

Sarajevo, novembar 2025.

**Naslov/Title:**

10. Studentski Kongres „Hrana-Ishrana-Zdravlje“ sa međunarodnim učešćem  
10th Student Congress „Food-Nutrition-Health“ with international participation

**Glavni urednik/Editor in Chief**

Aleksandra Porobić

**Izdavač/Published by**

Univerzitet u Sarajevu-Veterinarski Fakultet, Sarajevo, BiH  
University of Sarajevo-Veterinary Faculty, Sarajevo, BiH

**Za izdavača/For Publisher:**

Muhamed Smajlović

**Štampa/Printed by**

Štamparija Fojnica d.d., Fojnica

**Tiraž/Edition**

30

**10. Studentski Kongres „Hrana-Ishrana-Zdravlje“**  
sa međunarodnim učešćem

ZBORNIK RADOVA

**10th Students Congress „Food-Nutrition-Health“**  
with international participation

CONFERENCE PROCEEDINGS

Sarajevo, 2025

Univerzitet u Sarajevu-Veterinarski fakultet, Sarajevo, BiH  
Univerzitet u Sarajevu,-Farmaceutski fakultet, Sarajevo, BiH  
Univerzitet u Sarajevu,-Pedagoški fakultet, Sarajevo, BiH  
Univerzitet u Sarajevu,-Fakultet zdravstvenih studija, Sarajevo, BiH  
Univerzitet u Sarajevu,-Stomatološki fakultet s klinikama, Sarajevo, BiH  
Univerzitet u Sarajevu,-Medicinski fakultet, Sarajevo, BiH  
Univerzitet u Sarajevu-Prirodno-matematički fakultet, Sarajevo, BiH

organizuju

10. Studentski Kongres „Hrana-Ishrana-Zdravlje“ sa međunarodnim učešćem  
13.-15. novembar 2025. godine, Sarajevo, Bosna i Hercegovina

---

University of Sarajevo, Veterinary Faculty, Sarajevo, BiH  
University of Sarajevo, Faculty of Pharmacy, Sarajevo, BiH  
University of Sarajevo, Faculty of Educational Sciences, Sarajevo, BiH  
University of Sarajevo, Faculty of Health Studies, Sarajevo, BiH  
University of Sarajevo, Faculty of Dental Medicine and clinics, Sarajevo, BiH  
University of Sarajevo, Faculty of Medicine, Sarajevo, BiH  
University of Sarajevo-Faculty of Science, Sarajevo, BiH

organize

10th Student Congress „Food-Nutrition-Health“ with international participation  
November 13-15, 2025, Sarajevo, Bosna and Hercegovina

**Organizacioni/Koordinacioni odbor  
Organizing/Coordination Committee**

**Predsjednica/Chairwoman**

Jasmina Đedićbegović- Bosnia and Herzegovina

**Članovi/Members**

Marija Pajić-Serbia  
Andrej Ovca-Slovenija  
Faruk Čaklović-Bosnia and Herzegovina  
Kenan Čaklović- Bosnia and Herzegovina  
Elvira Nikšić- Bosnia and Herzegovina  
Emina Kiseljaković- Bosnia and Herzegovina  
Edina Lazović- Bosnia and Herzegovina  
Nusret Drešković- Bosnia and Herzegovina  
Arzija Pašalić- Bosnia and Herzegovina

**Naučni i urednički odbor/Scientific and  
Editorial Committee**

**Predsjednica/Chairwoman**

Aleksandra Porobić- Bosnia and Herzegovina

**Članovi/Members**

Savić-Radovanović Radoslava-Serbia  
Davor Korčok-Serbia  
Polonca Trebše-Slovenia  
Danijela Đukić Ćosić-Serbia  
Aida Lugušić- Bosnia and Herzegovina  
Alisa Tiro- Bosnia and Herzegovina  
Vildana Džemidžić- Bosnia and Herzegovina  
Radivoj Jadrić- Bosnia and Herzegovina  
Enida Članjak-Kudra- Bosnia and Herzegovina  
Sanela Rustempašić- Bosnia and Herzegovina  
Irma Čehić- Bosnia and Herzegovina

**Tehnički odbor/Technical Committee**

**Predsjednica/Chairwoman**

Amela Salihović - Bosnia and Herzegovina

**Članovi/Members**

Sabina Šečić-Selimović -Bosnia and Herzegovina  
Lamija Kulović-Bosnia and Herzegovina  
Alma Arnautović- Bosnia and Herzegovina  
Nur-Esma Gazdić-Bosnia and Herzegovina  
Amina Mrkonjić- Bosnia and Herzegovina  
Sanel Sefer-Bosnia and Herzegovina  
Emana Đonlić- Bosnia and Herzegovina  
Berina Hodžić- Bosnia and Herzegovina  
Latifa Suljić- Bosnia and Herzegovina  
Esma Hasanspahić- Bosnia and Herzegovina  
Džejla Kamenjaš- Bosnia and Herzegovina  
Eman Spahić- Bosnia and Herzegovina  
Amna Spahić- Bosnia and Herzegovina  
Mirela Ličina- Bosnia and Herzegovina  
Emina Ahmetspahić- Bosnia and Herzegovina  
Ajdin Džabija-Bosnia and Herzegovina  
Nejla Ibrišimović-Bosnia and Herzegovina



## PREDGOVOR

Poštovane kolege, profesori i studenti,

Ovogodišnji deseti jubilarni Studentski kongres Hrana-Ishrana-Zdravlje poseban je događaj sada već tradicionalnog okupljanja akademske zajednice Univerziteta u Sarajevu, uz učešće predstavnika državnih institucija i privrednih društava. Imajući u vidu da se kongres održava godišnje, s pravom možemo biti ponosni već na samu činjenicu da je kontinuitet održan čak i u vrijeme posebnih izazova s kojima smo se svi susreli u periodu Covid-19 pandemije.

Tokom ovih deset godina na kongresu je prezentirano oko 500 studentskih radova uz učešće više od 2500 studenata iz Bosne i Hercegovine i inostranstva. Imali smo učesnike sa svih većih univerziteta u BiH, uključujući Mostar, Tuzlu, Banja Luku, Bihać, kao i van BiH iz Srbije, Slovenije, Hrvatske, Crne Gore, Kosova, Austrije, Turske.

Kroz Kongres su učvršćene neke već postojeće i začete nove suradnje i prijateljstva među fakultetima Univerziteta u Sarajevu kao i sa drugim univerzitetima, a posebno Univerzitetima u Beogradu, Novom Sadu i Ljubljani. Kao produkt te suradnje do sada su već pripremljene dvije interdisciplinarne monografije, nekoliko zajedničkih interdisciplinarnih naučnoistraživačkih projekata i naučnih radova publiciranih u visoko rangiranim časopisima.

U okviru kongresa održano je više okruglih stolova koji su adresirali aktuelne teme, okupljali relevantne učesnike i dali doprinos javnoj diskusiji i rješavanju određenih problema u lokalnim zajednicama.

Teme su uključivale:

- osiguranje zdravstvene ispravnosti i kvaliteta hrane i zaštitu prava potrošača;
- visoko obrazovanje usklađeno s potrebama tržišta rada
- obezbjeđenje adekvatne prehrane za osobe s fenilketonurijom u Kantonu Sarajevo
- zbrinjavanje i postupanje s animalnim otpadom u kontekstu EU regulative
- unapređenje planiranja i realizacije naučnoistraživačkih projekata na UNSA
- izazovi u implementaciji regulative u oblasti sigurnosti hrane u BiH.

Iza svih navedenih postignuća stoji tim iznimno vrijednih i istrajnih nastavnika i saradnika UNSA kojima ovom prilikom želim zahvaliti na znanju, vremenu i energiji koje poklanjaju kongresu i čestitati im na

izuzetnom uspjehu kongresa. Zahvalnost dugujemo i kolegama iz Univerzitetskog tele-informatičkog centra UTIC, Univerzitetske biblioteke, Muzičke akademije i Akademije scenskih umjetnosti UNSA.

Finansijsku podršku kontinuirano nam pružaju privredna društva, čime je omogućena realizacija kongresa bez naplate kotizacije od učesnika. Posebnu zahvalnost dugujemo kompanijama Bosnalijek, Salveo, Dox Pharm, Abela Pharm te Mliječnoj industriji 99 – MIG Gradačac, Menprom, Akova, Sarajevska mljekara Milkos, Perutnina Ptuj BiH.

Ovaj kratki osvrt na dosadašnja postignuća ne iskazuje u potpunosti cjelokupan značaj Studentskog kongresa Hrana-Ishrana-Zdravlje, ali ipak prikazuje snagu jedinstva pojedinaca koji dijele zajedničku ideju i viziju unapređenja i rasta na individualnom i kolektivnom nivou, a za ostvarenje opšte dobrobiti. S ovim ciljem i svrhom, naš zajednički put nastavljamo i dalje.

Prof.dr. Jasmina Đedibegović

Predsjednica Organizacionog odbora



## Pozdravni govor sa otvaranja jubilarnog 10. kongresa ‘‘Hrana-Ishrana-Zdravlje’’

‘‘Dame i gospodo, dragi studenti

Studentski kongres Hrana Ishrana Zdravlje obilježio je dio akademske epohe u oblasti cjeloživotnog učenja i svrstao se u jedinstven edukacijski poligon koji plijeni svojom multidisciplinarnošću u najvažnijem životnom resursu, **hrani**, za koju su mnogi naučnici rekli da pored esencijalne funkcije, hrana snažno djeluje i na formiranje individualnog i društvenog identiteta.

Ovaj projekat su osmislili i realizirali pojedinci iz akademske zajednice, koji nose smisao progresivnog u svom intelektualnom biću i bezrezervno podržavaju put egzaktnosti. Ohrabruje da su studenti prihvatili ovaj izazov usavršavanja, svjesni, da će to biti prava podloga za razvoj sposobnosti razumnog spoznavanja stvari.

Ovakve konferencije jačaju i osvježavaju naš akademski prostor što je bitna pretpostavka za prirodniju akademsku sinergiju, važan potencijal u izgradnji i razvoju savremenijeg dizajniranja u obrazovnom i naučno-istraživačkom radu.

Danas je proučavanje pitanja i bitnosti hrane i prehrambene kulture postalo stvarni predmet ne samo zdravstvene i privredne, nego i etičke rasprave. U tom kontekstu pozicionirat će se i umjetna inteligencija.

Zato smo zajedno sa studentima i profesorima nekoliko bosanskohercegovačkih univerziteta kao i univerziteta iz Srbije, a prethodnih godina sa studentima i profesorima univerziteta iz Slovenije, Hrvatske, Makedonije, Turske i Austrije.

To nije početak saradnje, to je kontinuitet regionalnog diskursa, koji ima svoju tradicijsku i kulturnu vrijednost.

Svjesni ovog društvenog trenutka, više nego prije, mogu reći da smo ponosni na ovu međunarodnu studentsku konferenciju koja okuplja divne ljude iz akademskog, političkog, društvenog, prehrambenog i kulturnog života, dijeleći emocije ljubavi, poštovanja i divljenja prema svima koji večeras prisustvuju na ovoj naučnoj konferenciji.

Na kraju želim zahvaliti svima onima koji nas podržavaju i omogućavaju da ovaj projekat traje cijelu deceniju. Iako rektor Univerziteta u Sarajevu, prof. dr Tarik Zaimović nije u mogućnosti da prisustvuje kongresu, finansijskom podrškom omogućio je realizaciju ove jubilarne desete studentske konferencije. Zahvaljujem i na telegramu podrške koji nam je poslao Njegova ekselencija, predsjedavajući Predsjedništva BiH, gosp. Željko Komšić u kojem je svim učesnicima zaželio uspješan rad, a gostima lijep i prijatan boravak u Sarajevu i BiH.

Na riječima podrške i prepoznatom značaju interdisciplinarnog pristupa u organizaciji kongresa, što ga čini jedinstvenim projektom ove vrste u BiH, zahvaljujem i Akademiku Mirku Pejanoviću, potpredsjedniku ANU BiH.

Direktor Agencije za sigurnost hrane BiH, dr.sc. Sanin Tanković je u svome obraćanju istakao važnost osiguranja adekvatne količine zdravstveno ispravne i nutritivno vrijedne hrane, kao i posljedice neadekvatne ishrane na zdravlje stanovništva i posljedično na cjelokupan socijalni i ekonomski status društva. Stoga Agencija za sigurnost hrane BiH s pažnjom prati ovaj studentski kongres i ove, kao i prethodnih godina na čemu im se srdačno zahvaljujem u ime organizatora kongresa.

Zahvaljujem i predsjedniku Veterinarske komore Federacije BiH, prof. dr. Jasminu Ferizbegoviću na riječima podrške i pohvalama koje je uputio svim učesnicima kongresa.

Zahvaljujem na čestitkama i sekretaru Ureda za veterinarstvo BiH, gosp. Muameru Derviševiću, kao i pomoćniku Federalnog ministra poljoprivrede, vodoprivrede i šumarstva, mr.sc. Kenanu Muratoviću.

Zahvaljujem i prof. dr. Samiru Arnautoviću, predsjedniku filozofskog društva "Theoria" koji je u svom pozdravnom govoru dao akcenat na vrijednost i značaj teme Kongresa HIZ 2025, za koju kaže "da je vremenski neograničena i ostaje aktuelna u svim civilizacijskim epohama uz naglasak da ga raduje i učešće uvažene prof. dr. Eve Kamerer, profesorice sa Filozofskog fakulteta Univerziteta u Beogradu, koja će sa temom "Filozofska razmišljanja o hrani" dati snažnu eksplikaciju značaja o multidisciplinarnosti kongresne teme, a koja ima utemeljenje u svom polivalentnom biću".

Posebnu zahvalnost upućujem i Ministrici za nauku, visoko obrazovanje i mlade, prof. dr. Dušanki Bošković, na njenim optimističnim i ohrabrujućim porukama koje je uputila učesnicima i organizatorima kongresa uz želju da ova konferencija po svom konceptu jedinstvena u regionu preraste u mnogo veću i značajniju konferenciju koja će okupljati stručnjake na ovu temu iz Evrope i svijeta.

Hvala svima vama koji svojim učešćem u organizaciji i radu kongresa utičete da svake godine budemo sve bolji i bolji. "

prof. dr. Faruk Čaklovica, prof. emeritus

## Sadržaj/Contents

<b>PL-1</b>	Plenarno predavanje/Plenary lecture JESTI BRZO, JESTI SPORO? Filozofska razmišljanja o hrani/EATING FAST, EATING SLOW? Philosophical thoughts on food <i>Kamerer E.</i>	<b>1</b>
<b>1</b>	PRIMARNA PROIZVODNJA I PRERADA HRANE PRIMARY PRODUCTION AND PROCESSING OF FOOD	<b>3</b>
<b>1-O-1</b>	Uticaj različitih faktora na histologiju poprečno-prugastog mišićnog tkiva/The Influence of Various Factors on the Histology of Striated Skeletal Muscle Tissue <i>Buljina A., Đikić E.</i>	<b>5</b>
<b>1-O-2</b>	Unapređenje veterinarske nauke o mesu: Pristup obrazovanju pomoću 3D tehnologije i virtualne stvarnosti/Enhancing Veterinary Meat Science: A 3D and Virtual Reality Approach to Education <i>Hadžibajramović M., Anadolac S., Hadžimerović N., Tandir F., Čaklovica K.</i>	<b>16</b>
<b>1-O-3</b>	Kobilje i magareće mleko: od tradicije do regulatornog nadzora/Mare and Donkey Milk: From Tradition to Regulatory Oversight <i>Pajić K.</i>	<b>21</b>
<b>1-O-4</b>	Dobrobit goveda i kvalitet hrane: povezanost i zakonodavni okvir u Srbiji i EU/Cattle Welfare and Food Quality: Connections and Legislative Framework in Serbia and the EU <i>Sekulić O.</i>	<b>26</b>
<b>2</b>	TOKSIKOLOGIJA I SIGURNOST HRANE I OKOLIŠA FOOD AND ENVIRONMENT TOXICOLOGY AND SAFETY	<b>33</b>
<b>2-O-1</b>	Utvrđivanje prisustva koagulaza-pozitivnog <i>Staphylococcus aureus</i> u uzorcima gotovih hladnih jela i soseva serviranih na području Sarajeva/Determining the Presence of Coagulase-positive <i>Staphylococcus aureus</i> in Samples of Ready Cold Meals and Sauces Served in the Sarajevo Area <i>Ahmespahić V., Članjak-Kudra E., Rebić V.</i>	<b>35</b>
<b>2-O-2</b>	Uticaj društvenih mreža na trovanje hranom: slučaj sirovog mlijeka/The impact of social media on food poisoning: the case of raw milk <i>Alić E., Kruško L.</i>	<b>40</b>
<b>2-O-3</b>	Kontaminacija hrane patogenim mikroorganizmima – Pregled iz RASSF baze/Contamination of Food with Pathogenic Microorganisms – Overview from the RASFF Database <i>Dragolovčanin B., Biber I., Nezović L., Teparić H., Dedić E., Đedibegović J.</i>	<b>45</b>
<b>2-O-4</b>	Prah neema u ishrani i zdravlju: Preliminarni <i>in vitro</i> rezultati o genotoksičnim efektima/Neem powder in nutrition and health:	<b>53</b>

	Preliminary <i>in vitro</i> results of genotoxic effects <i>Duraković L., Kovačević M., Durmišević I., Hadžić Omanović M., Haverić S., Haverić A., Četković Pećar T.</i>	
<b>2-O-5</b>	Procjena radijacionog rizika od konzumacije divljih gljiva/ Assessment of radiation risk from consumption of wild mushrooms <i>Fulurija L., Hercegovac J., Šljivo B., Ilić J., Gradašćević N.</i>	<b>62</b>
<b>2-O-6</b>	Medicinska upotreba kanabisa - terapijski potencijal i izazovi/ Medicinal use of Cannabis - Therapeutic potential and challenges <i>Konjhodžić F., Koprivica E., Telibečirović I.</i>	<b>68</b>
<b>2-O-7</b>	Javnozdravstveni rizici vodosnabdjevanja u kriznim situacijama u Bosni i Hercegovini/ Public health risks of water supply in crisis situations in Bosnia and Herzegovina <i>Malkić M.</i>	<b>78</b>
<b>2-O-8</b>	Fizičke opasnosti u lancu hrane-rizici po zdravlje ljudi i mjere prevencije/ Physical hazards in the food chain: Risks to human health and prevention measures <i>Osmanović Zukić E., Ligata M., Smječanin E.</i>	<b>84</b>
<b>2-O-9</b>	Percepcija potrošača i senzorna procena razblaženog mleka: procena informisanosti i pragova uočljivosti/ Consumer perception and sensory assessment of diluted milk: evaluating awareness and detection limits <i>Pavlis A.</i>	<b>91</b>
<b>2-O-10</b>	Aflatoksin sa aspekta proizvođača i potrošača/Aflatoxin: Perspectives of Producers and Consumers <i>Peurača Đ.</i>	<b>96</b>
<b>2-O-11</b>	Budućnost proizvoda od kanabisa na tržištu Bosne i Hercegovine/ The future of cannabis products in Bosnia and Herzegovina <i>Tanković N., Bisić I., Popara S., Vrabac S., Žalić H., Porobić A.</i>	<b>102</b>
<b>2-P-1</b>	Povezanost ishrane i toksičnog stresa kod djece: pregled literature s naglaskom na ulogu nutritivnih deficita u pogoršanju toksičnog stresa i njihovim dugoročnim posljedicama/ Correlation between nutrition and toxic stress in children: a literature review with emphasis on the role of nutritional deficiencies in exacerbating toxic stress and their long-term consequences <i>Burić M.</i>	<b>110</b>
<b>2-P-2</b>	Detekcija <i>Enterococcus faecalis</i> u bunarskoj netretiranoj vodi/ Detection of <i>Enterococcus faecalis</i> in untreated well water <i>Fočo A.</i>	<b>115</b>
<b>2-P-3</b>	Javnozdravstveni rizici trovanja hranom u kriznim situacijama u Bosni i Hercegovini/ Public health risks of food poisoning in crisis situations in Bosnia and Herzegovina <i>Malkić M.</i>	<b>120</b>

