agriculture, University of Belgrade, Belgrade, Serbia

³Faculty of Chemistry, University of Belgrade, Belgrade, Serbia

⁴Faculty of Agriculture, Bijeljina University, Bosnia-Herzegovina

*Corresponding author: popovicb@ftn.kg.ac.rs

Abstract

According to the average annual production, sour cherries take the third place in Serbian fruit production. In the assortment, the most represented is the autochthonous variety ‘Oblačinska’, which is characterized by a very small fruit. In recent decades, large-fruited varieties bred at the Fruit Research Institute in Čačak, have become more widespread in sour cherry orchards. Some of the newly bred varieties, similar to ‘Oblačinska’, are characterized by combined properties and can be used as fresh fruit and/or for various types of processing. Sour cherries are mainly used in Serbia as raw material for obtaining numerous products. Frozen cherries dominate, but juices, sour cherry in brine, dried fruits, candied fruits, compote, wine, vinegar, liqueurs are also produced, and in recent years, sour cherry spirit is gaining interest. The paper presents the results of two-year examinations of the suitability of two varieties of sour cherries with combined properties - ‘Šumadinka’ (‘Köröser Weichsel’ × ‘Heimanns Konservenweichsel’) and ‘Sofija’ (‘Čačanski rubin’ × ‘Heimanns Konservenweichsel’), bred in Čačak, and standard variety ‘Heimanns Konservenweichsel’, for the production of spirits. The sour cherry spirits were produced from spontaneously fermented mashes of sour cherry fruits with stones, followed by double distillation in alembic of traditional design. The obtained monovarietal sour cherry spirits differed significantly in spirit yields and contents of the ten major volatile components. Based on the results of sensory analysis in both years, all obtained monovarietal sour cherry spirits can be classified as high-quality spirit drinks.

Keywords: *Prunus cerasus*, sour cherry spirit, yield of distillate, volatile components, sensory characteristics.

Introduction

Since the middle of the 20th century, the production of sour cherries in Serbia has been constantly increasing. In a short period of time, from 2016 to 2020, the area under sour cherries increased from 16,797 ha to 19,601 ha, while the average yield in this period was 115,831 t. Nowadays, Serbia is the fourth producer of sour cherries in Europe, and the seventh in the world (Milatović, 2023). The small-fruited cultivar ‘Oblačinska’, whose fruit weight depending on the clone varies between 2.62 and 3.52 g (Nikolić *et al.*, 2005), and which is mainly used for processing (Miletić, 2019), dominates in the sour cherry production with a share of 60 to 70%. There is a tendency for spreading varieties with large fruit, larger than 5 g, which can be used for processing, but also for fresh consumption (Stancević and Nikolić, 1987; Radičević and Cerović, 2015). Among large-fruited varieties, in addition to the most commonly grown introduced variety ‘Heimanns Konservenweichsel’, ‘Šumadinka’ and ‘Sofija’ resulting from the breeding work at the Fruit Research Institute in Čačak - are also grown in Serbia.

Sour cherries in Serbia are mainly used for processing; production of frozen cherries dominates (Milatović, 2023). The rest is used in industry and households for the production of juices, syrups, candied fruits, sour cherries in brine, liqueurs, and more recently for the production of dried sour cherries and sour cherry spirit (Radičević and Cerović, 2015). Unlike plum spirit, the Serbian national spirit drink, sour cherry spirit is produced to a much smaller extent, mostly in years when the purchase price of sour cherries on the market is low, i.e. when there is small demand for frozen cherries.