<b>3</b>	<b>ISHRANA TOKOM ŽIVOTNOG CIKLUSA NUTRITION THROUGH THE LIFE CYCLE</b>	<b>127</b>
<b>3-O-1</b>	Značaj primene sireva sa dugim zrenjem u ishrani ljudi/The Importance of Consumption Long-Ripened Cheeses in Human Nutrition <i>Barudžija S., Milinković M., Stojanović M., Stojanović B., Savić Radovanović R.</i>	<b>129</b>
<b>3-O-2</b>	Svjesno jedenje – koncept, pristup i alati za testiranje/Mindful eating – concept, approach, and assessment tools <i>Begić J., Čosić E., Čosić I., Halilović I., Muratović F., Đeđibegović J.</i>	<b>138</b>
<b>3-O-3</b>	Relativna energetska deficijencija u sportu: budući izazovi u fizioterapiji/Relative energy deficiency in sport: future challenges in physiotherapy <i>Čolpa M., Krstić M., Džaferović D.</i>	<b>146</b>
<b>3-O-4</b>	Analiza tržišta i stavova proizvođača kozjeg mleka na području Novog Sada/Market analysis and attitudes of goat milk producers in the Novi Sad area <i>Dukić I.</i>	<b>153</b>
<b>3-O-5</b>	Svjesno jedenje kao metod za kontrolu tjelesne mase/Mindful eating as a method for body weight control <i>Donko A., Jusić A., Kahrić L., Komarica A., Muharemović A., Đeđibegović J.</i>	<b>160</b>
<b>3-O-6</b>	Faktori rizika u ishrani za nezarazne bolesti među odraslom populacijom u Bosni i Hercegovini/Dietary risk factors for Noncommunicable diseases among the adult population in Bosnia and Hercegovina <i>Kustura H.</i>	<b>167</b>
<b>3-O-7</b>	Problem pretilosti kod učenika 4. i 5. razreda osnovne škole/The Problem of Obesity Among 4th and 5th Grade Elementary School Students <i>Mujezinović E., Nikšić E.</i>	<b>173</b>
<b>3-O-8</b>	Magareće mleko kao potencijalna alternativa majčinom mleku kod dece-nutritivni i medicinski aspekti/Donkey milk as a potential alternative to mother's milk in children - nutritional and medical aspects <i>Pantić B., Pajić M.</i>	<b>182</b>
<b>3-O-9</b>	Genom kao osnova za kreiranje personalizirane prehrane/The genome as a basis for creating personalized nutrition <i>Popara S., Vrabac S., Žalić H., Bisić I., Tanković N., Đeđibegović J.</i>	<b>188</b>
<b>3-O-10</b>	Značaj mikrobiote za normalne životne funkcije/The importance of the microbiota for normal vital functions <i>Vukman T., Korčok D. J.</i>	<b>193</b>
<b>3-P-1</b>	Postbiotici – novi perspektivan pristup unapređenju zdravlja crijeva	<b>199</b>

	i probave/Postbiotics - a new promising approach to improving gut and digestive health <i>Buza A., Mavrić I., Muhović E.</i>	
<b>3-P-2</b>	Naučna zasnovanost reklame za kurkumu: kritička recenzija/Scientific Basis of Turmeric Advertising: A Critical Review <i>Jusufobegović L., Pepić L., Hodžić V., Fakić L., Oberan I., Đeđibegović J.</i>	<b>204</b>
<b>3-P-3</b>	Informiranost potrošača o dodacima prehrani u Kantonu Sarajevo/Consumer awareness of dietary supplements in the Sarajevo Canton <i>Pepić L., Hodžić V., Imamović F. Đeđibegović J.</i>	<b>209</b>
<b>3-P-4</b>	Upotreba kolostruma u prehrani sportista i njegovi efekti na atletske performanse/The Use of Colostrum in Sports Nutrition and Its Effect on Athletic Performance <i>Šešum J.</i>	<b>215</b>
<b>4</b>	DIJETOTERAPIJA DIETOTHERAPY	<b>219</b>
<b>4-O-1</b>	Utjecaj prehrambenih navika na parametre lipidnog statusa/The impact of dietary habits on lipid status parameters <i>Alić I., Ibišević A., Papić E., Šahinagić M., Šegalo S.</i>	<b>221</b>
<b>4-O-2</b>	Uloga stabilnog unosa vitamina K u kontroli INR vrijednosti kod pacijenta na terapiji varfarinom: studija slučaja/The role of stable vitamin K intake in the control of INR values in a patient on warfarin therapy: a case study <i>Arnautović A.</i>	<b>226</b>
<b>4-O-3</b>	Uloga probiotika, prebiotika i sinbiotika u optimizaciji crijevne mikrobiote kod žena sa sindromom policističnih jajnika/The role of probiotics, prebiotics and synbiotics in optimizing the gut microbiota in women with polycystic ovary syndrome <i>Bajrović M., Šljivo N., Kulović L., Šečić-Selimović S.</i>	<b>232</b>
<b>4-O-4</b>	Primjena imunomodulatornih enteralnih formula u optimizaciji imunološke funkcije i nutritivnog statusa pacijenata/Application of immunomodulatory enteral formulas in optimizing immune function and nutritional status of patients <i>Nadina Džafić N., Grčić S., Arnautović A., Šečić-Selimović S., Kulović L.</i>	<b>239</b>
<b>4-O-5</b>	Uloga polifenola u očuvanju reproduktivnog zdravlja žena/The role of polyphenols in preserving women's reproductive health <i>Gazdić N.E., Mrkonjić A., Omeragić A., Šečić-Selimović S., Kulović L.</i>	<b>245</b>
<b>4-O-6</b>	Jestive vakcine: Aktuelni status i buduće perspektive/The research on edible vaccines: Current status and future perspectives <i>Durak B., Hečo N., Golović T., Halilović A., Hebibović S., Đeđibegović J.</i>	<b>253</b>

<b>4-P-1</b>	Podrška kontroli tjelesne mase u Kantonu Sarajevo: perspektiva pacijenata/Support for body weight management in Sarajevo Canton: patients' perspective <i>Mekić B., Malkoč A., Japić M., Turković A., Makan A., Đedibegović J.</i>	<b>258</b>
<b>5</b>	SAVREMENA DIJAGNOSTIKA I ANALITIKA HRANE MODERN FOOD DIAGNOSTICS AND ANALYSIS	<b>263</b>
<b>5-O-1</b>	Određivanje sadržaja polifenolnih spojeva u odabranim sortama <i>Cucurbita pepo L.</i> /Determination of Polyphenolic Compounds in Selected <i>Cucurbita pepo L.</i> Varieties <i>Zukić A., Fazlić Dž., Zahirović-Sinnović Ć., Karić L.</i>	<b>265</b>
<b>5-O-2</b>	Planiranje i implementacija nutritivnih intervencija za pacijente sa kardiovaskularnim oboljenjima/Planning and implementation of nutritional interventions for patients with cardiovascular diseases <i>Numanović A., Šečić-Selimović S., Bašić N.</i>	<b>274</b>
<b>5-P-1</b>	Ekstrakcija i karakterizacija fenolnih spojeva iz biljke <i>Achillea millefolium</i> /Extraction and characterization of phenolic compounds from the plant <i>Achillea millefolium</i> <i>Alibegić Dž., Kajtaž E., Alihodžić- Dilberović B., Alagić A., Nikšić H.</i>	<b>279</b>
<b>5-P-2</b>	Analiza sadržaja polifenola i antocijana u komercijalno dostupnim voćnim i biljnim čajevima/Analysis of polyphenol and anthocyanin content in commercially available fruit and herbal teas <i>Begović J., Ključo A., Idrizović N., Hajdarović N., Gosto A., Nikšić H.</i>	<b>290</b>





## **EATING FAST, EATING SLOW?**

### **Philosophical thoughts on food**

dr Eva KAMERER, associate professor

Faculty of Philosophy, University of Belgrade, Serbia

Corresponding author: Eva Kamerer, [evakamerer@yahoo.com](mailto:evakamerer@yahoo.com)

The power of food is immeasurable. Thus, the great German philosopher Friedrich Nietzsche claimed that man's destiny depends to a much greater extent on the issue of food than on religious salvation. Ludwig Feuerbach said something similar in one of his short writings from 1864. In it, he quotes the words of the famous French politician Savarin, "Man is what he eats", and derives from this the revolutionary lesson that the people do not need stories about sin but food, and not plant food but meat, which alone gives the strength necessary for action. Food is at the center of many philosophical and anthropological conceptions, and it is inextricably linked to various values and ideals: simple life, asceticism, purification, but also social justice. It is a well-known thought that food is closely related to community, that we eat to make friends, but also to make enemies.

We would not be wrong if we characterized the modern age as the age of food: in the matter of food production and its consumption, current political differences and conflicts are reflected. The trend of rapid food production characteristic for globalization, which sacrifices genetic variability and biodiversity for the sake of efficiency and profit, is opposed by new concepts. Among them, the one advocated by the Italian organization Slow Food is certainly the most well-known and structured. In the lecture, I will try to show the meaning of the central ideas of this organization that has grown into an international movement, above all the specific combination of modernity and traditionalism, local values and the connection between pleasure and politics.

**JESTI BRZO, JESTI SPORO?**

**Filozofska razmišljanja o hrani**

dr Eva KAMERER, vanredni profesor

Filozofski fakultet, Univerzitet u Beogradu, Srbija

Autor za korespondenciju: Eva Kameroner, evakameroner@yahoo.com

**Sažetak**

Moć hrane je neizmerna. Tako je veliki nemački filozof Fridrih Niče tvrdio da čovekova sudbina u mnogo većoj meri zavisi od pitanja hrane nego od religioznog spasenja. Nešto slično je rekao i Ludvig Foerbach u jednom svom kratkom spisu iz 1864. U njemu on citira reči čuvenog francuskog političara Savarena, „Čovek je ono što jede“, i iz toga izvodi revolucionarnu pouku da narodu nisu potrebne priče o grehu nego hrana, i to ne biljna hrana nego meso, koje jedino daje snagu neophodnu za delovanje. U središtu mnogih filozofskih i antropoloških koncepcija stoji upravo hrana i ona je neraskidivo povezana sa različitim vrednostima i idealima: sa jednostavnim životom, asketizmom, pročišćenjem, ali i socijalnom pravdom. Poznata je misao da je hrana u tesnoj vezi sa zajedništvom, da jedemo da bismo sticali prijatelje, ali i da bismo pravili neprijatelje.

Ne bismo pogrešili ako bismo savremeno doba okarakterisali kao doba hrane: u pitanju proizvodnje hrane i njene konzumacije reflektuju se aktuelne političke razlike i sukobi. Trendu brze proizvodnje hrane karakterističnom za globalizaciju, koji radi efikasnosti i profita žrtvuje genetičku varijabilnost i biodiverzitet, suprotstavljaju se nove koncepcije. Među njima je svakako najpoznatija i programski najprofilisanija ona koju zagovara italijanska organizacija *Slow Food*. U predavanju ću pokušati da pokažem kakav je smisao središnjih ideja ove organizacije koja je prerasla u međunarodni pokret, pre svega specifičnog spoja modernosti i tradicionalizma, vrednosti lokalnog i veze između zadovoljstva i politike.

1. PRIMARNA PROIZVODNJA I PRERADA HRANE  
PRIMARY PRODUCTION AND PROCESSING OF FOOD



## **The Influence of Various Factors on the Histology of Striated Skeletal Muscle Tissue**

Azra BULJINA\*, Enisa ĐIKIĆ

Faculty of Veterinary Medicine, University of Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Azra Buljina, [azra.buljina@student.vfs.unsa.ba](mailto:azra.buljina@student.vfs.unsa.ba)

### **Abstract**

The growth and development of striated skeletal muscle tissue in animals are not only important for veterinary science or meat production, but they are also directly connected to human nutrition and health. The size and quality of muscles depend on the number and thickness of muscle fibers, as well as on genetics, nutrition, and the lifestyle of the animal. By understanding how muscles develop, how different fiber types function, and how nutrition affects their growth, we can better comprehend the quality of the meat that reaches our plates, as well as why it holds nutritional value. In our research, we conducted histological analysis and measurements of the thickness of longitudinal sections of muscle fibers in *Musculus longissimus dorsi* – beef tenderloin (B). Proper animal nutrition, especially in the early growth period, is crucial for meat quality and for the intake of proteins and other essential nutrients in humans. Muscle fibers are not only the building blocks of muscles but also a reflection of animal health, and indirectly, of our own health. In this sense, concern for muscle growth and development in animals is not merely a scientific topic—it is also a way to better understand the connection between nature, food, and the human body.

*Keywords: histology, striated skeletal muscle tissue*

### **Introduction**

Striated skeletal muscle tissue is found in the composition of skeletal musculature, which is innervated by cerebrospinal nerves and is subject to voluntary control. It is also present in organs innervated by the autonomic nervous system, where it is not under voluntary control, such as the esophagus and the intestines of fish (Katica, Mlaćo, & Hasanbašić, 2010).

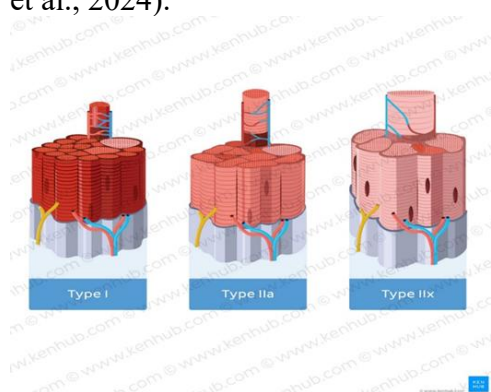
The growth and development of skeletal muscles are important both in veterinary science and in human medicine, as they help us better understand muscle function and their ability to adapt to various conditions. The size of a muscle is primarily influenced by the number and thickness of muscle fibers, while fat cells, connective tissue, and nerves play a comparatively minor role (Rehfeldt, Stickland, & Fiedler, 1999). In recent years, global meat consumption has been steadily increasing, driven by higher living standards and rising incomes. This has led to the development of modern livestock and poultry production methods, where the main goals are accelerated growth, improved feed efficiency, and a greater proportion of lean meat. In this way, large quantities of meat are produced to meet growing consumer demand (Wang, Zhang, & Liu, 2024).

Rahelić (1978) describes how the majority of a slaughtered animal's body mass consists of muscle tissue, which is the richest source of protein and therefore the most valuable component of meat for human nutrition. Consequently, in recent decades, particular attention has been devoted to the breeding of cattle and pigs that exhibit rapid growth and muscle development. However, muscle quantity alone is insufficient—quality is equally important, since in some early-maturing breeds, meat may display undesirable traits. Muscles are chemically complex, and during storage and processing they undergo changes that influence taste, texture, and overall meat quality. These changes begin immediately after slaughter and continue throughout chilling, freezing, salting, smoking, or cooking. For this reason, understanding muscle development during life, their chemical composition, and their post-mortem transformations is essential for producing high-quality meat.

Despite the efficiency of modern production systems, this approach has also led to a decline in meat quality. Meat quality is particularly important because it significantly influences consumer purchasing decisions and is largely determined by appearance and functional properties (Wang et al., 2024). After birth, muscles predominantly grow by increasing the length and thickness of fibers, since the number of fibers is established primarily during fetal development. The number of fibers, however, determines the growth potential of the muscle, its endurance, and its adaptability to stress, while in livestock it influences both the quantity and quality of meat (Sample B1; Rehfeldt et al., 1999).

Each muscle fiber is surrounded by a membrane—the sarcolemma. Inside the fiber lies the sarcoplasm, which contains contractile structures known as myofibrils. The muscle fiber (myocyte) contains a large number of nuclei, positioned in adult organisms along the periphery, just beneath the sarcolemma. These nuclei are oval in shape and contain fine granular

chromatin and one or two nucleoli. The sarcoplasm is highly organized within the fiber. Myofibrils are filamentous protein structures that constitute the contractile apparatus of the muscle. The presence and distribution of connective tissue ultimately affect the extent and uniformity of marbling, which, it should be emphasized, is a desirable trait (Mlačo, Katica, & Rukavina, 2017). All skeletal muscles are composed of different types of muscle fibers, and the ratio among them enables muscles to perform diverse movements. Muscle fibers are highly flexible, capable of altering size or even transforming into other fiber types to optimize muscle function. For this reason, their classification is never absolute but rather approximate. Muscle fibers differ in contraction speed, energy metabolism, and fatigue resistance. Type I fibers (slow-twitch) contract slowly, rely on oxygen for energy through oxidative metabolism, and are highly resistant to fatigue, making them suitable for prolonged, low-intensity activities. These fibers contain numerous mitochondria and high concentrations of myoglobin, which gives the meat a red coloration. Type IIA fibers (intermediate) contract more rapidly than Type I fibers and utilize both oxidative and glycolytic metabolism. They are moderately resistant to fatigue and are adapted for activities of medium intensity. Type IIX/IIB fibers (fast-twitch) contract very quickly, rely primarily on glycogen for energy via glycolytic metabolism, and fatigue rapidly. They support short bursts of intense activity, and meat containing a high proportion of these fibers is typically lighter in color (Wang et al., 2024).



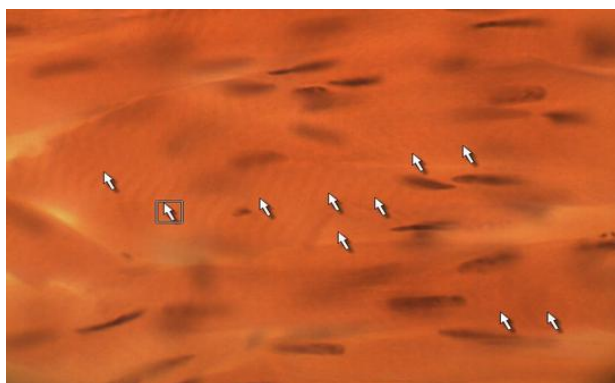
**Figure 1.** Types of muscle fibers in skeletal muscles (Vraka, 2024).

Different genes encode these types of muscle fibers, and their distribution depends on the species and the specific muscle. For example, in pigs and cattle, all fiber types are present, whereas in birds, the pectoral muscles are predominantly composed of fast-twitch fibers (Wang et al., 2024).

**Table 1.** Characteristics of different muscle fibers (Wang et al., 2024).

Characteristics	Type I	Type IIA	Type IIB
Meat color	Light red	Red	White
Contraction speed	Slow (+)	Medium (++)	Fast (+++)
Energy metabolism	Oxidative	Oxidative-glycolytic	Glycolytic
Fatigue resistance	High (+++)	Medium (++)	Low (+)
Cross-sectional area (CSA)	Small (+)	Medium (++)	Large (+++)
Glycogen content	Low (+)	Medium (++)	High (+++)
Mitochondrial content	High (+++)	Medium (++)	Low (+)
ATPase activity	Low (+)	Medium (++)	High (+++)
Activity type	Low intensity, endurance	Moderate intensity, aerobic	Short, high-intensity bursts

*Note: Oxidative fibers (Type I, IIA) produce redder meat due to their higher myoglobin content, whereas glycolytic fibers (Type IIX, IIB) result in lighter-colored meat.*



**Figure 2.** Sample B1 – longitudinal section of muscle; white arrows indicate cross-striations (IMMERSION). Copyright© A. Katica, N. Mlaćo

## ***Experimental***

Striated skeletal muscle was sampled from fresh beef steak (Sample B). The specimens were stored in screw-cap plastic vials containing 10% formalin until histological preparations were made, i.e., until embedding in paraffin blocks. The samples were first placed in 70% ethanol for two days, then in 96% ethanol for one day, and finally in 100% ethanol for one day. Following this step, the specimens were transferred into a mixture of 100% ethanol and toluene for two hours, and subsequently into pure toluene for four hours. Prepared muscle samples were then placed in paraffin I for five hours and in



paraffin II for twelve hours. This completed the embedding process into paraffin blocks.

Processing of samples from fixation to paraffin embedding was carried out using a rotational tissue processor (MICRON, model STP-120). After embedding, the muscle tissue was sectioned using a digital microtome (LEICA RM 2145) into serial sections of 0.5–1.5  $\mu\text{m}$  thickness. The sections were mounted on glass slides, stained with hematoxylin and eosin (H&E), covered with cover slips, and sealed with Canada balsam. Histological preparations were analyzed using a binocular light microscope (MOTIC, TYPE 120M) under magnifications of 100 $\times$ , 200 $\times$ , and 400 $\times$ , including oil immersion. Microscopic documentation and measurements were performed using the specialized software Motic Image Plus 2.0ML.