Sour cherry spirit is a delicacy product, consumed colorless, as an aperitif (Nikićević and Paunović, 2013). There are two important steps in sour cherries processing that are related to the characteristics of the fruits, and are considered important for obtaining high quality sour cherry spirit. The first step is the separation of the stalks before processing (Dürr, 2000). The second step is the presence of stones in the mash, which results in a more intense aroma (stone like tone) of the sour cherry spirit than in the case when pitted fruits are fermented and distilled (Nikićević and Paunović, 2013). Beside the method of production, the sour cherry variety has a decisive effect on the quality of the sour cherry spirit (Nikićević *et al.*, 2011). Similar to some plum varieties bred in Čačak that were not primarily aimed as brandy varieties, but were used in this way (Popović *et al.*, 2021), Čačak's sour cherry varieties also were not bred with the intention of being brandy varieties, but were used in this way in certain years. Thus the aim of this work was to examine the suitability of Čačak's sour cherry varieties for the production of brandy (spirit).

Materials and methods

Fully ripe fruits without stalks of the sour cherry cultivars ‘Šumadinka’, ‘Sofija’ and ‘Heimanns Konservenweichsel’ were picked (70 kg fruits from each cultivar tested) in experimental orchard in Čačak, Serbia, during 2016 and 2017. The Mettler technical scale was used for the fruit and stone mass determination; stone ratios were calculated from these values. Standard methods (Trajković *et al.*, 1983) were used for determination of soluble solids contents (SSC) (by refractometry), total sugars, invert sugars and sucrose contents (Luff-Schoorl method), total acids (by neutralisation with 0.1 M NaOH) and pH values (by pH metry). The sugar/acid ratio was calculated.

Polyethylene vessels for alcoholic fermentation (three replications for each cultivar) were filled with 20 kg of manually crushed fruits with stones. Sour cherry mashes with stones were spontaneously fermented at a temperature of approximately 20 °C. The dynamics of mash alcoholic fermentations was monitored daily (by refractometry). The mashes were distilled immediately after completion of alcoholic fermentation. Pilot-scale copper alembic (volume of the boiler was 25 L) was used for fermented mashes distillation; the first distillates with an ethanol content of 22 vol.% were obtained. For the second distillation (redistillation of the first distillate), the same distillation equipment was used; three fractions were separated during the second distillation: head (1% of the first distillate volume put in the boiler of alembic), heart (60 vol% ethanol content) and tail. Only the middle fractions (hearts) were used for further chemical and sensory analyses. Before analyses, the ethanol content in the heart-fractions obtained by the second distillation was reduced with deionised water from 60 to 42 vol.%. Yield of the sour cherry distillates was expressed as the yield of the first distillate (expressed in L, with an ethanol content of 22 vol%) obtained by distillation of 20 kg of mash, and then multiplied by 5, to be expressed on 100 kg fruits (L of distillate containing 22 vol% ethanol/100 kg fruits with stones).

The methanol, higher alcohols, ethyl acetate and acetaldehyde contents in the sour cherry spirits were determined by gas chromatography with flame ionization detection (GC/FID) method (Popović *et al.*, 2021), and the content of benzaldehyde was determined by the official

spectrophotometric method (Sl. list SFRJ 70, 1987). The sensory analysis of colourless sour cherry spirits was conducted by a four-member expert panel using the Buxbaum method (Popović *et al.*, 2021). Correlation analyses were performed using STATISTICA 7.0 software (Statsoft, Tulsa, OK, USA).

Results and discussion

The fruit characteristics of the tested sour cherry varieties are shown in Table 1. All three varieties, with a fruit weight of around 7 g, belong to the group of varieties with large fruit although this characteristic is not important for spirit production. From the point of view of the suitability of the variety for the production of sour cherry spirit, the most important characteristics of the fruits are sugar content, stone ratio and aroma (Pieper *et al.*, 1993).

Table 1. Fruit characteristics of sour cherry cultivars.

Characteristics	Cultivars					
	Heimanns Konservenweichsel		Šumadinka		Sofija	
	2016	2017	2016	2017	2016	2017
Fruit mass (g)	6.70	6.65	7.54	7.52	7.09	7.01
Stone mass (g)	0.52	0.54	0.68	0.67	0.54	0.50
Stone ratio (%)	7.76	8.12	9.02	8.91	7.62	7.13
Soluble solids (%)	13.60	14.30	11.90	12.70	13.10	12.00
Total sugars (%)	8.44	9.20	6.48	6.96	8.16	7.44
Inverted sugars (%)	7.85	8.10	6.10	6.48	7.85	7.10
Sucrose (%)	0.56	1.04	0.46	0.47	0.29	0.32
Total acids (%)	1.88	2.15	1.86	0.95	1.34	1.96
pH	3.30	3.24	3.19	3.16	3.38	3.08
Sugars/acids ratio	4.49	4.28	3.48	7.33	6.09	3.80

Varieties with higher total sugar content can potentially produce higher distillate yields. According to the content of total sugars, the most suitable variety for the production of sour cherry spirit was 'Heimanns Konservenweichsel' (8.44 and 9.20%), followed by the variety 'Sofija' (8.16 and 7.44%), and finally the variety 'Šumadinka' (6.48 and 6.96%). The stone ratio affects the content of benzaldehyde and the specific favorable aroma (expressed stone-like tone) of the sour cherry spirit. In both years, the lowest stone ratio was found in 'Sofija' (7.62 and 7.13%), and the highest in 'Šumadinka' fruits (9.02 and 8.91%). The content of total acids significantly influences the formation of the taste of the fruit, mainly through the value of the sugar/acid ratio, which is important for sour cherries used for fresh consumption and for processing that does not include distillation. However, the pH value is much more important for spirit production. The pH value in the fruits of the tested cultivars was very close to 3.0 (from 3.08 to 3.38). This indicates that there is no need to acidify the mash for cleaner alcoholic fermentation, which is in accordance with the recommendations of other authors (Dürr, 2000; Nikićević and Paunović, 2013) and with the fact that the optimal pH for sour cherry mash fermentation is 3.25 (Pham *et al.*, 2021).

Alcoholic fermentation of the mashes lasted from 12 to 18 days (Table 2). Although the lowest distillate yields were obtained from the variety 'Šumadinka' (15.8 and 14.9 L of distillate with 22 vol.% ethanol), whose fruits contained the least total sugars, the correlation analysis did not reveal a statistically significant relationship between distillate yield and the content of total sugars ($r = 0.74$). The value of the correlation coefficient between SSC and distillate yield is even lower ($r = 0.44$), making the use of SSC as a reliable indicator for

predicting potential distillate yield questionable. The highest distillate yields were obtained by processing the fruits of the variety 'Sofia' (23.3 and 21.1 L of distillate with 22 vol.% ethanol), although it would be expected that, considering the highest content of total sugars, the highest yields of brandy would be obtained from the fruits of the 'Heimanns' Konservenweichsel'. These differences might be due to the different sugar profiles in the fruits of the examined cultivars, but also due to various profile of spontaneous microflora in the mashes during alcoholic fermentation of examined cultivars. It is interesting to note that the highest distillate yield is 56% higher than the lowest yield. The obtained data show how much the production efficiency expressed as production yield differs among the sour cherry varieties, processed in the same way.

Table 2. Duration of alcoholic fermentation (DAF, days) and yield of sour cherry distillates (YSCD, L 22 vol. % distillate/100 kg mash).

Characteristics	Cultivars					
	Heimanns Konservenweichsel		Šumadinka		Sofija	
	2016	2017	2016	2017	2016	2017
DAF (days)	13	12	12	12	15	18
YSCD (L 22 vol.% distillate/ 100 kg mash)	20.4	21.1	15.8	14.9	23.3	21.1