### ***Results and Discussion***

During embryonic development, myoblasts originate from precursor cells of mesodermal origin and are predetermined to become muscle cells. These cells proliferate to form a reserve of myoblasts, and under specific signals, they cease dividing, differentiate, and fuse into myotubes, which later give rise to muscle fibers. Muscle fibers develop in two distinct waves: primary fibers establish the basic muscle structure, while secondary fibers appear later, filling the spaces between primary fibers and thereby enhancing the functional capacity of the muscle.

Additionally, a portion of myoblasts remain as satellite cells that persist alongside muscle fibers and contribute both to postnatal muscle growth and to the regeneration of damaged fibers. After birth, the primary mode of muscle growth is the enlargement of existing fibers, while the number of fibers generally remains unchanged. However, in the early days of life, an apparent increase in fiber number can sometimes be observed, which is actually the result of maturation and separation of pre-existing myotubes.

The number of fibers plays a significant role in postnatal growth rates: with fewer fibers, individual fibers grow faster, whereas when fiber number is higher, the growth of each individual fiber is slower. Both fiber size and fiber number jointly determine the total muscle cross-sectional area, which means that both parameters contribute to muscle strength and overall function (Sample B2). Over the course of life, the number of muscle fibers generally remains constant, though it may gradually decline with aging, while satellite cells continue to enable adaptation and regeneration. Postnatal muscle growth and development represent a complex process in which genetics, nutrition, physical activity, and other environmental factors exert significant influence on fiber size and quality (Rehfeldt et al., 1999). Histological analysis of

muscle fibers from sample B (beef steak), in longitudinal section, revealed uniformity in the longitudinal profiles of muscle fibers, as well as the presence of numerous basophilically stained, spindle-shaped nuclei located along the inner side of the sarcolemma (Sample B2).

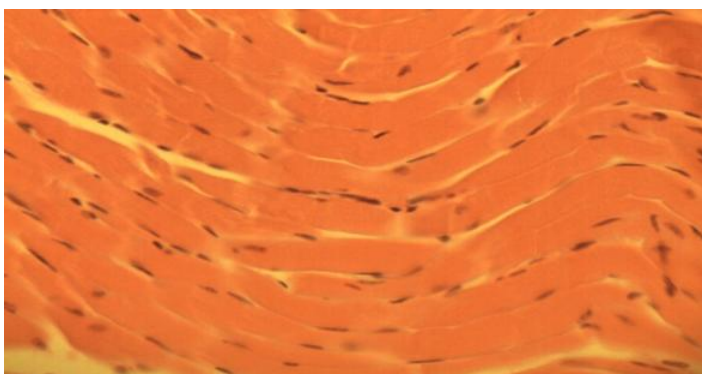
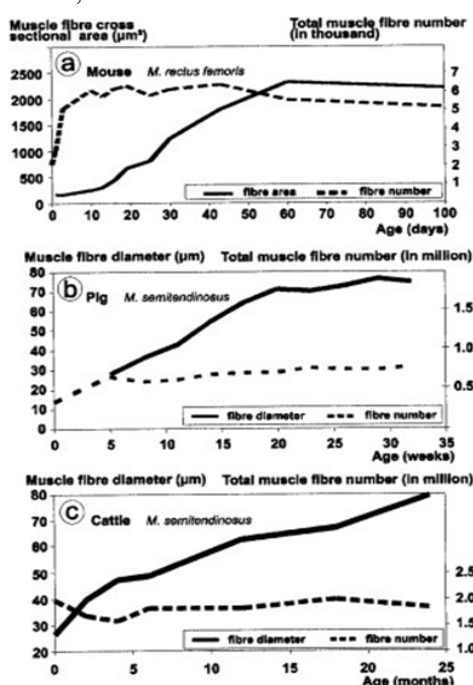


Figure 3. Sample B2 – longitudinal section of muscle tissue (H&E,  $\times 400$ ). Copyright© A. Katica, N. Mlaćo

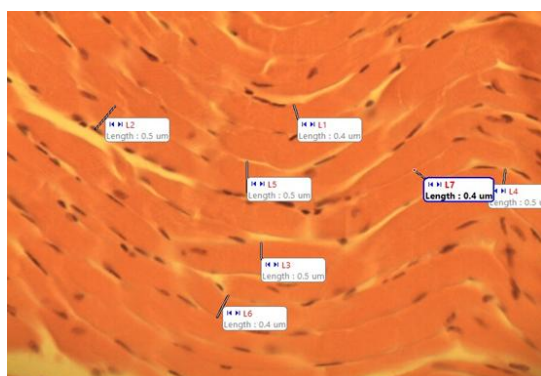


**Figure 4.** Postnatal development of muscle fiber thickness (cross-sectional area or diameter) and the total number of muscle fibers per muscle cross-section in:  
 a) *rectus femoris* muscle of laboratory mice; b) *semitendinosus* muscle of Landrace pigs; c) *semitendinosus* muscle of Holstein–Friesian cattle (Rehfeldt et al., 1999).

Muscle growth after birth depends on the total number of muscle fibers. When fiber number is high, the growth of individual fibers is slower, whereas with fewer fibers, individual fiber growth occurs more rapidly. The number of fibers is inversely related to their thickness; however, both parameters together determine the total cross-sectional area of the muscle. Although techniques for measuring fiber number may vary, it is generally accepted that fiber number is largely established before birth. Among animal species, there are substantial differences in both fiber number and fiber size. Body size is not always proportional to fiber diameter—for example, the largest fibers are not found in the largest animal (the whale), but in the pig. Overall, differences in muscle mass across species are primarily determined by the total number of fibers, while fiber diameter exhibits less variability (Rehfeldt et al., 1999). By measuring the width of longitudinal sections of muscle fibers (Sample B3), we determined a mean value of 0.35  $\mu\text{m}$ .

**Table 2.** Diameter of muscle fibers in *musculus longissimus* of adult individuals from different species (Rehfeldt et al., 1999; Sample B3).

Species	Fiber diameter ( $\mu\text{m}$ )	Species	Fiber diameter ( $\mu\text{m}$ )
Chicken	20	Reindeer	45
Goat	22	Water buffalo	26
Sheep	25	Zebu	78
Wild boar	72–85	Yak	70
Domestic pig	40–80	Cattle	55–67
Fallow deer	19	Elephant	51
Whale	55		



**Figure 5.** Sample B3 – width of striated muscle fibers in micrometers ( $\mu\text{m}$ ) (H&E,  $\times 400$ ). Copyright© A. Katica, N. Mlačo

**Table 3.** Number and diameter of muscle fibers in two muscles of laboratory mice and rats (Rehfeldt et al., 1999).

Species	<i>Extensor digitorum longus</i> (Fiber number)	<i>Soleus</i> (Fiber number)	<i>Extensor digitorum longus</i> (Fiber diameter, $\mu\text{m}$ )	<i>Soleus</i> (Fiber diameter, $\mu\text{m}$ )
Mouse	1000–1300	450–860	20–41	25–28
Rat	2600–3500	2000–3050	39–64	47–60

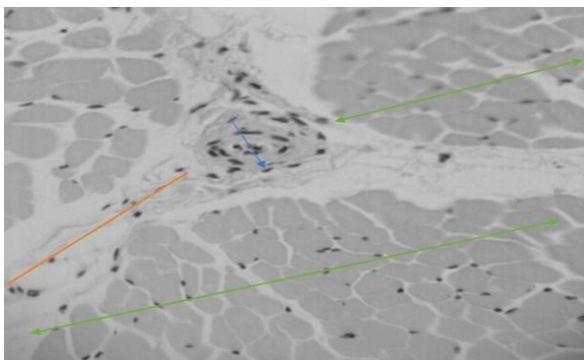
Meat is defined as the edible portion of animal muscle and internal organs after the removal of most fat and connective tissue. It represents an important source of nutrients and is valued for its distinctive flavor.

As living standards rise, consumers increasingly demand high-quality fresh meat, particularly red meat, with quality being influenced by factors such as appearance, taste, tenderness, color, pH value, and water content (Wang et al., 2024).

Individual animal characteristics, nutrition, and genetics contribute to the diversity of muscle fibers in livestock. Well-nourished animals generally develop thicker and more robust muscles compared to undernourished ones.

Muscle structure also depends on the manner in which the animal is used during its lifetime: working muscles tend to be firmer and coarser, whereas the muscles of stall-raised animals are softer, more tender, and larger. The size of muscle bundles and fibers depends on multiple factors shaping muscle morphology, which directly affects the quality of meat as a raw material (Rahelić, 1978).

Wang et al. (2024) further emphasize that genetic factors can rapidly and effectively alter the proportion and types of muscle fibers. For this reason, a comprehensive understanding of the relationship between muscle fiber characteristics, animal growth, and meat quality requires the simultaneous consideration of all these factors (Sample B4).



**Figure 6.** Sample B4 – cross-section of muscle tissue: blue arrow indicates a blood vessel; orange line indicates connective tissue; green arrows indicate muscle bundles and fascicles (H&E,  $\times 400$ ). Copyright© A. Katica, N. Mlaćo

In the cross-section of sample B, uniform bundles and fascicles of densely packed muscle fibers are visible. Between the fascicles, the presence of elastic and collagen fibers can be observed, along with the cross-section of a blood vessel (Sample B4), which is consistent with the findings of Brooks et al. (2011).

As previously noted, proper nutrition is crucial for the growth of skeletal muscles. Postnatal food deprivation reduces both body mass and muscle mass. Nutritional restriction—particularly diets deficient in protein—reduces the diameter of muscle fibers in both animals and humans, while the total number of fibers generally remains unchanged. Only in cases of severe malnutrition does fiber loss occur.

Moderate malnutrition primarily limits fiber growth due to reduced protein intake and decreased nuclear accumulation. The early postnatal period and maternal nutrition are especially important, as nutritional deficiencies during prenatal and early postnatal development may have long-term consequences for muscle growth and meat quality (Rehfeldt et al., 1999).

**Table 4.** Changes in muscle fiber diameter of lambs depending on age and nutrition (Rahelić, 1978).

	Age (days)	Muscle diameter ( $\mu\text{m}$ )		
		<i>Long.dorsi</i>	<i>Rectus femoris</i>	<i>Gastrocnemius</i>
Normally fed animals	0	9,0	10,4	10,9
	60	31,7	33,8	35,8
	290	48,2	49,5	45,5
Poorly fed animals	0	7,3	8,3	8,7
	60	17,3	19,8	21,3
	290	35,0	36,3	39,5

## ***Conclusion***

In conclusion, the evidence presented demonstrates that genetics, nutrition, breeding practices, and proper animal care collectively shape meat quality, human diet, and ultimately human health. Attention to these factors reflects not only a pursuit of more efficient production but also a responsible attitude toward food and life. Through our histological investigation of striated skeletal muscle in beef steak samples, we aimed to microscopically illustrate the structural characteristics of high-quality consumable meat—specifically, beef steak.

***Acknowledgment:*** This research is the result of joint work between the Department of Animal Production and Biotechnology and the Department of Basic Sciences of Veterinary Medicine, University of Sarajevo – Faculty of Veterinary Medicine, under the mentorship of Prof. Dr. Emeritus Faruk Čaklović, Prof. Dr. Nadžida Mlaćo, Prof. Dr. Amela Katica, and Prof. Dr. Kenan Čaklović.

## ***References***

Brooks MA, Choi CW, Lunt DK, Miller RK, Choi CB, Smith SB. Carcass and meat characteristics and M. longissimus thoracis histology of beef from calf-fed and yearling-fed Angus steers. *The Professional Animal Scientists*. 2011;27(4):385-393.

Katica A, Mlaćo N, Hasanbašić D, Hamzić E. *Osnove veterinarske histologije*. Sarajevo: Univerzitet u Sarajevu, Veterinarski fakultet; 2010.

Mlaćo N, Katica A, Rukavina D. *Histološke osnove tkiva*. Sarajevo: Univerzitet u Sarajevu, Veterinarski fakultet; 2017.

Rahelić S. *Osnove tehnologije mesa: mišić-sastav i postmortalne promjene*. Zagreb: Školska knjiga; 1978. 236 p.

Rehfeldt C, Stickland NC, Fiedler I, Wegner J. Environmental and Genetic Factors as Sources of Variation in Skeletal Muscle Fibre Number. *Journal of Animal Science* 1999;77:1–12.

Wang Y, Zhang D, Liu Y. Research Progress on the Regulating Factors of Muscle Fiber Heterogeneity in Livestock: A Review. *Animals*. 2024;14:2225.

Vraka K. Skeletal muscle fiber types: fast vs slow-twitch [Internet]. Reviewed by Simos YV. Kenhub; 2024 Jan 18 [cited 2025 Sep 23]. Available at: <https://www.kenhub.com>

## Uticaj različitih faktora na histologiju poprečno-prugastog mišićnog tkiva

Azra BULJINA\*, Enisa ĐIKIĆ

Veterinarski fakultet, Univerzitet u Sarajevu, Bosna i Hercegovina

\*Autor za korespondenciju: Azra Buljina, [azra.buljina@student.vfs.unsa.ba](mailto:azra.buljina@student.vfs.unsa.ba)

### Sažetak

Rast i razvoj poprečno-prugastog mišićnog tkiva-skeletnih mišića kod životinja nisu važni samo za veterinarsku nauku ili proizvodnju mesa, već imaju i direktnu povezanost s ljudskom ishranom i zdravljem. Veličina i kvaliteta mišića zavise od broja i debljine mišićnih vlakana, ali i od genetike, ishrane i načina života životinje. Kada razumijemo kako se mišići razvijaju, kako različiti tipovi vlakana funkcionišu i kako prehrana utiče na njihov rast, možemo bolje shvatiti i kakvo meso dolazi na naše tanjire, ali i zašto je ono nutritivno vrijedno.

U našim istraživanjima vršili smo histološku analizu i mjerenja debljine uzdužnih presjeka mišićnih vlakana *Musculus longissimus dorsi* - biftek (B). Pravilna ishrana životinja, posebno u ranom periodu rasta, ključna je za kvalitet mesa, a time i za unos proteina i drugih važnih nutrijenata kod ljudi. Mišićna vlakna nisu samo gradivni blokovi mišića, već su i ogledalo zdravlja životinje, a posredno i našeg zdravlja. U tom smislu, briga o rastu i razvoju mišića kod životinja nije samo naučna tema – to je i način da bolje razumijemo povezanost prirode, hrane i našeg tijela.

*Ključne riječi: histologija, poprečno - prugasto mišićno tkivo*

## 1-O-2

### **Enhancing Veterinary Meat Science: A 3D and Virtual Reality Approach to Education**

Merjem HADŽIBAJRAMOVIĆ\* Anesa ANADOLAC Nedžad  
HADŽIOMEROVIĆ Faruk TANDIR Kenan ČAKLOVICA

Faculty of veterinary Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

\*Corresponding autor: Merjem Hadžibajramović,  
merjem.hadzibajramovic@student.vfs.unsa.ba

### **Abstract**

Meat classification and safety are core components of veterinary education, with important implications for public health. Accurate identification of meat and its muscle structures ensures proper inspection, quality control, and compliance with legal standards. Applying theoretical knowledge of muscle anatomy to practical meat classification remains challenging for students. This study assessed the effectiveness of three teaching methods: traditional classroom lectures, computer-based 3D models, and immersive virtual reality (VR). A digital library of 3D meat cuts, 3DMeat, was developed for computer and VR use. Results showed that interactive methods significantly increased student engagement: 3D models led to highest immediate test scores, while VR participants achieved superior medium-term knowledge retention. These findings demonstrate the potential of digital technologies and VR to enhance veterinary education while providing insights relevant to human nutrition and food safety.

*Keywords: Meat classification, Veterinary education, Food safety, 3D models, Virtual reality*

### **Introduction**

Graduates of veterinary medicine are expected to possess essential knowledge and skills to ensure food safety, public health, and quality control. Veterinarians play a crucial role in preventing and controlling pathogen transmission through meat (EAEVE, 2019; McKenzie, Hathaway, 2006). During the practical course *Hygiene and Technology of Meat and Meat Products*, students learn post-mortem inspection, meat authenticity, processing, and recognition of non-meat additives (Ballin, 2010).



One ongoing challenge in veterinary education is the accurate identification of individual muscles in meat cuts. This is partly due to the time gap between anatomy courses (usually early semesters) and meat science courses (later semesters), which makes practical application difficult (Kapoor, Singh, 2022). The increasing incidence of meat fraud raises concerns for public health and the food industry (Sezer, Bjelak, Velioglu, Hakkı Boyacı, 2022). Technologies such as augmented reality (AR), VR, and 3D models have become increasingly integrated into veterinary education, especially after the COVID-19 pandemic (Hadžiomerović, Hadžiomerović, Avdić, et al. Students, 2023; DeBose, 2020). VR provides an immersive experience that can enhance knowledge retention, clinical reasoning, and student satisfaction (Padilha, Machado, Ribeiro, Ramos, Costa, 2019; Garcia-Ara, Sandoval-Barron, Seguino, 2023). While VR is widely used in anatomy teaching and procedural simulations, its application to detailed meat cut identification remains limited. This study explores the potential of 3D and VR learning to improve veterinary students' competence in meat classification.

### ***Experimental***

*3D Scanning and Digital Library:* Real meat cuts were scanned using the Einscan Pro 2X scanner, capturing detailed shapes and textures. Files were converted to OBJ format and uploaded to Sketchfab under the *3DMeat* collection, annotated with cut names, muscles, categories, and anatomical origins.

*Virtual Reality Environment:* Students interacted with meat cuts in VR using HTC Vive Pro 2 and Open Brush VR software, arranged circularly with interactive information panels.

*Study Design:* Fourth-year veterinary students were divided into three groups: classroom lectures ( $n \approx 8$ ), 3D model computer learning ( $n \approx 8$ ), and immersive VR ( $n \approx 9$ ). Sessions lasted 45 minutes for classroom/computer groups and 10 minutes per student for VR.

*Assessment:* Knowledge was tested immediately and two weeks post-session using a 20-question multiple-choice test, validated by experts.

### ***Results and discussion***

Immediate post-session tests showed highest scores for the 3D models group (mean  $\approx 16.4$ ), followed by classroom ( $\approx 15.6$ ), with VR lowest ( $\approx 11.7$ ) but with highest variability. Two weeks later, retention was highest in the VR group ( $\approx 99\%$ ), followed by 3D models ( $\approx 78.5\%$ ) and classroom ( $\approx 77.6\%$ ). Boxplots indicated large effect sizes between groups despite  $p > 0.05$ . The VR group's consistent retention supports evidence that immersive environments

improve medium-term memory for visual-spatial content (Garcia-Ara et al; Liu, Wang, Koszalka, Wan, 2022; Hadžimerović, Šunje-Rizvan, Maksimović, Šatrović, Tandır, 2025; Arif, 2021).

Self-directed learning with 3D models enhances immediate understanding, while immersive VR promotes long-term retention, even if initial scores are lower. These findings align with previous research demonstrating VR's benefits for learning anatomy and procedural skills (Kapoor et al; Padilha et al; Garcia-Ara et al; Liu et al). Traditional lectures remain effective but are enhanced when complemented with interactive digital tools. VR also reduces student stress and anxiety in complex tasks, offering a safe environment to explore anatomy without real-world risks (Bell, Baillie, Kinnison, 2010; Hadžimerović et al).

### ***Conclusion***

Combining traditional teaching with 3D models and immersive VR offers a promising strategy for veterinary education. 3D models provide detailed visual representation enhancing comprehension, while VR fosters long-term retention and engagement. Integrating these technologies supports practical skills relevant to meat safety, quality control, and broader implications for public health and human nutrition. Future research should explore longer VR sessions, collaborative learning, and application to clinical reasoning.

***Author Contributions:*** Conceptualization, M.H., A.A., N.H., F.T., K.Č.; methodology: M.H., A.A.; investigation: M.H., A.A.; writing—original draft preparation: M.H., A.A.; writing—review and editing: M.H., A.A.; visualization: M.H., A.A.; supervision: N.H.; All authors have read and agreed to the published version of the proceeding.

***Funding:*** This research was funded by a grant from the Sarajevo Canton Ministry for Sciences, Higher Education and Youth for 2024, number 27-02-35-33087-38/24.

***Acknowledgments:*** We thank Professors N.H., F.T., K.Č. and assistants Fazlović, Dučić, and Vejzović for guidance, and all participating students for their engagement.

***Conflicts of Interest:*** The authors declare no conflicts of interest.

### ***References***

Arif F. Application of Virtual Reality for Infrastructure Management Education in Civil Engineering. *Educ. Inf. Technol.* (2021) 26:3607–3627. doi:10.1007/s10639-021-10429-y

Ballin NZ. Authentication of meat and meat products. *Meat Sci.* (2010) 86:577-87. doi:10.1016/j.meatsci.2010.06.001

Bell C, Baillie S, Kinnison T, Cavers A. Preparing veterinary students for extramural clinical placement training: issues identified and a possible solution. *J Vet Med Educ.* (2010) 37:190-7. doi:10.3138/jvme.37.2.190

DeBose K. Virtual Anatomy: expanding veterinary student learning. *J Med Libr Assoc.* (2020) 108:647-8. doi:10.5195/jmla.2020.1057

EAEVE. List of subjects and Day One Competences. (2019). [https://www.eaeve.org/fileadmin/downloads/eccvt/List\\_of\\_subjects\\_and\\_Day\\_One\\_Competences\\_approved\\_on\\_17\\_January\\_2019.pdf](https://www.eaeve.org/fileadmin/downloads/eccvt/List_of_subjects_and_Day_One_Competences_approved_on_17_January_2019.pdf)

Garcia-Ara A, Sandoval-Barron E, Seguino A. Survey of students' learning experience using a virtual slaughterhouse simulator in three UK veterinary schools during the COVID-19 pandemic. *Vet Rec.* (2023) 193:e3307. doi:10.1002/vetr.3307

Hadžiomerović N, Hadžiomerović AI, Avdić R, et al. Students' performance in teaching neuroanatomy using traditional and technology-based methods. *Anat Histol Embryol.* (2023) 52:115-22. doi:10.1111/ahe.12876

Hadžiomerović N, Šunje-Rizvan A, Maksimović A, Šatrović L, Tandir F. Use of 3D printed low-cost models for veterinary clinical skills training. *Open Vet J.* (2025) 15:863-70. doi:10.5455/OVJ.2025.v15.i2.35

Hunt JA, Heydenburg M, Anderson SL, Thompson RR. Does virtual reality training improve veterinary students' first canine surgical performance? *Vet Rec.* (2020) 186:562. doi:10.1136/vr.105749

Kapoor K, Singh A. Veterinary anatomy teaching from real to virtual reality: An unprecedented shift during COVID-19 in socially distant era. *Anat Histol Embryol.* (2022) 51:163-69. doi:10.1111/ahe.12783

Liu R, Wang L, Koszalka TA, Wan K. Effects of immersive virtual reality classrooms on students' academic achievement, motivation and cognitive load in science lessons. *J. Comput. Assist. Learn.* (2022) 38:1422-1433. doi:10.1111/jcal.12688

McKenzie AI, Hathaway SC. The role and functionality of Veterinary Services in food safety throughout the food chain. *Rev Sci Tech.* (2006) 25:837-48

Padilha JM, Machado PP, Ribeiro A, Ramos J, Costa P. Clinical Virtual Simulation in Nursing Education: Randomized Controlled Trial. *J Med Internet Res.* (2019) 21:e11529. doi:10.2196/11529

Piovesan SD, Passerino LM, Pereira AS. Virtual Reality as a Tool in the Education. In Proceedings of the IADIS International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2012); 2012 19–21 October; Madrid, Spain, pp. 295–8

Sezer B, Bjelak A, Murat Velioglu H, Hakkı Boyacı I. Identification of meat species in processed meat products by using protein based laser induced breakdown spectroscopy assay. Food Chem. (2022) 372:131245. doi:10.1016/j.foodchem.2021.131245

### **Unapređenje veterinarske nauke o mesu: Pristup obrazovanju pomoću 3D tehnologije i virtuelne stvarnosti**

Merjem HADŽIBAJRAMOVIĆ\* Anesa ANADOLAC Nedžad  
HADŽIOMEROVIĆ Faruk TANDIR Kenan ČAKLOVICA

Veterinarski fakultet Univerziteta u Sarajevu, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Merjem Hadžibajramović,  
merjem.hadzibajramovic@student.vfs.unsa.ba

### **Sažetak**

Klasifikacija mesa i sigurnost hrane su ključni elementi veterinarske edukacije, sa značajnim implikacijama za javno zdravlje i ljudsku ishranu. Precizno prepoznavanje mesa i razumijevanje njegove mišićne strukture omogućavaju pravilnu inspekciju, kontrolu kvaliteta i usklađenost sa zakonskim standardima. Studenti veterine često imaju poteškoća u primjeni teorijskog znanja o mišićnoj anatomiji na praktičnu klasifikaciju mesa. Cilj ovog istraživanja bio je ispitati kako različite metode nastave utiču na učenje i angažman studenata. Upoređivali smo tradicionalne predavanja i prezentacije u učionici, računalno učenje uz 3D modele i imerzivne simulacije u virtualnoj stvarnosti (VR). Razvijena je digitalna biblioteka 3D modela rezova mesa, “3DMeat”, koja je korištena i u računalnoj i u VR grupi. Naši rezultati pokazali su da interaktivne metode značajno povećavaju interes i razumijevanje studenata za kompleksne teme: 3D modeli su doveli do najviših rezultata na neposrednom testu, dok su učesnici u VR grupi pokazali najbolju zadržanost znanja u srednjem periodu. Ovi nalazi naglašavaju potencijal digitalnih tehnologija i VR-a za unapređenje veterinarske edukacije i sigurnosti hrane u širem društvenom kontekstu.

## **Mare and Donkey Milk: From Tradition to Regulatory Oversight**

Katarina PAJIĆ

University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine, Novi Sad, Serbia

Corresponding author: Katarina Pajić, katarina.cobanov20@gmail.com

### **Abstract**

Demand for healthy, alternative dairy products is continuously rising. Mare and donkey milk, traditionally used for centuries, have gained renewed interest due to their similarity to human milk in composition, hypoallergenic potential, and beneficial health effects. Despite promising nutritional properties, equid milk is mainly consumed raw, which carries hygienic risks and challenges for safety control. In the EU, sale of raw milk is regulated by EC 853/2004, which defines microbiological criteria for milk of other species, while in Serbia the Rulebook on Raw Milk Quality (2017) includes equid milk under 'other domestic animals' without prescribing specific somatic cell thresholds. These gaps create uncertainty for producers and consumers. This study reviews the current regulatory framework for mare and donkey milk in Serbia and the EU, highlights the challenges arising from undefined parameters, and stresses the need for harmonization and clearer standards.

*Keywords: mare milk, donkey milk, raw milk consumption, food safety, regulation*

### **Introduction**

Mare's (*Equus caballus*) and donkey's (*Equus asinus*) milk have been valued in human nutrition and medicine for centuries, with documented use dating back to ancient times. In Asian countries, particularly Mongolia and Russia, the fermented product kumis has traditionally been consumed both as part of the daily diet and for its therapeutic properties (Shaikh et al., 2022). Based on their chemical composition, these two types of milk are most similar to human milk and represent a potential alternative for infants and children with cow's milk protein allergy (Pieszka et al., 2016; Deng et al., 2022). Their nutritional profile, characterized by low fat content and a favorable protein fraction dominated by whey proteins, further supports their classification as functional foods with potential health benefits (Tratnik and Božanić, 2012).

Despite these promising characteristics, the production and commercialization of raw mare's and donkey's milk present multiple challenges. These include low milk yield, the need for frequent milking, and most importantly, a lack of clearly defined and standardized regulatory parameters for quality and safety, both at the national and international level (Pajić et al., 2025).

Therefore, the aim of this study is to provide an overview of regulations and standards governing the quality and safety of mare's and donkey's milk in Serbia and the European Union, with special emphasis on challenges and inconsistencies in the current legislative framework.

### ***Experimental***

For the purposes of this study, an analysis of available literature was carried out, including scientific articles, review papers, European Union regulations, and current national rulebooks in the Republic of Serbia. Publications in both English and Serbian were included, focusing on the nutritional properties, hygienic safety, and legal framework for mare's and donkey's milk.

### ***Results and Discussion***

EU Regulation (EC 853/2004) permits the sale of raw milk from other domestic animals provided that the total microbial count at 30 °C does not exceed 1,500,000 cfu/mL, calculated as the geometric mean over a two-month period with at least two samples per month. However, there are no specific provisions for somatic cell counts in mare or donkey milk (EC, 853/2004).

In Serbia, the 2017 Regulation on the Quality of Raw Milk included these types of milk for the first time: Based on the results of raw milk quality testing in an authorized laboratory, goat, sheep and raw milk from other domestic animals, depending on the total number of microorganisms, is classified into: Class I milk - contains up to 1,500,000 cfu/mL; Class II milk - contains more than 1,500,000 cfu/mL.

Limits were defined only based on total microbial counts, while values for somatic cell counts were not established (Serbian National Regulation on the Quality of raw milk, 2017). This situation creates a legal gap, as producers and consumers lack clear standards for assessing quality and safety. In contrast to cow's milk, which has well-defined parameters and standards, producers of mare and donkey milk rely on internal production specifications or general scientific knowledge. This opens the possibility for uneven product quality, as well as potential public health risks when the milk is consumed raw (Pajić et al., 2025).

Research indicates that hygiene practices, such as proper milking techniques and rapid cooling of milk, are critical to maintaining microbial safety in equid milk (Shaikh et al., 2022; Ragona et al., 2015). These studies emphasize that current EU regulations do not provide specific microbial thresholds for mare or donkey milk, highlighting the need for species-specific regulatory updates.

Although research data indicate that when appropriate hygiene practices are followed during milking and handling, mare and donkey milk can achieve good microbiological quality comparable to milk from other species (Bogdanović et al., 2025), but the absence of clear regulations constitutes a barrier to the commercialization of these products. Moreover, studies point out that inconsistencies between EU and national regulations, and the lack of somatic cell guidelines, may limit market expansion and affect consumer confidence (Ragona et al., 2015; Plotuna et al., 2025). Harmonization with EU standards and the definition of threshold values for quality and safety parameters are essential steps for the development of this sector.

## ***Conclusion***

Mare and donkey milk possess significant nutritional and therapeutic potential; however, the legal framework regulating their quality and safety remains insufficiently developed. In both the EU and Serbia, clearly defined criteria for all quality parameters are lacking, posing challenges for producers and consumers. Particularly, the absence of specific somatic cell thresholds prevents accurate monitoring of udder health, while reliance solely on total microbial counts may not fully reflect milk quality or hygienic safety. Research indicates that good hygienic practices during milking and handling can result in safe and high-quality milk, highlighting the importance of standardized hygiene protocols. Further research and harmonization of regulations with EU standards are necessary to enable safer and broader utilization of these products. Establishing comprehensive regulatory standards, including microbial and somatic cell criteria, will be essential for consistent product quality, enhanced consumer safety, and sustainable development of the mare and donkey milk sector.

***Funding:*** This work was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No. 451-03-137/2025-03/200117 and Contract No. 451-03-136/2025-03/200143).

***Informed Consent Statement:*** Not applicable.

**Acknowledgments:** A special thanks to Prof. Dr. Marija Pajić and Prof. Dr. Radoslava Savić Radovanović for her guidance and support during this study.

**Conflicts of Interest:** The author declares no conflicts of interest.

## **References**

Bogdanović, M., Ivanov, S., Pajić, K., Kureljušić, J., Pajić, M., Trailović, R., Savić Radovanović, R. (2025). Uporedna analiza mleka ekvida. Peti regionalni simpozijum Zaštita agrobiodiverziteta i očuvanje autohtonih rasa domaćih životinja, Dimitrovgrad, 19-21. jun 2025, 125-133.

Deng, L., Yang, Y., Li, Z., Li, J., Zhu, Y., Meng, Q., Liu, J., Wang, X. (2022): Impact of different dietary regimens on the lipidomic profile of mare's milk. Food Research International 156, 111305. <https://doi.org/10.1016/j.foodres.2022.111305>

EC, Regulation No 853/2004 of the European Parliament and of the council of 29 April 2004 laying down specific hygiene rules for food of animal origin. Official Journal of the European Union, 2004.

Pajić, M., Pajić, K., Čobanović, K., Savić Radovanović, R. (2025): Kobilje i magareće mleko-propisi i standardi. Simpozijum Mikrobiologija hrane-Izazovi i prilike, 15. maj 2025, Novi Sad, 32-33.

Pieszka, M., Łuszczynski, J., Zamachowska, M., Augustyn, R., Długosz, B., Hędrzak, M. (2016): Is mare milk an appropriate food for people?—a review. Annals of Animal Science 16 (1), 33-51. <https://doi.org/10.1515/aoas-2015-0041>

Plotuna, A., Hotea, I., Ban-Cucerzan, A., Badea, C., Mladin, A., Tîrziu, E. (2025): The microbial landscape of donkey milk: a systematic review. Romanian Journal of Veterinary Sciences. 58. 309-318. <https://doi.org/10.59463/rjvs.2025.2.17>

Pravilnik o kvalitetu sirovog mleka. Službeni Glasnik RS br. 106/17. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/ministarstva/pravilnik/2017/106/3>

Ragona, G., Lombardo, A., Piazza, A., Paladini, I., Brocherel, G., Casati, D. Corrias, F., Brajon, G. (2015): Hygiene and animal health requirements for donkey milk production. <https://doi.org/10.13140/RG.2.2.12649.54889>

Shaikh, A., Mehta, B. M., Jana, A. H. (2022): Chemistry, nutritional properties and application of Mare's milk: A review. Agricultural Reviews 43 (3), 355-361. <https://doi.org/10.18805/ag.R-2232>



Tratnik, L., Božanić, R. (2012): Mlijeko i mliječni proizvodi. Hrvatska mljekarska udruga, Zagreb.

## **Kobilje i magareće mleko: od tradicije do regulatornog nadzora**

Katarina PAJIĆ

Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za veterinarsku medicinu,  
Novi Sad, Srbija

Auttor za korespondenciju: Katarina Pajić, katarina.cobanov20@gmail.com

### **Sažetak**

Potražnja za zdravim, alternativnim mlečnim proizvodima kontinuirano raste. Kobilje i magareće mleko, tradicionalno korišćeno vekovima, ponovo je privuklo pažnju zbog svoje sličnosti sa ljudskim mlekom u sastavu, povoljnijim efektima po zdravlje, te potencijalu da izazove manje alergijskih reakcija. Uprkos obećavajućim nutritivnim svojstvima, mleko ekvida se uglavnom konzumira sirovo, što nosi higijenske rizike i izazove u kontroli bezbednosti. U EU, prodaja sirovog mleka reguliše se regulativom EC 853/2004, koja definiše mikrobiološke kriterijume za mleko drugih vrsta životinja, dok Pravilnik o kvalitetu sirovog mleka u Srbiji (2017) obuhvata mleko ekvida pod kategorijom „ostalih domaćih životinja“, bez propisivanja specifičnih granica za somatske ćelije. Ove praznine stvaraju nesigurnost za proizvođače i potrošače. Ova studija daje pregled aktuelnog regulatornog okvira za kobilje i magareće mleko u Srbiji i EU, ističe izazove koji proizlaze iz neodređenih parametara i naglašava potrebu za harmonizacijom i jasnijim standardima.

*Ključne reči: kobilje mleko, magareće mleko, konzumacija sirovog mleka, bezbednost hrane, regulativa*

## **Cattle Welfare and Food Quality: Connections and Legislative Framework in Serbia and the EU**

Ognjen SEKULIĆ

Department of Veterinary Medicine, Faculty of Agriculture, University of Novi Sad, Novi Sad, Serbia

\*Corresponding author: Ognjen Sekulić, email: ognjensekulic.vet.polj@gmail.com

### **Abstract**

The aim of this study was to examine the relationship between cattle welfare (*Bos taurus*) and the quality of animal-derived food, as well as to analyse differences between the legislative frameworks in Serbia and the European Union. Stress, inadequate nutrition, and suboptimal housing conditions were found to negatively affect yield, nutritional composition, and the safety of milk and meat, while provision of appropriate housing and feeding contributed to improved animal health, reduced use of medications, and higher-quality products. Legislative analysis revealed that Serbia possesses a basic legal framework through the Animal Welfare Act, but, compared to the EU, lacks detail and consistent implementation, particularly in transport and slaughter regulations. Conversely, the EU enforces minimum standards and specialised directives for specific cattle categories with systematic monitoring. Survey results indicate that farmers generally maintain livestock in free housing systems but rarely provide pasture access, follow veterinary guidance, and implement balanced nutrition. In conclusion, enhancing cattle welfare is crucial not only ethically, but also economically and for food safety, leading to higher-quality products and increased market competitiveness. Aligning Serbian legislation with EU standards represents a necessary step toward improved welfare and food safety.

*Keywords: cattle welfare, food quality, legislation, Serbia, European Union*

### **Introduction**

Cattle welfare represents a cornerstone of modern livestock production and an essential prerequisite for obtaining high-quality animal products. Increasing evidence indicates that milk and meat quality is influenced not only by genetics or processing technology but also by the conditions in which animals are raised. Meeting the animals' needs for feed, space, care, and

protection from stress positively affects their health, productivity, and the nutritional composition of products reaching the market (Voogt et al., 2023). Conversely, poor housing conditions and neglect of welfare principles can result in reduced yield, lower organoleptic quality, and food safety risks (Sandøe et al., 2023). Beyond ethical and health considerations, cattle welfare has become a market issue, as consumers increasingly consider the origin and production conditions of food products (Tammenlehto & Koskela, 2025). This study examines the relationship between cattle welfare and food quality, as well as legislative differences between Serbia and the European Union. Cattle welfare encompasses physical health, mental state, and the ability to express natural behaviours. Its improvement contributes to enhanced productivity and superior food quality (Nielsen, 2023).

## ***Experimental***

### **Survey Methodology**

A structured survey was conducted among cattle farmers in Serbia to assess current welfare practices and perceptions regarding legislation. The survey included 50 respondents from diverse regions, covering both dairy and beef production systems. Farmers were asked about housing systems, pasture access, veterinary care, feeding regimes, and awareness of animal welfare legislation. Responses were analysed quantitatively to identify trends and assess alignment with legislative standards.

### **Legislative Review**

The study involved a detailed comparative analysis of Serbian and EU legislation. Serbian legal sources included the Animal Welfare Act (2009) and relevant bylaws. EU legislation reviewed comprised Council Directives 98/58/EC and 2008/119/EC, as well as Regulation (EC) No 1/2005 on transport and Council guidelines on slaughter. Differences in specificity, implementation, and monitoring mechanisms were evaluated.

## ***Results and Discussion***

### **Impact of Stress on Milk and Meat**

Stress is a key factor linking welfare and food quality. In dairy cows, stress reduces milk yield, decreases fat and protein content, and increases somatic cell count, indicating inflammatory conditions such as mastitis, resulting in lower technological quality (Nielsen, 2023). For beef cattle, pre-slaughter

stress accelerates glycogen depletion in muscles, impairing meat maturation and leading to darker, firmer meat with a shorter shelf life (EFSA, 2022).

### **Nutrition and Nutritional Quality**

Balanced nutrition directly influences product composition. Animals receiving adequate energy, protein, vitamins, and minerals produce milk with stable chemical composition. Pasture access or omega-3 enriched feed improves fatty acid profiles, beneficial for human consumption (Danyer et al., 2024). Inadequate diets can lead to metabolic disorders and inferior product quality (Nielsen, 2025).

### **Housing and Behaviour**

Housing conditions impact health and behaviour. Overcrowded or unhygienic facilities increase disease risk and reduce productivity. Optimal housing includes clean, dry bedding, adequate ventilation, freedom of movement, and access to clean water (Voogt et al., 2023). Pasture-raised cows produce milk with higher antioxidant and conjugated linoleic acid (CLA) content, positively affecting human nutrition (Nielsen, 2023).

### **Health Status and Medication Use**

Compromised welfare increases disease incidence and antibiotic usage, raising the risk of residues and antimicrobial resistance. Systematic welfare management reduces medication needs, enhancing product safety and quality (Sandøe et al., 2023).

### **Consumer Perception and Market**

Increasing numbers of consumers demand organic, high-quality products. Welfare-conscious production can command higher prices and improve market access (Ethical Appetite, 2025).