The chemical composition and sensory evaluation of monovarietal sour cherry spirits are shown in Table 3. According to Nikićević and Paunović (2013), among all fruit brandies, sour cherry spirit contains potentially the least amount of methanol (5,900 mg/L a.a.). Methanol contents in experimentally produced sour cherry spirits ranged from 3,410 mg/L a.a. ('Sofija', 2016) up to 6,330 mg/L a.a. ('Šumadinka', 2017). This is significantly less than the maximum level required by law (10,000 mg/L a.a.). Based on GC-FID analysis, Pham *et al.* (2021) found that the main aromatic components of sour cherry spirit are 1-propanol, 2-methyl-1-propanol, 2-methyl-1-butanol, 3-methyl-1-butanol, and ethyl acetate, which are formed mainly during alcoholic fermentation and participate in the formation of the "body" of the sour cherry spirit. The contents of acetaldehyde (45-225 mg/L a.a.) and ethylacetate (500-1,339 mg/L a.a.) were within the ranges that give a pleasant fruity character of the aroma. Seasonal differences in the content of these components in spirits of the same variety, are probably the result of a different composition of the indigenous microbial flora. The contents of 1-propanol, 2-methyl-1-propanol, 1-butanol, 2/3-methyl-1-butanol in the obtained spirits were in much narrower ranges than those reported by Nikićević and Paunović (2013). The differences in the contents of higher alcohols found in monovarietal sour cherry spirits could be attributed to the fine differences in the fruits composition and differences in indigenous microbial flora. Also, varietal differences affected the different contents of 1-hexanol, which is produced by enzymatic synthesis through the lipoxygenase pathway during fruit processing and alcoholic fermentation. The contents of total higher alcohols also were in a narrower range (4,534-5,958 mg/L a.a.) than the range (3,794-7,783 mg/L a.a.) reported by Nikićević and Paunović (2013). In our samples, the range of the proportion of 1-propanol in the total higher alcohols was lower (25-37%) than those given by the above authors (35-60%). Among the analyzed higher alcohols, only the contents of 1-propanol were significantly higher in 2017 than in 2016. This confirms the findings of Kovacs *et al.* (2018) that the contents of 1-propanol and 1-butanol can be used to classify fruit distillates based on the year of harvest. The proportions of higher alcohols depend on the composition of the raw material and can serve as one of the factors for determining the authenticity of the distillate. In the case of sour cherry spirit, the ratio of isoamyl alcohol and isobutanol (IA/IB) can be used to distinguish

distillates of the 'Šumadinka' variety from distillates produced of the other two varieties. Benzaldehyde is the characteristic and main aromatic compound of sour cherry spirits, especially those obtained by processing the fruits with stones (Nikićević *et al.*, 2011). Benzaldehyde contents ranged from 16.2 to 86.2 mg/L a.a. The highest concentrations were found in sour cherry spirits of the 'Šumadinka' variety, followed by 'Sofija', and then 'Heimanns Konservenweichsel'. It was found that the content of benzaldehyde was significantly higher in 2017 than in 2016 in all monovarietal sour cherry spirits. Based on the results of sensory analysis, all obtained sour cherry spirits can be classified in the category of excellent quality products, since they have an average score above 18.01. It is interesting that the subtle differences in sensory evaluations are related to the stone weight (correlation coefficient $r = 0.85$), i.e. sour cherry spirits obtained from fruits with larger stones were evaluated slightly better. According to Nikićević *et al.* (2011), a higher content of benzaldehyde, along with some other ingredients (linalool), affects the higher sensory evaluation of monovarietal sour cherry spirits.

Table 3. Chemical composition (mg/L a.a.) and sensory assesment (points) of sour cherry spirits