### **Legislative Framework in Serbia**

Serbia's Animal Welfare Act (2009) sets general guidelines on housing, feeding, veterinary care, and protection from pain and stress ("Službeni glasnik RS", 41/2009). Implementation challenges persist due to limited inspectorate capacity and farmer education (Voogt et al., 2023).

### **Legislative Framework in the EU**

EU legislation includes general standards (Council Directive 98/58/EC) and species-specific directives (2008/119/EC for calves). Transport and slaughter are regulated by Regulation (EC) No 1/2005. Enforcement involves systematic inspections and compliance reporting, essential for market access (Sandøe et al., 2023).

### **Comparative Analysis: Serbia vs EU**

Detail of Legislation: EU provides detailed directives; Serbia relies on a general law.

Implementation: EU conducts systematic monitoring; Serbia faces inspectorate capacity constraints.

Transport and Slaughter: EU regulations are precise; Serbia regulates these within broader laws.

Alignment Efforts: Serbia is gradually harmonising its laws with EU standards.

### **Survey Results**

Survey findings show that most Serbian farmers maintain cattle in free housing systems but rarely provide pasture. Veterinary care is primarily preventive, with medications administered only by veterinarians. Nutrition is balanced in approximately 90% of farms. Farmers demonstrated partial awareness of welfare concepts and legislation, recognising Serbia's lag behind EU standards. Major barriers include production costs and market limitations, yet they acknowledge potential long-term benefits for animal health, product quality, and economic sustainability.

### **Conclusion**

Cattle welfare is a fundamental prerequisite for producing high-quality, safe animal-derived food. Poor housing, stress, and inadequate care negatively affect productivity, nutritional composition, and organoleptic properties. Proper housing, nutrition, and veterinary care enhance animal health, reduce medication reliance, and improve product quality.

Serbia has a foundational legal framework but lacks detailed regulations and consistent implementation compared to the EU. Aligning Serbian legislation with EU standards is crucial for welfare improvement and international market competitiveness. Survey data highlight current practices and challenges, indicating a need for farmer education and regulatory support.

**Author Contributions:** Conceptualization; methodology; investigation; writing—original draft preparation; writing—review and editing; visualization: Ognjen Sekulić; supervision: Prof. Marija Pajić.

**Funding:** This work did not receive funding.

**Acknowledgments:** The author expresses great gratitude to the local farmers for their participation in the research.

**Conflicts of Interest:** The author declares no conflicts of interest.

## References

- Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. *Official Journal of the European Communities*, L221, 23–27. Retrieved from EUR-Lex
- Council Directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves. *Official Journal of the European Union*, L10, 7–13. Retrieved from EUR-Lex
- Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations. *Official Journal of the European Union*, L3, 1–44. Retrieved from EUR-Lex
- Animal Welfare Act. (“Zakon o dobrobiti žvotinja”, *Službeni glasnik RS*, br. 41/2009). Retrieved from Paragraf.rs
- Danyer, I. A., Smith, L. J., & Rodríguez, P. M. (2024). *State of the art of the cow-calf systems in beef and dairy production*. *Journal of Animal Science*, 102(5), 1452–1467. <https://doi.org/10.xxxx/jas.2024.102.1452>
- EFSA Panel on Animal Health and Welfare (AHAW). (2022). *Scientific opinion on cattle transport and welfare*. *EFSA Journal*, 20(6), e07212. <https://doi.org/10.2903/j.efsa.2022.7212>
- Ethical Appetite. (2025). *Consumer preferences and price premiums for animal welfare-friendly food products*. *arXiv preprint*, arXiv:2501.08456. Retrieved from <https://arxiv.org/abs/2501.08456>
- Nielsen, S. S. (2023). *Welfare of dairy cows: Current challenges and future directions*. *CAB Reviews*, 18(045), 1–15. <https://doi.org/10.1079/PAVSNNR202318045>
- Nielsen, S. S. (2025). *Welfare of beef cattle: A review*. *CAB Reviews*, 20(012), 1–14. <https://doi.org/10.1079/PAVSNNR202520012>
- Sandøe, P., Nielsen, B. L., & Forkman, B. (2023). *Dairy cattle welfare – The relative effect of legislation and management practices*. *Animal Welfare*, 32(3), 275–289. <https://doi.org/10.7120/09627286.32.3.275>
- Tammenlehto, L., & Koskela, T. (2025). *Food safety vs. animal welfare – Does the moral status of animals really matter?* *Food Ethics*, 10(1), 18–31. <https://doi.org/10.1007/s41055-025-00145-8>

Voogt, A. M., Wemelsfelder, F., & de Jong, I. C. (2023). *From the Five Freedoms to a more holistic perspective on animal welfare*. *Frontiers in Animal Science*, 4, 1197842. <https://doi.org/10.3389/fanim.2023.1197842>

## **Dobrobit goveda i kvalitet hrane: povezanost i zakonodavni okvir u Srbiji i EU**

Ognjen SEKULIĆ

Poljoprivredni fakultet, Univerzitet u Novom Sadu, Departman za veterinarsku medicinu,  
Novi Sad, Srbija

Autor za korespondenciju: Ognjen Sekulić, e-mail: ognjensekulic.vet.polj@gmail.com

### **Sažetak**

Cilj ovog istraživanja bio je da se ispita povezanost dobrobiti goveda (*Bos taurus*) sa kvalitetom hrane životinjskog porekla, kao i da se analiziraju razlike između zakonodavnog okvira u Srbiji i Evropskoj uniji. Utvrđeno je da stres, neadekvatna ishrana i nepovoljni uslovi smeštaja negativno utiču na prinos, nutritivni sastav i bezbednost mleka i mesa, dok obezbeđivanje optimalnih uslova držanja i ishrane doprinosi boljem zdravstvenom statusu životinja, smanjenoj upotrebi lekova i proizvodima višeg kvaliteta. Analizom zakonodavstva pokazano je da Srbija poseduje osnovni pravni okvir kroz Zakon o dobrobiti životinja, ali da u poređenju sa EU nedostaje detaljnost i dosledna primena, naročito u oblastima transporta i klanja. EU propisuje minimalne standarde i specijalizovane direktive za pojedine kategorije goveda uz sistematsku kontrolu. Rezultati ankete sprovedene među farmerima pokazuju da većina gaji stoku u slobodnom sistemu, ali retko obezbeđuje ispašu; veterinarska nega se sprovodi planski, dok se lekovi daju isključivo po preporuci veterinara. Zaključeno je da unapređenje dobrobiti goveda ima ključni etički, ekonomski i zdravstveni značaj, dovodi do kvalitetnije hrane i povećava konkurentnost na tržištu. Usklađivanje srpskog zakonodavstva sa standardima EU predstavlja neophodan korak ka poboljšanju dobrobiti i bezbednosti hrane.

*Ključne reči: dobrobit goveda, kvalitet hrane, zakon, Srbija, Evropska unija*





2. TOKSIKOLOGIJA I SIGURNOST HRANE I OKOLIŠA  
FOOD AND ENVIRONMENT TOXICOLOGY AND SAFETY



## Determining the Presence of Coagulase-positive *Staphylococcus aureus* in Samples of Ready Cold Meals and Sauces Served in the Sarajevo Area

Vedad AHMESPAHIĆ<sup>1\*</sup> Enida ČLANJAK-KUDRA<sup>2</sup> Velma REBIĆ<sup>1</sup>

<sup>1</sup>Medical Faculty of the University of Sarajevo, Sarajevo, Bosnia and Herzegovina

<sup>2</sup>Veterinary Faculty of the University of Sarajevo, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Vedad Ahmespahić, vedad.ahmespahic18442-21@mf.unsa.ba

### Abstract

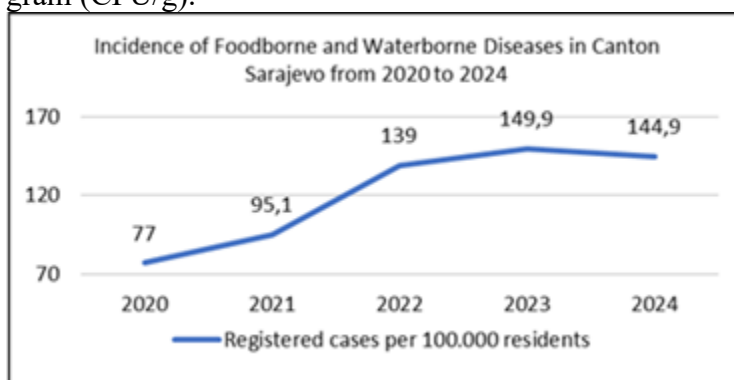
Alimentary intoxications and toxoinfections are becoming an increasing burden on the medical system globally. This problem is also present in the Canton Sarajevo of Bosnia and Herzegovina. This work aims to assess the existence of *Staphylococcus aureus*, as one of the most abundant pathogens that causes these diseases, in cold meals and sauces served in restaurants in Sarajevo. The samples were gathered from a self-service establishment on four separate occasions and examined for presence of coagulase-positive staphylococci. The results of the analysis showed that none of the samples had any traces of coagulase-positive *S. aureus* contamination (<10 CFU/g), which corresponds to the results of similar relevant studies done in this area. The results of this research can not prove that there is a significant colonisation of *S. aureus* in the cold foods and sauces served in the open in restaurants in Sarajevo.

**Keywords:** *Staphylococcus aureus*, contamination, intoxication, restaurant

### Introduction

Alimentary intoxications and toxoinfections are a group of infectious diseases of the gastrointestinal system caused by infective agents and their specific toxins respectively, which are ingested through consumption of contaminated food or water (Baljić, 2022). They present a serious healthcare problem, as indicated by the World Health Organisation (WHO) reports, which estimate 600 million cases and 420,000 deaths caused by foodborne diseases yearly (WHO, 2025). According to data from the Institute of Public Health of the Federation of Bosnia and Herzegovina (ZZJZ FBiH), there has been an increase in the incidence of foodborne and waterborne diseases in Canton Sarajevo over a five-year period (Figure 1). The goal of this work is

to explore one potential pathogen that can cause this increase—*Staphylococcus aureus*. This bacterium secretes a thermostable enterotoxin, which causes onset of vomiting and diarrhoea 1–6 hours after ingestion. This pathogen is most commonly found in potato salads, mayonnaise-based sauces and dressings, heated meats etc. (Kasper, Braunwald, Fauci, et al., 2005). Since cases of *S. aureus* are usually not reported (except for the cases of resistant species) or tested for in food poisoning, it is unknown how widely spread the infections are. However, considering the bacterias prevalence on human skin, its existence in samples of widely consumed foods can point to a conclusion that a significant number of food poisoning cases with unisolated pathogens are caused by *S. aureus* and its toxin. We hypothesise that there is a significant colonisation of *S. aureus* in the cold foods and sauces served in the open in restaurants in Sarajevo. To examine this hypothesis, we tested collected samples of food for coagulase-positive *S. aureus* and expressed the results in the number of colony-forming units per gram (CFU/g).



**Figure 1.** Incidence of foodborne and waterborne diseases in Canton Sarajevo from 2020 to 2024 (Data from the Institute of Public Health of the Federation of Bosnia and Herzegovina <https://www.zzjzfbih.ba/knjiznica/biblioteka/publikacije/godisnji-epidemioloski-bilteni/>)

## Experimental

The samples were gathered from restaurants in Sarajevo which served their food in the open. Due to the limited resources, only one establishment was tested. This establishment works on a self-service system, which makes it easier for the pathogen to spread, not just from staff to customers, but also between customers. To increase the relevancy of the results, the samples were taken on four separate occasions, with three-day gaps between samplings (Table 1). The selected samples were of cold ready meals and sauces because the samples were tested on the presence of the pathogen, which is heat sensitive. The samples were taken using the utensils and containers provided by the restaurant, in order to simulate the customers'

interaction with the food as closely as possible. The samples were kept at the temperature of -19°C before being transported to the laboratory for analysis. Preparation of the initial suspension and dilutions of the samples was carried out according to the BAS ISO 6887-1:2018, and BAS ISO 6888-1:2023 for microbiological examinations of coagulase-positive staphylococci.

**Table 1.** Samples gathered from the examined location

Sample number	Sampling day	Sample
1	Day 1	Ranch dressing
2		Caesar dressing
3		Onion salad
4		Long island dressing
5	Day 2	Long island dressing
6		Ranch dressing
7		Onion dressing
8		BBQ sauce
9		Hot sauce
10	Day 3	Long island dressing
11		Ranch dressing
12		BBQ sauce
13		Hot sauce
14		Ketchup
15	Day 4	Hot sauce
16		Long island dressing
17		Onion dressing
18		Yoghurt dressing
19		Yoghurt dressing

## Results and Discussion

The results of the analysis show that none of the samples had any traces of coagulase-positive *S. aureus* contamination (<10 CFU/g). These results show that there are no living specimen of *S. aureus* present in the examined samples. This, however, does not eliminate the possibility that enterotoxin is present in the samples. This fact is relevant because the toxin itself can survive the digestive tract and cause intoxication (Argudín, Mendoza, Rodicio, 2010). The fact that only one location was examined can present a confounding factor for this research. However, the concept of the restaurant itself promotes contamination, regardless of the measures taken by the staff themselves. Because of that, we still believe that our results hold relevancy. Our findings correspond with the results of Šegalo, Maestro, Obradović et al. (2020). They tested samples of nasal swabs from food handlers in Canton Sarajevo, and found that only 7.1% carried *S. aureus*, which they deemed a

statistically insignificant amount (Šegalo et al.). This is relevant for our research, because *S. aureus* does not compete well with indigenous microbiota in raw foods, therefore the contamination usually happens during handling (Argudín et al.). The lack of available data for the Sarajevo area makes it hard to gauge the accuracy of this experiment. However, some research has been done in the western Balkan region, as shown in a paper by Lika, Puvača, Jeremić et al from 2021., which proves the existence of *S. aureus* in all gathered samples of raw chicken meat in Vojvodina, Serbia. These results do not match our findings. Our research should be expanded to cover more and varied establishments in the Sarajevo area. Also, heated foods, especially chicken meat, should be tested for the presence of thermostable toxins, which are often by themselves causes of intoxication.

### **Conclusion**

The results from our research point to the rejection of the hypothesis that there is a significant colonisation of *S. aureus* in the cold foods and sauces served in the open in restaurants in Sarajevo. Due to the scale of the research, however, the hypothesis can not be fully dismissed. This work serves only as a basis for larger future researches, which is needed, considering the lack of data regarding this topic in the last five years. It also does not dismiss *S. aureus* as a serious healthcare problem, and the pathogen characteristics should be more examined in this area in order to help with its detection and treatment.

**Author contributions:** Conceptualization, V.A. and E.Č.-K.; methodology, E.Č.-K.; investigation, V.A.; writing—original draft preparation, V.A.; writing—review and editing, V.R.; visualization, V.A.; supervision, V.R.; All authors have read and agreed to the published version of the proceeding.

**Conflicts of Interest:** The authors declare no conflicts of interest.

### **References**

- Argudín, M.Á., Mendoza, M.C., Rodicio, M.R. (2010). Food poisoning and *Staphylococcus aureus* enterotoxins. *Toxins*; 2(7): 1751-73.
- Baljić, R. (2022). *Infektivne bolesti*. Sarajevo Publishing.
- Kasper, D.L., Braunwald, E., Fauci, A.S., Hauser, S.L., Longo, D.L., Jameson, J.L. (2005). *Harrisonov priručnik medicine*. (16th Ed.) Brad-Fin
- Lika, E., Puvača, N., Jeremić, D., Stanojević, S., Shtylla Kika, T., Cocoli, S., de Llanos Frutos, R. (2021). Antibiotic Susceptibility of *Staphylococcus* Species Isolated in Raw Chicken Meat from Retail Stores. *Antibiotics*, 10(8): 904.

Šegalo, S., Maestro, D., Obradović, Z., Jogunčić, A. (2020). Nasal carriage rate and antimicrobial resistance pattern of *Staphylococcus aureus* among the food handlers in Canton Sarajevo, Bosnia and Herzegovina. *Journal of Health Sciences*; 10(2):139-146

World Health Organisation, <https://www.who.int/>, (2025)

Zavod za javno zdravstvo FBiH, <https://www.zzjzfbih.ba>, (04/2025)

## **Utvrđivanje prisustva koagulaza-pozitivnog *Staphylococcus aureus* u uzorcima gotovih hladnih jela i soseva serviranih na području Sarajeva**

Vedad AHMESPAHIĆ<sup>1</sup>\* Enida ČLANJAK-KUDRA<sup>2</sup> Velma REBIĆ<sup>1</sup>

<sup>1</sup>Medicinski fakultet Univerziteta u Sarajevu, Sarajevo, Bosna i Hercegovina

<sup>2</sup>Veterinarski fakultet Univerziteta u Sarajevu, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Vedad Ahmespahić, vedad.ahmespahic18442-21@mf.unsa.ba

### **Sažetak**

Alimentarne intoksikacije i toksonifekcije postaju sve veći teret za zdravstveni sistem globalno. Ovaj problem je prisutan i u Kantonu Sarajevo u Bosni i Hercegovini. Ovaj rad ima za cilj da procijeni prisustvo *Staphylococcus aureus*, kao jednog od najprisutnijih patogena koji uzrokuje ove bolesti, u hladnim jelima i sosevima koji se serviraju u restoranima u Sarajevu. Uzorci su prikupljeni iz restorana samouslužnog tipa četiri puta i ispitani na prisustvo koagulaza-pozitivnih stafilocoka. Rezultati analize su pokazali da nijedan od uzoraka nije sadržavao tragove kontaminacije koaguaza-pozitivnim *S. aureusom* (<10 CFU/g), što se slaže sa rezultatima sličnih, relevantnih istraživanja na ovom području. Rezultati ovog istraživanja ne mogu dokazati da postoji signifikantna kontaminacija *S. aureusom* u hladnim jelima i sosevima serviranim na otvorenom u restoranima u Sarajevu.

*Ključne riječi: Staphylococcus aureus, kontaminacija, intoksikacija, restoran*

## **The impact of social media on food poisoning: the case of raw milk**

Elmin ALIĆ\* Lejla KRUŠKO

University of Sarajevo, Veterinary faculty, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Elmin Alić, elmin.2000@hotmail.com

### **Abstract**

The increasing popularity of raw milk consumption, particularly through social media and influencer promotion, has raised public health concerns. This review aims to analyze the influence of social media on the perception and consumption of raw milk, examining both the claims made by advocates and the associated health risks. Literature data and case examples indicate that raw milk is prone to contamination with pathogenic bacteria such as Salmonella, Listeria monocytogenes, E. coli, and Campylobacter, which can cause severe gastrointestinal and systemic illnesses. Despite alleged benefits promoted by influencers, including higher nutrient content, antimicrobial properties, and potential suitability for individuals with lactose intolerance or asthma, scientific evidence demonstrates that these claims are largely unsubstantiated or misleading. Pasteurization, including standard and ultra-high temperature treatments, effectively eliminates pathogens while preserving the majority of nutrients, providing a safer alternative for consumption. The review highlights the role of influencers and alternative communities in spreading misinformation, emphasizing the need for consumers to rely on verified sources when making dietary decisions. These findings underscore the importance of public awareness regarding the risks of raw milk and the benefits of pasteurization in preventing foodborne illnesses.

*Keywords: raw milk, pasteurization, foodborne pathogens, social media, health risks*

### **Introduction**

In recent years, raw milk has gained increasing popularity among consumers who believe it provides unique health benefits. This trend has been amplified by social media influencers and public figures who promote raw milk as a natural, superior product. Their claims often include improved nutritional value, protection against allergies and asthma, and better tolerance for individuals with lactose intolerance. However, these statements conflict with established scientific evidence. This paper aims to analyze such claims, compare raw and pasteurized milk in terms of nutritional and microbiological



characteristics, and explore the role of social media in spreading misinformation and shaping consumer behavior.

### ***Experimental***

The paper was conducted as a literature review. Scientific data were collected from publications addressing the nutritional, microbiological, and safety aspects of raw and pasteurized milk. As well as epidemiological data on foodborne illnesses linked to dairy consumption. In addition, online platforms were examined to identify the main groups of influencers and organizations promoting raw milk, their communication strategies, and the narratives they use to support its consumption. This included reviewing social media posts, online campaigns, and influencer content (Hill, 2023; Miller, 2024; Aggeler, 2024).

### ***Results and discussion***

Supporters of raw milk often argue that pasteurization reduces nutritional value by destroying vitamins, minerals, fatty acids, and proteins. In reality, nutrient losses caused by pasteurization are minimal and nutritionally insignificant. Casein, the main milk protein, is highly resistant to heat, while whey proteins are only slightly affected. The fatty acid composition remains unchanged, and some studies even suggest that digestibility is improved after pasteurization. Raw and pasteurized milk contain the same amount of lactose, meaning raw milk does not improve tolerance in lactose-intolerant individuals. Similarly, while some studies suggest a correlation between raw milk consumption and reduced incidence of asthma or allergies, no causal relationship has been established (Hill, 2023).

Raw milk is an ideal medium for bacterial growth due to its high water content, neutral pH, and abundance of nutrients. While milk is sterile in the upper udder, contamination occurs immediately after milking through contact with the udder, skin, feces, equipment, and during storage. Pathogens frequently found in raw milk include *Campylobacter*, *Salmonella*, *Escherichia coli*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Yersinia enterocolitica*, and *Coxiella burnetii*. These microorganisms can cause severe foodborne illnesses with symptoms such as vomiting, diarrhea, abdominal pain, dehydration, fever, and headache. In serious cases, complications may include Guillain-Barré syndrome, miscarriage, chronic inflammation, arthritis, or even death (Hill, 2023).

Epidemiological data reinforce these concerns. In the United States, between 1993 and 2006, 60% of all dairy-related outbreaks were linked to raw milk or cheese. Specifically, 82% of milk-related illnesses were caused by raw milk, while only 18% were associated with pasteurized milk. Consumers of raw

milk were 13 times more likely to require hospitalization compared to those consuming pasteurized milk (Hill, 2023). These findings highlight the ongoing public health risks of raw milk consumption, particularly for vulnerable groups such as children, pregnant women, the elderly, and immunocompromised individuals.

Thermal processing remains the most effective method for ensuring milk safety. Traditional pasteurization (72°C for 15 s) and low-temperature long-time pasteurization (63°C for 30 min) inactivate most pathogenic microorganisms, while ultra-high temperature (UHT) treatment at 135°C ensures extended shelf-life of up to nine months. These methods preserve the nutritional quality of milk while protecting public health (Hill, 2023).

Social media plays a central role in the promotion of raw milk. Distinct subgroups such as “tradwives,” “crunchy moms,” and biohackers frame raw milk as part of alternative lifestyles that emphasize natural living, resistance to modern medicine, and distrust of food industry practices. Influencers with large audiences, such as Hannah Neeleman (Ballerina Farm, with over 10 million followers), frequently showcase raw milk in everyday life, while Courtney Luna incorporates it into her “carnivore diet” content (Miller, 2024). Other prominent figures, including Paul Saladino (“Carnivore MD”), portray pasteurized milk as harmful, equating it with ultra-processed food, a comparison designed to resonate with modern consumer anxieties about industrial food (Aggeler, 2024).

Even companies such as “Heart and Soil,” which market nutritional supplements, actively produce promotional materials defending raw milk, claiming it is misunderstood and unfairly restricted in mainstream markets (Aggeler, 2024). At the same time, organizations like the “Raw Milk Institute” present themselves as scientific authorities while repeatedly circulating claims of raw milk’s alleged benefits. These messages often overlap with broader controversial views, including political radicalism and anti-vaccination movements. For example, RFK Jr., a well-known anti-vaccine activist, publicly endorses raw milk consumption (Aggeler, 2024).

Alarming, new risks continue to emerge. In March 2024, experts in California reported the detection of avian influenza virus in raw cow’s milk, following transmission of the virus from birds to cattle. Despite these warnings, many pregnant women and other vulnerable individuals continue to consume raw milk, encouraged by influencers who share positive personal experiences and present raw milk as a symbol of natural health (Aggeler, 2024).

## ***Conclusion***

The growing trend of raw milk consumption, fueled largely by social media, represents a significant public health concern. Scientific evidence consistently shows that raw milk does not provide unique health benefits compared to pasteurized milk, while it poses a high risk of transmitting serious pathogens. Thermal processing, including pasteurization and UHT treatment, ensures safety with minimal nutritional loss. Nevertheless, online promotion of raw milk is widespread, often linked to alternative lifestyles and pseudoscientific beliefs, and reinforced by influential figures with large audiences. Effective public health communication is essential to counteract misinformation, highlight the proven safety of pasteurized milk, and encourage consumers to make informed dietary decisions.

***Author Contributions:*** Conceptualization, E. A. and L. K.; methodology, E. A.; investigation, L. K.; writing—original draft preparation, E. A.; writing—review and editing, L. K.; visualization, E. A.; supervision, L. K.; All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding.

***Informed Consent Statement:*** Not applicable.

***Conflicts of Interest:*** The authors declare no conflicts of interest.

## ***References***

Aggeler Madeleine, 2024. The truth about raw milk and why experts are ‘absolutely horrified’ by the trend. The Guardian - <https://www.theguardian.com/wellness/2024/nov/26/what-is-unpasteurized-raw-milk> (05.09.2025.)

Hill Caroline, 2023. Raw Milk: Do Its Benefits Outweigh the Dangers? Healthline-<https://www.healthline.com/nutrition/drinking-raw-milk> (05.09.2025.)

<https://www.dictionary.com/terms/influencer>, tradwife, crunchy mom, biohacker (05.09.2025.)

Miller Merlyn, 2024. Why Is Social Media Telling Us It’s OK to Drink Raw Milk? Food and wine - <https://www.foodandwine.com/is-raw-milk-safe-social-media-trend-8700797> (05.09.2025.)

Raw milk institute Instagram and web page <https://www.instagram.com/rawmilkinstitute/>, <https://www.rawmilkinstitute.org/> (05.09.2025.)

## Uticaj društvenih mreža na trovanje hranom: slučaj sirovog mlijeka

Elmin ALIĆ\*, Lejla KRUŠKO

Veterinarski fakultet, Univerzitet u Sarajevu, Bosna i Hercegovina

\*Autor za korespondenciju: Elmin Alić, elmin,2000@hotmail.com

### Sažetak

Rastuća popularnost konzumacije sirovog mlijeka, posebno putem društvenih mreža i promocije influencera, izazvala je zabrinutost za javno zdravlje. Ovaj rad ima za cilj analizirati uticaj društvenih mreža na percepciju i konzumaciju sirovog mlijeka, ispitujući kako tvrdnje zagovornika, tako i povezane zdravstvene rizike. Podaci iz literature i primjeri slučajeva ukazuju da je sirovo mlijeko podložno kontaminaciji patogenim bakterijama poput *Salmonella*, *Listeria monocytogenes*, *E. coli* i *Campylobacter*, koje mogu izazvati teške gastrointestinalne i sistemske bolesti. Uprkos navodnim prednostima koje promovišu influenceri, uključujući veći sadržaj hranjivih materija, antimikrobna svojstva i potencijalnu pogodnost za osobe s intolerancijom na laktozu ili astmom, naučni dokazi pokazuju da su ove tvrdnje uglavnom neutemeljene ili obmanjujuće. Pasterizacija, uključujući standardne i ultra-visoke temperaturne tretmane, efikasno eliminiše patogene dok zadržava većinu hranjivih materija, pružajući sigurniju alternativu za konzumaciju. Rad naglašava ulogu influencera i alternativnih zajednica u širenju dezinformacija, ističući potrebu da potrošači koriste provjerene izvore pri donošenju odluka o ishrani. Ovi nalazi naglašavaju značaj javne svijesti o rizicima sirovog mlijeka i prednostima pasterizacije u prevenciji bolesti izazvanih hranom.

*Ključne riječi: sirovo mlijeko, pasterizacija, patogeni u hrani, društvene mreže, zdravstveni rizici*

## **Contamination of Food with Pathogenic Microorganisms – Overview from the RASFF Database**

Berina DRAGOLOVČANIN\* Ilhana BIBER Lejla NEZOVIĆ

Hana TEPARIĆ Enida DEDIĆ Jasmina ĐEĐIBEGOVIĆ

Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

\* Corresponding author: Berina Dragolovčanin, [berinadragolovcanin@ffsa.unsa.ba](mailto:berinadragolovcanin@ffsa.unsa.ba)

### **Abstract**

Microbiological contamination of food is one of the most common causes of food spoilage, as various microorganisms can significantly reduce food quality and compromise consumer safety. The aim of this paper was to analyze data on microbiological contamination of food in the Western Balkans, using information from the RASFF database, in order to identify pathogens that are frequent causes of contamination and to assess their potential impact on consumer health. Reported cases of contamination in the specified region during 2020-2025 time period were analyzed. The results indicate that *Salmonella spp.* and *Listeria monocytogenes* are the predominant pathogens responsible for food contamination in the observed period, emphasizing the need for the implementation of preventive measures, such as the introduction of HACCP and ISO systems, with the aim to reduce the risk of microbiological contamination and preserve food quality.

*Keywords: microbiological contamination, RASFF database, pathogens, Western Balkans*

### **Introduction**

Contamination of food with pathogenic microorganisms represents a serious public health problem that can have severe consequences for human health. Pathogenic microorganisms, such as bacteria, viruses, parasites, and fungi, can enter food during various stages of production, processing, distribution, and consumption. When contaminated products are consumed, they can cause a wide range of diseases, from mild gastrointestinal disturbances to severe infections, and even death (Bunia, 2018). Therefore, it is important to understand the ways in which contamination occurs, as well as the preventive measures that can reduce the risk of illnesses. Due to the increasing number of cases and the spread of new strains of pathogenic microorganisms, it is

crucial to identify the risk factors leading to food contamination and to apply appropriate control measures to protect consumers.

The aim of this work is to investigate and analyze, using data from the RASFF database, cases of food contamination by pathogenic microorganisms in the Western Balkans region (Bosnia and Herzegovina, Croatia, Serbia, Monte Negro and North Macedonia), to emphasize their impact on human health, as well as the methods of prevention and control of contamination.

The paper will address strategies and techniques for food protection, such as proper storage, hygienic practices, and food processing methods, in order to reduce the risk of microbiological contamination and increase food safety for consumers.

### ***Experimental***

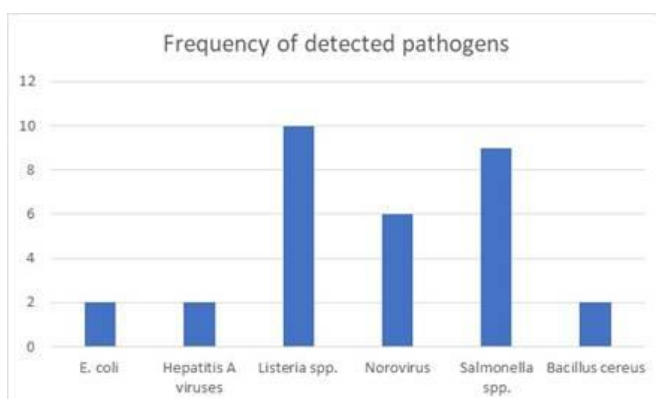
For the purpose of analyzing food contamination by pathogenic microorganisms in the countries of the Western Balkans (country of origin), data from the RASFF portal were used. Data for pathogenic micro-organisms in food were extracted for the time period 2020-2025.

The RASFF system (Rapid Alert System for Food and Feed) is a rapid alert system for food and feed, established in 1979 by the European Union to enable the swift exchange of information between Member States, the European Commission, and other relevant authorities regarding risks related to the safety of food and feed.

The main purpose of this system is the protection of public health through timely recognition and response to potential hazards in the food chain. All members of the RASFF system are obliged to report potential risks once they are identified. The RASFF database, which is publicly accessible, ensures transparency and provides a detailed overview of cases reported through this system (RASFF, 2025).

### ***Results and Discussion***

The search criteria yield 30 reports in total: 14 for food produced in Serbia, 10 for food produced in Croatia, and 6 for food produced in Bosnia and Herzegovina, while no reports were recorded for food originated from Monte Negro and North Macedonia (Figure 1).



**Figure 1.** Frequency of food pathogens in RASFF reports

Reports related to Bosnia and Herzegovina as the country of origin included mostly *Salmonella* spp. (4 reports). Hepatitis A virus was reported only in food from Serbia (Table 1).

**Table 1.** Reports list from RASFF database

Reference	Category	Subject	Origin	Hazards
2023.6044	poultry meat and poultry meat products	salmonella in chicken wings from Croatia	Croatia	Salmonella
2024.1313	fruits and vegetables	Serbia	Serbia	norovirus
2024.1520	bivalve molluscs and products thereof	norovirus in tartufo (venus verrucosa) from Croatia	Croatia	norovirus
2023.1842	fish and fish products	norovirus (GII/2g) in truffles (venus verrucosa) from Croatia	Croatia	norovirus
2020.2528	fish and fish products	Listeria monocytogenes in smoked salmon	Serbia	Listeria monocytogenes
2024.4227	meat and meat products (other than poultry)	Listeria in smoked salmon in dried pork meat product	Croatia	Listeria monocytogenes
2025.5093	fish and fish products	Listeria in smoked salmon from Serbia	Serbia	Listeria monocytogenes
2021.5583	meat and meat products (other than poultry)	Salmonella spp. in meat preparation from Serbia	Serbia	Salmonella enteritidis
2023.5894	fish and fish products	Salmonella spp. in sea bass or sea bass (dicentrarchus labrax) 400/600 Croatia	Croatia	Salmonella
2024.2218	eggs and egg products	Salmonella enteritidis in spigola o branzino (dicentrarchus labrax) 400/600 Croatia	Croatia	Salmonella Enteritidis
2024.8375	poultry meat and poultry meat products	Salmonella enteritidis in chicken breast fillets from Bosnia and Herzegovina	Herzegovina	Salmonella Enteritidis
2021.5530	poultry meat and poultry meat products	Salmonella enterica ser. Enteritidis in chilled chicken drumsticks from Bosnia and Herzegovina	Bosnia and Herzegovina	Salmonella Enteritidis
2022.5723	cereals and bakery products	Salmonella Typhimurium in flavored cream wafers hazelnuts, from Bosnia and Herzegovina	Herzegovina	Salmonella typhimurium DT 120
2022.5996	ices and desserts	Salmonella Typhimurium in filled wafers from Bosnia and Herzegovina	Bosnia and Herzegovina	Salmonella spp.
2021.6021	herbs and spices	Salmonella Bareilly and Bacillus cereus (enterotoxin) in Tumeric	Herzegovina	Salmonella enteritidis
2020.0973	fruits and vegetables	Norovirus in frozen raspberries from Serbia	Serbia	norovirus
2021.1903	fruits and vegetables	Norovirus in frozen raspberries	Serbia	norovirus
2024.8563	fruits and vegetables	Norovirus in blackberries from Serbia	Serbia	norovirus
2023.4775	fish and fish products	Listeria monocytogenes in smoked salmon from Serbia	Serbia	Listeria monocytogenes
2021.5834	fish and fish products	Listeria monocytogenes in salmon affumicato/L. monocytogenes in smoked salmon from Serbia	Serbia	Listeria monocytogenes
2023.0573	milk and milk products	Listeria monocytogenes in goat cheese from Croatia	Croatia	Listeria monocytogenes
2020.2409	fish and fish products	Listeria monocytogenes in frozen smoked Salmon fillets	Norway, Serbia	Listeria monocytogenes
2021.4747	fish and fish products	Listeria monocytogenes (up to 650 CFU/g) in chilled baccala spread from Croatia	Croatia	Listeria monocytogenes
2021.7187	meat and meat products (other than poultry)	Listeria monocytogenes (< 100 CFU/g) in chilled cooked ham from Serbia	Serbia	Listeria monocytogenes
2021.5992	fish and fish products	Listeria monocytogenes in baccala mantecato/Listeria monocytogenes in whipped codfish	Croatia	Listeria monocytogenes
2021.6580	milk and milk products	High count of Escherichia coli in cream from Bosnia and Herzegovina	Herzegovina	Escherichia coli too high count
2025.5259	fruits and vegetables	Hepatitis A viruses in frozen mixed berries from Serbia, via Germany	Serbia	hepatitis A virus
2025.0824	bivalve molluscs and products thereof	E. coli in mussels from Croatia	Croatia	Escherichia coli High count
2022.5259	other food product / mixed	Bacillus cereus in humus	Serbia	Bacillus cereus enterotoxin producing
2022.4823	fruits and vegetables	Hepatitis A virus in frozen fruit from Belgium	Belgium, Latvia, Poland, Serbia	hepatitis A virus

Based on the data extracted from the RASFF system, we conclude that the most common pathogenic species of microorganisms in meat and products of poultry origin is *Salmonella enteritidis*. *Salmonella* can naturally be found in the intestines of poultry, domestic animals, and humans. The possibility of contamination is increased due to the colonization of the intestines of animals with *Salmonella*, and contamination occurs during the slaughter processing of the animal. Eggs can also represent a “reservoir” of *Salmonella*, especially of

the *enteritidis* genus, which in eggs stored at room temperature develop up to  $10^{11}$  cells per yolk. (Darwin and Miller, 1999) The presence of *Salmonella* in food, as mentioned, is assessed as a serious risk, and the most common sources of infection are the consumption of contaminated meat, eggs, dairy and fish products. (Darwin and Miller, 1999) *Salmonella* is the leading cause of foodborne diseases worldwide that infects the gastrointestinal tract and causes diarrhea, nausea, and cramps in humans. (Shaji, Selvaraj and Shanmugasundaram, 2023)

Preventive measures against *Salmonella* include comprehensive farm-to-fork interventions, such as on-farm biosecurity, vaccination of poultry, vermin control, and microbial testing. At the preharvest level, strategies include probiotics, vaccination, feed additives (e.g., sodium chlorate), and monitoring wildlife contamination. At harvest and processing, measures include carcass washing, lactic acid sprays, high-pressure processing, antimicrobial treatments, and sanitary dressing procedures. Regulatory frameworks emphasize microbiological testing of flocks pre-slaughter, process control verification, and final product standards. Consumer-focused efforts include education on hygiene, proper cooking, and food handling practices. (Food Safety Net Services, 2022)

One of the pathogens that is also characterized as a serious risk is *Listeria monocytogenes*, found predominantly in meat, dairy products, and fish. It is assumed that the origin of this contamination in meat is the presence of the pathogen in the muscles of the processed animal. Research has determined that the growth of this microorganism is most influenced by the storage temperature (optimal up to 25°C), the pH of the meat, and the type of processed tissue. The presence of *Listeria monocytogenes* carries a serious health risk, since infection through contaminated food leads to the development of the disease listeriosis. Although relatively rare, listeriosis is very serious disease with a high mortality rate, especially in vulnerable groups, and it can cause miscarriage in pregnant women. (US CDC, 2025)

The regulations imposed for the handling of foods contaminated with *L. monocytogenes* are essential, given the difficulty of eradicating this bacterium. The regulations in force cover personal hygiene, surface cleanliness, and processing technology. In many cases, a single method is not sufficient to effectively control *L. monocytogenes*. A combination of techniques, known as “barrier technology”, has proven more effective. Studies have shown that a combination of plant-derived antimicrobial compounds, along with heat treatments, can effectively control bacteria in various food products. In addition, another study showed that the combined application of pulsed electric fields, moderate heat, and natural essential oils was effective in inactivating *L. monocytogenes*. Biocontrol methods represent



an alternative solution to inhibit the growth of *L. monocytogenes*. (Dabija, Afloarei, Dabija, 2025)

Data (Table 1.) also indicate food contamination with *Norovirus* in fruits and vegetables contamination of *Norovirus* in fruits and vegetables. *Norovirus* in frozen fruits and vegetables can develop because of contact with freezing water of the products that are infected with this pathogen. *Norovirus* causes vomiting and diarrhea, and consequently the risk of dehydration, which can lead to health complications in consumers affected by this type of contamination through food.