Characteristics	Cultivars					
	Heimanns Konservenweichsel		Šumadinka		Sofija	
	2016	2017	2016	2017	2016	2017
Methanol	3480	4170	4730	6330	3410	4080
Acetaldehyde	70	116	70	148	45	225
Ethyl acetate	584	836	500	638	556	1339
1-Propanol (1-P)	1385	1836	1590	2073	1227	1794
2-Methyl-1-propanol (IB)	1250	975	1297	1490	967	1033
1-Butanol	12	9	6	6	11	5
2/3-Methyl-1-butanol (IA)	2801	2280	2172	2372	2323	2071
1-Hexanol	13	17	7	17	6	8
Total higher alcohols	5461	5117	5072	5958	4534	4911
Benzaldehyde	16.2	27.3	61.5	86.2	25.7	66.5
IA/IB ratio	2.24	2.34	1.67	1.59	2.40	2.00
IB/1-P ratio	0.90	0.53	0.81	0.72	0.79	0.58
IA/1-P ratio	2.02	1.24	1.37	1.14	1.89	1.15
Sensory assesment	18.16	18.21	18.25	18.34	18.19	18.19

Conclusion

The large-fruited sour cherry varieties ('Šumadinka' and 'Sofija'), bred at the Fruit Research Institute in Čačak, are an interesting raw material for the production of sour cherry spirit. From both varieties, spirit of excellent sensory quality can be obtained. However, it should be taken into account that, considering the characteristics of the fruits, the processing of the variety 'Šumadinka' can yield up to 36% less distillate than the processing of the variety 'Sofija'.

Acknowledgement

This study was supported by the The Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number: 451-03-47/2023-01/200215).

References

- Dürr P. (2000). Mashing fruit for distillation. Schweizer Zeitschrift für Obst- und Weinbau, 135 (14), 333-336. (In German).
- Kovacs A., Szölloši A., Szölloši D., Panyik I., Nagygyörgy L., Hoschke A., Nguyen Q. (2018). Classification and identification of three vintage designated Hungarian spirits by their volatile compounds. Periodica Polytechnica Chemical Engineering, 62 (2), 175-181.
- Milatović D. (2023). Stone fruits. Naučno voćarsko društvo Srbije, Čačak. (In Serbian).
- Miletić R. (2019). Oblačinska sour cherry. Institut za voćarstvo, Čačak. (In Serbian).
- Nikićević N., Paunović R. (2013). Technology of spirit drinks. Poljoprivredni fakultet, Beograd. (In Serbian).
- Nikićević N., Veličković M., Jadranin M., Vučković I., Novaković M., Vujisić L., Stanković M., Urošević I., Tešević V. (2011). The effects of the cherry variety on the chemical and sensorial characteristics of cherry brandy. Journal of the Serbian Chemical Society, 76 (9), 1219-1228.
- Nikolić D., Rakonjac V., Milutinović M., Fotirić M. (2005). Genetic divergence of Oblačinska sour cherry (*Prunus cerasus* L.) clones. Genetika, 37 (3), 191-198.
- Pham T., Sun W., Bujna E., Hoschke A., Friedrich L., Nguyen Q. (2021). Optimization of fermentation conditions for production of Hungarian sour cherry spirit using response surface methodology. Fermentation, 7 (209) 1-12.
- Pieper H. J., Bruchmann E. W., Kolb E. (1993). Technology of fruit spirits. Eugen Ulmer, Stuttgart. (In German).
- Popović B., Mitrović O., Glišić I., Milošević N., Nikićević N., Tešević V., Urošević I. (2021). Suitability of new plum genotypes developed in Čačak for processing into plum spirit. Acta Horticulturae, 1322, 363-370.
- Radićević S., Cerović R. (2015). New sour cherry (*Prunus cerasus* L.) cultivars developed at Fruit Research Institute in Čačak. Journal of Pomology, 49 (191-192), 115-121. (In Serbian).
- Official Gazette of the SFRY (1987). Rulebook on methods of taking samples and performing chemical and physical analyzes of alcoholic beverages. Official Journal, 87 (70), 1646-1663.
- Stančević A., Nikolić M. (1987). Sour cherry breeding and the characteristics of selected hybrids. Journal of Yugoslav Pomology, 21 (82), 3-9. (In Serbian).
- Trajković J., Baras J., Mirić M., Šiler S. (1983). Food analysis. Tehnološko-metalurški fakultet, Beograd. (In Serbian)