Prevention of contamination will depend on a very high level of compliance with hand hygiene (i.e. handwashing with running water and soap and drying with disposable towels). Special attention is required at the final stages of production, as moisture content in the end product may be corrected by adding water. If appropriate production and washing water are used, it is unlikely that they will introduce contamination. The proper use of gloves throughout the process will also ensure optimal hand hygiene. The use of hand alcoholic sanitizer alone is not sufficient to achieve the reduction needed for viral safety. (FCC, 2011)

Additionally, the case of contamination of frozen fruit with hepatitis A virus is also significant. According to the FDA, illness usually occurs within 15 to 50 days after eating or drinking contaminated food or water. Symptoms of hepatitis A virus infection include fatigue, nausea, vomiting, abdominal pain, jaundice, dark urine, and pale stool. In some instances, particularly in children under the age of six, hepatitis A infection may be asymptomatic. (US FDA, 2023)

RT-qPCR enables a quantitative viral detection of interest for hazard risk assessment analysis and its use in the improvement of public health measures and food-related regulations. Therefore, several protocols have been reported and focused to different aims such as the applicability to various types of foods and the absence of potential inhibitors in molecular reactions. Unfortunately, a unique protocol encompassing all these ideal features is not available to date and the number of available protocols is overwhelming. As a breakdown, two recently released ISO procedures, ISO 15216-1:2017 and ISO 15216-2:2019, specify standardized protocols for quantitative and qualitative detection of HAV. These methods describe the concentration of viral particle from several high-risk food items. (Randazzo and Sánchez, 2020)

Croatia is the only of the analyzed countries which is EU member state and can notify the RASFF. It is interesting to note that only three out of 10 cases of contaminated food produced in Croatia was also reported by Croatia. Such discrepancy between country of origin and notifying country points out that

the food safety risk wasn't always recognized at the earliest possible time point of the product's life span. Thus, the access to information in the RASFF window is very valuable both for member and non-member countries.

Ensuring food safety and public health requires preventing food contamination. Preventing contamination in the food industry demands an approach that includes strict hygiene practices, better quality control, and compliance with regulations. Some of the key strategies are:

1. Establishing a Food Safety Management System
2. Maintaining Hygienic Facilities
3. Employee Hygiene and Training
4. Raw Material Quality Control
5. Preventing Cross-Contamination
6. Quality Testing and Monitoring

## **Conclusion**

Based on the database analysis, the greatest risk of contamination comes from microorganisms of the *Salmonella* and *Listeria* genera, which is why it is necessary to implement specific measures to prevent contamination, thus protecting consumer health as well as economy of the country. Although the RASFF notifications are not direct and absolute indicators of the level of the safety of food produced in a certain country, here presented data indicate need for better pathogens control at least in Serbia, Croatia, and Bosnia and Herzegovina.

**Author contributions:** Conceptualization, I. B. and E.D.; methodology, B.D. and I.B.; Investigation, H.T. and L. N.; writing - original draft preparation, B. D. and E. D.; writing - review and editing, E. D.; visualization, H, T and L. N.; supervision, J.Đ.

**Funding:** This work did not receive funding.

**Conflicts of interest:** The authors declare no conflicts of interest.

## **References**

Bhunja, K. (2018). *Foodborne Microbial Pathogens Mechanisms and Pathogenesis*, New York, Springer New York, USA.

Dabija, A., Afloarei, C.Ş., Dabija, D., Chetrariu, A. (2025). Conventional and Innovative Methods for Reducing the Incidence of *Listeria monocytogenes* in Milk and Dairy Products. *Appl. Sci.*, 15, 6580. <https://doi.org/10.3390/app15126580>

Darwin, K.H., Miller, V.L. (1999). Molecular basis of the interaction of Salmonella with the intestinal mucosa. Clin Microbiol Rev, 12(3): 405-28. doi: 10.1128/CMR.12.3.405. PMID: 10398673; PMCID: PMC100246.

Food Safety Net Services. Mitigating The Risk Of Salmonella In Food. Available at: <https://fsns.com/mitigating-the-risk-of-salmonella-in-food/>. Accessed: 23.09.2025.

Randazzo, W. and Sánchez, G. (2020). Hepatitis A infections from food. J. Appl. Microbiol., 129: 1120-1132. <https://doi.org/10.1111/jam.14727>

RASFF (2025), <https://webgate.ec.europa.eu/rasff-window/screen/search>

Shaji, S., Selvaraj, R.K., Shanmugasundaram, R. (2023). Salmonella Infection in Poultry: A Review on the Pathogen and Control Strategies. Microorganisms, 11(11): 2814. doi: 10.3390/microorganisms11112814. PMID: 38004824; PMCID: PMC10672927.

The Food Chain Crisis Management Framework (FCC). (2011). Prevention and control of Hepatitis A Virus (HAV) and Norovirus (NoV) in ready-to-eat semi-dried products. Available at: [https://www.fao.org/fileadmin/user\\_upload/agns/pdf/HAV\\_Tomatoes.pdf](https://www.fao.org/fileadmin/user_upload/agns/pdf/HAV_Tomatoes.pdf) Accessed 24.09.2025.

US Centers for Disease Control and Prevention. Clinical Overview of Listeriosis. Available at: <https://www.cdc.gov/listeria/hcp/clinical-overview/index.html>. Accessed 22.09.2025.

US FDA (2023). Outbreak Investigation of Hepatitis A Virus Infections: Frozen Strawberries. Available at: <https://www.fda.gov/food/outbreaks-foodborne-illness/outbreak-investigation-hepatitis-virus-infections-frozen-strawberries-february-2023> Accessed: 24.09.2025.

## Kontaminacija hrane patogenim mikroorganizmima – Pregled iz RASSF baze

Berina DRAGOLOVČANIN\* Ilhana BIBER Lejla NEZOVIĆ

Hana TEPARIĆ Enida DEDIĆ Jasmina ĐEĐIBEGOVIĆ

Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

\* Autor za korespondenciju: Berina Dragolovčanin, berinadragolovcanin@ffsa.unsa.ba

### Sažetak

Mikrobiološka kontaminacija hrane predstavlja jedan od najčešćih uzroka kvarenja hrane, različiti mikroorganizmi mogu značajno dovesti do smanjenja kvaliteta hrane i ugroziti bezbjednost potrošača. Cilj rada bila je analiza podataka o mikrobiološkoj kontaminaciji hrane u zemljama Zapadnog Balkana, korištenjem informacija iz RASFF baze, kako bi se identifikovali patogeni koji su nerijetki uzročnici kontaminacije i procjena njihovog potencijalnog uticaja na zdravlje potrošača. Analizirani su prijavljeni slučajevi kontaminacije na navedenom području u vremenskom periodu 2020–2025. godine. Rezultati ukazuju da *Salmonella spp.* i *Listeria monocytogenes* predstavljaju dominantne patogene odgovorne za kontaminaciju hrane u posmatranom periodu, što naglašava potrebu za implementacijom preventivnih mjera, poput uvođenja HACCP i ISO sistema, kako bi se smanjio rizik od mikrobiološke kontaminacije hrane i dovelo do očuvanja kvaliteta hrane.

*Ključne riječi: mikrobiološka kontaminacija, RASFF baza, patogeni, Zapadni Balkan*

## Neem powder in nutrition and health: Preliminary *in vitro* results of genotoxic effects

Lamija DURAKOVIĆ<sup>1,\*</sup> Milica KOVAČEVIĆ<sup>1,\*</sup> Irma DURMIŠEVIĆ<sup>2</sup>  
Maida HADŽIĆ OMANOVIĆ<sup>2</sup> Sanin HAVERIĆ<sup>2</sup> Anja HAVERIĆ<sup>2</sup> Tamara  
ČETKOVIĆ PEČAR<sup>2</sup>

<sup>1</sup> University of Sarajevo - Faculty of Science, Sarajevo, Bosnia and Herzegovina

<sup>2</sup> University of Sarajevo - Institute for Genetic Engineering and Biotechnology, Sarajevo, Bosnia and Herzegovina

\*Corresponding authors: Lamija Duraković, [lamija.durakovic17@gmail.com](mailto:lamija.durakovic17@gmail.com);  
Milica Kovačević, [milicakovacevic910@gmail.com](mailto:milicakovacevic910@gmail.com)

### Abstract

The limitations of synthetic drugs have increased interest in natural remedies, including neem (*Azadirachta indica* A. Juss.). Native to South and Southeast Asia, neem has long been used in Ayurveda, Unani medicine, and homeopathy for its bioactive compounds. Different parts of the plant contain unique constituents, applied in medicine, cosmetics, and pharmacy. In the food industry, neem acts as a natural preservative, replacing synthetic additives. Despite its widespread use, its potential toxicity, particularly at high doses or with prolonged exposure, remains underexplored. The aim of this study was to evaluate the genotoxic effects of commercially available neem powder (BIOfan) on human whole blood cells. The tested concentrations ranged from 2.5 to 100 µg/ml. Genotoxicity was assessed by measuring the comet tail intensity (Tail intensity, TI) using the alkaline comet assay after 3 hours of exposure. The values of TI revealed significant DNA damage at concentrations of 80 and 100 µg/ml ( $p < 0.001$ ). In conclusion, higher doses of neem powder induced DNA damage, indicating a potential risk of genotoxicity associated with its use.

**Keywords:** *Azadirachta indica*, alkaline comet assay, tail intensity, lymphocytes

### Introduction

The use of medicinal plants for therapeutic purposes dates back to ancient times. Despite the remarkable progress of modern medicine, their application remains widespread, especially in developing countries with limited access to formal healthcare. Among widely used medicinal plants, *Azadirachta indica*

*A. Juss.* (neem) stands out because of its diverse pharmacological potential. Neem has long been a key component of Ayurvedic, Unani, and homeopathic systems of medicine, and it has attracted considerable attention in modern biomedical research. In Sanskrit, the neem tree is called *Arishtha*, meaning “the reliever of illness,” and is often locally referred to as *Sarbaroganibarini*, or “the cure for all diseases” (Biswas, Chattopadhyay, Banerjee et al., 2002; Koul, 2004).

Neem is native to the Indian subcontinent and parts of Myanmar and is now naturalized and cultivated in more than 80 countries worldwide (Koul, 2004). Almost every part of the plant, including flowers, leaves, seeds, fruits, bark, and roots, has been used traditionally, mostly as water-based extracts for treating a variety of ailments (Poltronieri, Sasikala and Srinivasan, 2023).

Considering the significant therapeutic potential of *A. indica*, comprehensive toxicity evaluations of its commercially available formulations are crucial for generating safety data that can support evidence-based risk assessment and promote its safe clinical application.

A broad range of biological activities has been reported for neem, including antimicrobial, anti-inflammatory, antioxidant, antimalarial, hepatoprotective, immunomodulatory, antidiabetic, and potential anticancer effects (Singh, 2022; Poltronieri et al., 2023).

Phytochemical studies have identified more than 150 bioactive constituents in neem. These compounds can be grouped broadly into isoprenoids (e.g., diterpenoids, triterpenoids, and limonoids such as azadirachtin, salanin, and nimbin) and a variety of non-isoprenoid molecules (including proteins, carbohydrates, sulfur-containing compounds, and polyphenols such as flavonoids, coumarins, and tannins) (Tembe-Fokunang, Fokunang, Kaba et al., 2019). Because many of these constituents are biologically active, widespread human exposure to neem preparations, both traditional and commercial, calls for careful safety evaluation.

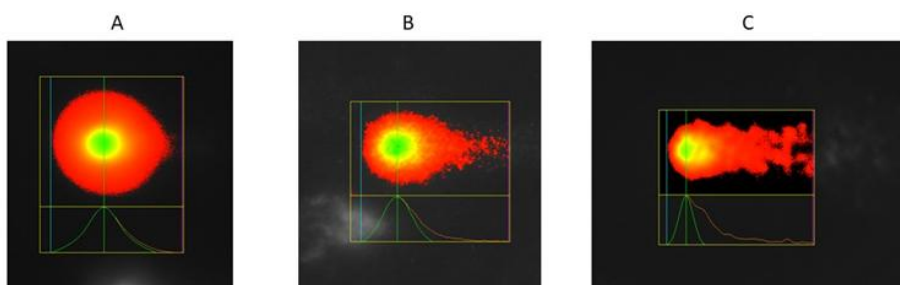
Neem products are widely used beyond traditional medicine: neem oil, leaf extracts, and seed cake are applied in pest control, cosmetics, personal care products (creams, shampoos, toothpastes, soaps), and as agricultural supplements (John, Pawane, Marchande et al., 2024; Patil, Bais and Rajgire, 2023). Also, recent research highlights its potential use in food preservation, particularly due to its activities as a pesticide, plasticizer and in many other applications (Kumar, Singh, Devi et al., 2022).

These applications increase the potential for topical and oral human exposure, reinforcing the importance of assessing possible adverse effects, including genotoxicity.

## Experimental

The aim of this study was to evaluate the genotoxic effects of commercially available neem powder (BIOfan) on human whole blood cells using the alkaline comet assay ( $\text{pH} > 13$ ). Experiments were carried out in centrifuge tubes containing 5 mL of PB-Max medium and 400  $\mu\text{L}$  of whole blood from a single donor. After 48 h incubation at 37 °C and 5%  $\text{CO}_2$ , cultures were treated with neem powder (2.5–100  $\mu\text{g}/\text{mL}$ ) for 3 h. A negative control (NC) and a 30 s treatment with 70  $\mu\text{M}$   $\text{H}_2\text{O}_2$  as a positive control were included. The alkaline comet assay was performed according to MIRCA guidelines with minor modifications.

After treatment, samples were centrifuged at 1000 rpm for 5 min, supernatant reduced to 2 mL, and cells gently resuspended. A detailed procedure for gel preparation has been described in previous study (Cetkovic, Haveric, Caluk Klacar et al., 2021). After electrophoresis (24 V, 300 mA (1 V/cm) for 20 min, the slides were washed twice with phosphate-buffered saline (PBS), fixed in ethanol, and rehydrated prior to staining with DAPI (3  $\mu\text{g}/\text{mL}$ ). All steps were conducted under dimmed light to prevent additional DNA damage. Comet visualization and image analysis were performed using a fluorescent microscope (Olympus BX51, Tokyo, Japan) at 40 $\times$  magnification. DNA damage was quantified using Comet Assay IV software (Instem, UK), analyzing total 100 comets per treatment (Figure 1). The percentage of DNA in the comet tail (TI%) was used as a parameter of DNA damage. To ensure normal distribution and homogeneity of variances, TI values were log-transformed prior to analysis. Differences between tested concentrations and controls were evaluated using one-way ANOVA followed by Scheffé post hoc test.



**Figure 1.** Software comet assay images showing A) negative control with no DNA damage; B) cells treated with concentration 100  $\mu\text{g}/\text{mL}$  inducing DNA damage; C) positive control (70  $\mu\text{M}$   $\text{H}_2\text{O}_2$ ) with high DNA damage

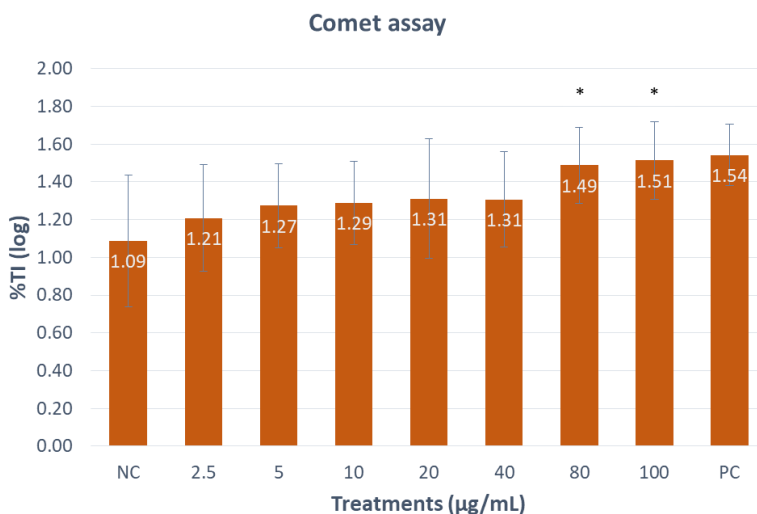
## Results and Discussion

The level of DNA damage in whole blood samples was assessed using the alkaline comet assay and expressed as tail intensity (TI).

The effects of various concentrations of commercial neem powder (BIOfan) (2.5–100 µg/mL) were compared to those of a positive control (70 µM H<sub>2</sub>O<sub>2</sub>) and a negative control (untreated cells).

The highest mean values of log-transformed TI were observed in the positive control (1.54), as well as in the treatment groups exposed to 80 and 100 µg/mL neem powder (1.49 and 1.51, respectively), with statistically significant differences ( $p < 0.001$ ).

The lowest tested concentration (2.5 µg/mL) did not show a significant difference compared to the negative control (Figure 2).



**Figure 2.** DNA damage in whole blood samples, expressed as tail intensity percentage (TI %), following 3-hour treatment with diluted commercial neem powder (2.5–100 µg/mL). Data are presented as logarithmically transformed mean values  $\pm$  standard deviation (SD). Statistically significant increases compared to the negative control (NC) (untreated cells) are indicated by an asterisk ( $p < 0.001$ ).



**Table 1.** DNA damage in whole blood samples evaluated by the alkaline comet assay after treatment with commercial neem powder (2.5–100 µg/mL). Results are expressed as tail intensity (TI %), presented as mean ± standard deviation (SD), based on analysis of 100 cells per treatment

<i>Treatments (µg/mL)</i>	<i>Tail intensity (TI %)</i> <i>Mean ± SD</i>
<i>Negative control</i>	1,0868 ± 0,3499
2.5	1,2084 ± 0,2830
5	1,2737 ± 0,2239
10	1,2894 ± 0,2206
20	1,3116 ± 0,3160
40	1,3069 ± 0,2530
80	1,4879 ± 0,2026*
100	1,5137 ± 0,2064*
<i>Positive control</i> <i>(70 µM H<sub>2</sub>O<sub>2</sub>)</i>	1,5426 ± 0,1630

*Statistically significant increases compared to the negative control (untreated cells) are indicated by an asterisk (p < 0.001).*

Although numerous studies have examined the pharmacological activities of neem (Singh, 2022; Poltronieri et al., 2023), studies regarding its genotoxic potential in blood cells are limited, particularly for commercially available neem powders (i.e., marketed formulations intended for human use). Given the plant's complex phytochemistry and widespread use, genotoxicity testing of commonly used formulations is warranted. The genotoxicity assessment of neem powder dilutions on blood samples using the comet assay involves evaluating DNA damage in individual cells.

Our study observed dose-dependent DNA damage in blood samples. Similarly, a study by Meza Ojeda, Vega Contreras and Salazar Mercado (2025) on human lymphocytes reported comparable results, indicating that the genotoxic effects of *A. indica* extract increase with concentration. These findings suggest that dosage is a critical factor in its genotoxicity.

In a study by Santos, Costa, Bessa et al. (2023), the comet assay was employed to assess DNA damage induced by phenolic extracts of *A. indica*—specifically, hexane extract (HE) at concentrations of 10, 15, and 20 µg/mL, and ethyl acetate extract (EAE) at 12.5, 15, and 17.5 µg/mL—in human B-lymphoblastoid (TK6) cells. A significant increase in DNA damage was observed in TK6 cells treated with both HE and EAE compared to the negative control at all tested concentrations. Furthermore, the extent of DNA strand breaks was comparable between the two extracts.

These findings are consistent with earlier reports by Chandra and Khuda-Bukhsh (2004) and Klopman, Contreras, Rosenkranz et al. (1985), who suggested that during the metabolism of *Azadirachta*, electrophilic ions and reactive radicals are generated, which can interact with nucleophilic sites in DNA, resulting in strand breaks and other forms of genotoxic damage.

In contrast, the study by Muangphra and Gooneratne (2011) showed that, in a comet assay performed on earthworm coelomocytes, neither the commercial neem extract NEEM (at concentrations of 0.39, 0.78, 1.57, 2.35, and 3.13  $\mu\text{g cm}^{-2}$ ) nor pure azadirachtin (Aza) (at a concentration of 0.09  $\mu\text{g cm}^{-2}$ ) had any significant effect on tail DNA%, tail length, or tail moment compared to the negative control. These findings suggest that the tested substances do not induce DNA damage at the concentrations used in that study, which are higher than those typically applied in the field as an insecticide (0.09  $\mu\text{g cm}^{-2}$ ).

### **Conclusion**

Based on the obtained results, it can be concluded that exposure to neem powder leads to an increase in DNA damage in human lymphocytes, as confirmed by the analysis of the tail intensity in the comet assay. The two highest tested concentrations showed a statistically significant difference compared to the negative control, indicating a potential genotoxic effect at higher doses of the extract. Considering that neem-based products are widely used in cosmetics, pharmaceuticals, and as dietary supplements due to their numerous bioactive properties, it is important to emphasize that excessive exposure may have adverse effects on genetic material. These findings highlight the need for careful assessment of safe concentrations of neem-derived ingredients in consumer and health-related products.

**Author contributions:** Conceptualization, T.Ć.P. and I.D.; methodology, M.K. and L.D.; investigation, T.Ć.P., I.D., M.K. and L.D.; writing—original draft preparation, T.Ć.P., I.D., M.K. and L.D.; writing—review and editing, A.H. and M.H.O.; visualization, T.Ć.P. and I.D.; supervision, S.H.; All authors have read and agreed to the published version of the proceeding.

**Funding:** This work did not receive funding.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

- Biswas, K., Chattopadhyay, I., Banerjee, R. K., & Bandyopadhyay, U. (2002). Biological activities and medicinal properties of neem (*Azadirachta indica*). *Current Science*, 82(11), 1336–1345. <http://www.jstor.org/stable/24106000>
- Cetkovic, T., Haveric, A., Caluk Klacar, L., Hadzic Omanovic, M., & Haveric, S. (2021). In vitro assessment of genotoxic and cytotoxic effects of *Artemisia annua* L. tincture. *Genetics & Applications*, 5(2), 1–9. <https://doi.org/10.31383/ga.vol5iss2pp1-9>
- Chandra, P., & Khuda-Bukhsh, A. R. (2004). Genotoxic effects of cadmium chloride and azadirachtin treated singly and in combination in fish. *Ecotoxicology and environmental safety*, 58(2), 194–201. <https://doi.org/10.1016/j.ecoenv.2004.01.010>
- John, C. V., Pawane, S. S., Marchande, S. S., Patil, S. D., & Bhole, R. (2024). Formulation and evaluation of moringa and neem herbal toothpaste for comprehensive oral care. *World Journal of Advanced Research and Reviews*, 23(1), 649–661. <https://doi.org/10.30574/wjarr.2024.23.1.2034>
- Klopman, G., Contreras, R., Rosenkranz, H. S., & Waters, M. D. (1985). Structure-genotoxic activity relationships of pesticides: comparison of the results from several short-term assays. *Mutation research*, 147(6), 343–356. [https://doi.org/10.1016/0165-1161\(85\)90003-2](https://doi.org/10.1016/0165-1161(85)90003-2)
- Koul, O. (2004). Neem: A global perspective. In O. Koul & S. Wahab (Eds.), *Neem: Today and in the new millennium* (pp. 1–19). Springer. [https://doi.org/10.1007/1-4020-2596-3\\_1](https://doi.org/10.1007/1-4020-2596-3_1)
- Kumar, S., Singh, N., Devi, L. S., Kumar, S., Kamle, M., Kumar, P., & Mukherjee, A. (2022). Neem oil and its nanoemulsion in sustainable food preservation and packaging: Current status and future prospects. *Journal of Agriculture and Food Research*, 7, 100254. <https://doi.org/10.1016/j.jafr.2021.100254>
- Meza Ojeda, J. C., Vega Contreras, N. A., & Salazar Mercado, S. A. (2025). Determination of genetic damage induced by *Azadirachta indica* extract in human lymphocytes. *NOVA Biomedical Sciences Journal*, 23(45), 27–39. <https://doi.org/10.22490/24629448.10144>
- Muangphra, P., & Gooneratne, R. (2011). Toxicity of commercial neem extract to earthworms (*Pheretima peguana*). *Applied and Environmental Soil Science*, 2011, Article 925950. <https://doi.org/10.1155/2011/925950>

- Patil, M. A., Bais, S. K., & Rajgire, A. D. (2023). Uses of neem in cosmetics and skincare. *International Journal of Advanced Research in Science, Communication and Technology*, 3(3), 99–102. <https://doi.org/10.48175/568>
- Poltronieri, P., Sasikala, S., & Srinivasan, N. (2023). Multifaceted applicative uses of neem (*Azadirachta indica*). *Journal of Xidian University*, 17(8), Article 2023. <https://doi.org/10.37896/jxu17.8/039>
- Santos, K. S., Costa, C., Bessa, M. J., Teixeira, J. P., Muniz, A. V. C. d. S., Padilha, F. F., Dariva, C., & Oliveira, M. B. P. P. (2023). *Azadirachta indica* A. Juss (neem) phenolic extract inhibits human B-lymphoblastoid cells growth via cell cycle arrest, apoptosis induction, and DNA damage. *Exploration of Foods and Foodomics*, 1, 130–142. <https://doi.org/10.37349/eff.2023.00011>
- Singh, R. K. (2022). Pre-clinical toxicity studies of neem (*Azadirachta indica*) in mice and rats. *World Journal of Pharmaceutical Research*, 11(10), 1259–1265. <https://doi.org/10.20959/wjpr202210-24989>
- Tembe-Fokunang, E. A., Fokunang, C., Kaba, N., Gatsing, D., Agbor, M., & Ngadjui, B. (2019). The potential pharmacological and medicinal properties of neem (*Azadirachta indica* A. Juss) in the drug development of phytomedicine. *Journal of Complementary and Alternative Medical Research*, 7(1), 1–18.

## **Prah neema u ishrani i zdravlju: Preliminarni *in vitro* rezultati o genotoksičnim efektima**

Lamija DURAKOVIĆ<sup>1,\*</sup> Milica KOVAČEVIĆ<sup>1,\*</sup> Irma DURMIŠEVIĆ<sup>2</sup>  
Maida HADŽIĆ OMANOVIĆ<sup>2</sup> Sanin HAVERIĆ<sup>2</sup> Anja HAVERIĆ<sup>2</sup> Tamara  
ĆETKOVIĆ PEĆAR<sup>2</sup>

<sup>1</sup> Univerzitet u Sarajevu - Prirodno- matematički fakultet, Sarajevo, Bosna i Hercegovina

<sup>2</sup> Univerzitet u Sarajevu - Institut za Genetičko Inženjerstvo i Biotehnologiju, Sarajevo, Bosna i Hercegovina

\*Autori za korespondenciju: Lamija Duraković, [lamija.durakovic17@gmail.com](mailto:lamija.durakovic17@gmail.com);  
Milica Kovačević, [milicakovacevic910@gmail.com](mailto:milicakovacevic910@gmail.com)

### **Sažetak**

Ograničenja sintetičkih lijekova povećala su interes za prirodne lijekove, uključujući neem (*Azadirachta indica* A. Juss.). Neem, porijeklom iz Južne i Jugoistočne Azije, tradicionalno se upotrebljava u Ajurvedi, Unani medicini i homeopatiji radi svojih bioaktivnih komponenti. Različiti dijelovi biljke sadrže jedinstvene supstance koje se primjenjuju u medicini, kozmetici i farmaciji. U prehrambenoj industriji, neem djeluje kao prirodni konzervans, zamjenjujući sintetičke aditive. Uprkos širokoj primjeni, njegov potencijalni toksični učinak, naročito pri visokim dozama ili dugotrajnoj izloženosti, ostaje nedovoljno istražen. Cilj ove studije bio je procijeniti genotoksične efekte komercijalno dostupnog neem praha (BIOfan) na humane ćelije pune krvi. Testirane koncentracije kretale su se od 2,5 do 100 µg/ml. Genotoksičnost je procijenjena mjerenjem intenziteta repa kometa (engl. *Tail intensity*, TI) pomoću alkalnog komet testa, odrađenim nakon 3 sata izloženosti. Vrijednosti TI su pokazale prisustvo značajnog oštećenja DNK pri koncentracijama od 80 i 100 µg/ml ( $p < 0.001$ ). Zaključno, više doze neem praha izazvale su oštećenja DNK, što ukazuje na potencijalni rizik nastanka genotoksičnosti prilikom njegove upotrebe.

*Ključne riječi:* *Azadirachta indica*, *alkalni komet test*, *dužina repa*, *limfociti*

## 2-O-5

### Assessment of radiation risk from consumption of wild mushrooms

Lejla FULURIJA<sup>1\*</sup> Jasmina HERCEGOVAC<sup>1</sup> Berina ŠLJIVO<sup>1</sup> Jasmina ILIĆ<sup>1</sup> Nedžad GRADAŠČEVIĆ<sup>2</sup>

<sup>1</sup> Faculty of Veterinary Medicine, University of Sarajevo, Sarajevo, BiH

<sup>2</sup> Laboratory for radioactivity control, Faculty of Veterinary Medicine UNSA, Sarajevo, BiH

\*Corresponding author: Lejla Fulurija, lejla.fulurija@student.vfs.unsa.ba

### Abstract

This paper aims to determine the activity concentrations and radiation risk of radioactive isotope  $^{137}\text{Cs}$  in wild mushrooms, with a focus on samples intended for export to the EU. Gamma spectrometry was used to measure  $^{137}\text{Cs}$  levels, and the annual ingestion dose was calculated based on average consumption. The results show a significant variation among species and sample types, with the highest  $^{137}\text{Cs}$  concentrations and radiation risk found in dried golden chanterelles exceeding the legal limit. Elevated levels were also detected in other species but mostly remained within acceptable safety margins. These findings emphasize the need for continued radiological monitoring of wild mushrooms, and highlight the potential risk to public health.

*Keywords:*  $^{137}\text{Cs}$ , mushrooms, gamma spectrometry, activity concentrations, ingestion dose

### Introduction

Due to their high ability to accumulate radionuclides from soil, mushrooms are considered significant bioindicators of radioactive contamination. Their intense absorption capacity, particularly for cesium isotopes ( $^{137}\text{Cs}$ ,  $^{134}\text{Cs}$ ), results in concentrations that are 10 to 100 times higher than the levels of the same radionuclide in the soil (Rosén, Vinichuk, Nikolova, et al., 2011). In cases of radioactive contamination, this characteristic leads to extremely high rates of radionuclides in wild mushrooms, which can subsequently result in increased radionuclide intake in humans and animals after consumption.

According to the available literature, explanations for mushrooms' affinity for radio-caesium absorption ( $^{137}+^{134}\text{Cs}$ ) vary, but most authors associate this phenomenon with their heterotrophic feeding method and morphological characteristics of the mycelium. The mycelium as the primary feeding structure of mushrooms spreads through soil layers where cesium

radioisotopes are retained in the highest concentrations (Mietelski, Jasinska, Kubica, et al., 1994). This property not only contributes to elevated  $^{137}+^{134}\text{Cs}$  levels in mushrooms but also to the prolonged retention of cesium in forest and mountain ecosystems (Vinichuk, Rosén, Johanson, et al., 2011). Mushrooms also show a pronounced affinity for potassium, with its content in various species ranging from 1.5 to 117 g/kg of dry matter (Kalač, 2001), which is significantly higher than in other plants. In addition to radionuclides, numerous studies have shown that mushrooms can also accumulate heavy metals such as cadmium (Cd), copper (Cu), lead (Pb), as well as certain microelements (Fe) and essential elements (Se) (Tuzen, 2003; Sesli & Tuzen, 1999; Falandysz, 2008).

From a health standpoint, radioactive cesium ingested through food distributes relatively homogeneously inside the body, with children being more sensitive than adults. High doses of  $^{137}\text{Cs}$  are associated with medullary dystrophy, reproductive dysfunction, and liver-related effects. Bone mineralization disorders and brain damage have also been described in humans as a result of high  $^{137}\text{Cs}$  intake. Furthermore, at low doses,  $^{137}\text{Cs}$  can disrupt sleep cycles and cardiovascular function. In higher concentrations, it leads to immunodeficiency, congenital and fetal deformities, thyroid cancer, and neurological disorders (Muftić, 2025)

This paper presents the results of measured  $^{137}\text{Cs}$  activity concentrations in mushroom samples collected from various locations across Bosnia and Herzegovina. The aim of the research was to evaluate  $^{137}\text{Cs}$  levels in mushrooms intended for export to the European Union and to assess the radiation risk associated with the consumption of this type of food based on the obtained values.

## ***Experimental***

In recent years, the Laboratory for Radioactivity Control at the Faculty of Veterinary Medicine, University of Sarajevo, has received mushroom samples intended for export to the European Union. The levels of  $^{137}\text{Cs}$  in these samples were determined using gamma spectrometry. The gamma spectrometry measurements were conducted on a vertical coaxial HPGe POP-TOP p-type detector, manufactured by “ORTEC,” model “GEM 30P4,” with a relative efficiency of 30% and a resolution of 1.85 keV at 1.33 MeV.  $^{137}\text{Cs}$  activity concentrations were measured at the energy of 661.6 keV. The levels of  $^{134}\text{Cs}$  were below the detection limit of the measuring instrument.

The annual intake of  $^{137}\text{Cs}$  and the resulting annual effective dose from ingestion of wild mushrooms were calculated using the following formula:

$$\text{DI} = A \times \text{AC} \times \text{CF}$$

Where: DI = annual ingestion dose (nSv), A = Activity of  $^{137}\text{Cs}$  in mushrooms (Bq/kg), AC = Annual consumption of mushrooms (kg) and  $\text{CF}(^{137}\text{Cs})$  = Dose conversion factor for adults (0.013 nSv/Bq)

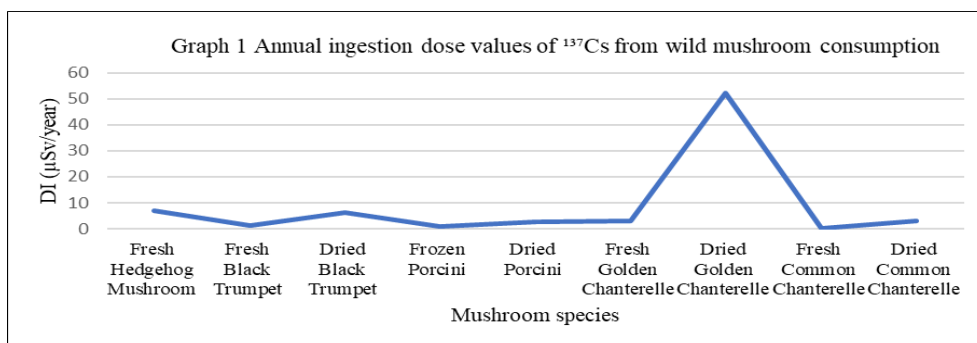
### Results and discussion

The obtained results, presented in table 1 below, show that the activity levels of  $^{137}\text{Cs}$  in the tested samples depended on the dry matter content of the samples. The highest values of  $^{137}\text{Cs}$  were recorded in dried mushroom samples, while generally lower values were found in fresh and frozen mushrooms. Regarding mushroom species, the highest  $^{137}\text{Cs}$  values were recorded in dried golden chanterelles (*Cantharellus tubaeformis*) with maximum of 1596.2 Bq/kg and dried black trumpets (*Craterellus cornucopioides*) with maximum of 766.7 Bq/kg. Among fresh mushroom samples, the highest value was found in hedgehog mushrooms (*Hydnum repandum*) with 780.9 Bq/kg. These levels, especially in samples of dried golden chanterelle, exceeded the maximum permitted limit of 600 Bq/kg defined by the regulation (Službeni glasnik Bosne i Hercegovine, 2014).

**Table 1.** Activity concentrations of  $^{137}\text{Cs}$  in edible mushroom samples from Bosnia and Herzegovina over the past 10 years (Bq/kg) and annual ingestion dose (DI)

Mushroom Species	$^{137}\text{Cs}$			DI (nSv/year)
	Mean	Min	Max	
Fresh Hedgehog Mushroom ( $n=8$ )	176,6	12,5	780,9	6,89
Fresh Black Trumpet ( $n=6$ )	28,4	3,3	113,8	1,11
Dried Black Trumpet ( $n=7$ )	164,7	18,6	766,7	6,42
Frozen Porcini ( $n=3$ )	21,7	20,6	23,6	0,85
Dried Porcini ( $n=13$ )	69,8	17,1	199,4	2,72
Fresh Golden Chanterelle ( $n=4$ )	77,2	49,8	125,2	3,01
Dried Golden Chanterelle ( $n=3$ )	1346,8	1220,9	1596,2	52,42
Fresh Common Chanterelle ( $n=2$ )	2,4	2,0	2,8	0,09
Dried Common Chanterelle ( $n=6$ )	81,2	41,8	143,1	3,17





**Graph 1.** Calculated annual ingestion dose values of <sup>137</sup>Cs from wild mushroom consumption

From the Graph 1., it is evident that the values of annual ingestion dose from wild mushrooms followed the average <sup>137</sup>Cs activity in the mushrooms (Table 1). The highest dose values and radiation risk were recorded for dried golden chanterelles (*C. tubaeformis*), followed by dried black trumpets (*C. cornucopioides*) and fresh hedgehog mushrooms (*H. repandum*).

The exceptionally high levels of <sup>137</sup>Cs in dried golden chanterelles are concerning, as they exceed the regulatory threshold thus present a potential risk for export to EU markets and also raise concerns about the safety of unregulated local consumption. The increased levels of <sup>137</sup>Cs can be used as a bioindicators for radioactive contamination. While the estimated ingestion doses for most mushroom species remain below thresholds considered harmful at average consumption levels, certain scenarios such as high consumption rates or consumption by sensitive populations (children, pregnant women, immunocompromised individuals) may require further risk assessment. The elevated levels of <sup>137</sup>Cs highlight the importance of continued monitoring and emphasize the need for adaptive regulatory frameworks and public health measures.

## Conclusions

Mushroom samples from Bosnia and Herzegovina, collected over the past 10 years, have shown elevated levels of <sup>137</sup>Cs compared to previous years. The increased levels were attributed to dry and extremely hot summers, which resulted in non-selective absorption of nutrients from the soil. The calculated annual ingestion doses from wild mushroom consumption indicated that the highest dose and the highest radiation risk was associated with the consumption of dried golden chanterelles. In this species, most of the measured <sup>137</sup>Cs levels exceeded the legally prescribed limits. For other wild

mushroom species, the annual dose values did not indicate significantly increased radiation risk and did not pose a health threat to consumers with an average annual intake of 3 kg.

**Author contributions:** Conceptualization, L.F. and J.H.; methodology, L.F. and J.H.; investigation, N.G.; writing—original draft preparation, L.F. and J.H.; writing—review and editing, J.H., L.F., B.Š. and J.I.; supervision, N.G. All authors have read and agreed to the published version of the proceeding.

**Conflict of interest:** The authors declare no conflicts of interest.

## **References**

- Falandysz, J. (2008). Selenium in edible mushrooms, *J Environ Sci Health C Environ Carcinog Ecotoxicol Rev*, 26:256-99.
- Kalač P. (2001). A review of edible mushroom radioactivity, *Food Chem*, 75:29–35.
- Mietelski, J.W., Jasinska, M., Kubica, B., Kozak, K., Macharski, P. (1994). Radioactive contamination of Polish mushrooms, *Sci Total Environ*, 157: 217-226.
- Muftić, E. (2025). Distribucija radiaktivnosti pri preradi mlijeka u vlašićki, livanjski i svježi kravljji sir. Doktorska disertacija, Univerzitet u Sarajevu, Veterinarski fakultet.
- Rosén, K., Vinichuk, M., Nikolova, I., Johanson, K. (2011). Long-term effects of single potassium fertilization on <sup>137</sup>Cs levels in plants and fungi in a boreal forest ecosystem. *J Env Rad*, 102, 178-184.
- Sesli, E., Tuzen, M. (1999). Levels of trace elements in fruiting bodies of macrofungi growing in the East Black Sea region of Turkey, *Food Chemistry*, 65:43–46.
- Službeni glasnik BiH, 2014. Pravilnik o maksimalno dozvoljenim koncentracijama za određene kontaminante u hrani. Službeni glasnik BiH, br. 68/14.
- Tuzen, M. (2003). Determination of heavy metals in soil, mushroom and plant samples by atomic absorption spectrometry, *MICROCHEM J*, 74:289-297.
- Vinichuk, M., Rosén, K., Johanson, K.J., Dahlberg, A. (2011). Correlations between potassium, rubidium and cesium (<sup>133</sup>Cs and <sup>137</sup>Cs) in sporocarps of *Suillus variegatus* in a Swedish boreal forest, *J Env Rad*, 102:386-392.

## **Procjena radijacionog rizika od konzumacije divljih gljiva**

*Lejla FULURIJA<sup>1\*</sup> Jasmina HERCEGOVAC<sup>1</sup> Berina ŠLJIVO<sup>1</sup> Jasmina ILIĆ<sup>1</sup> Nedžad GRADAŠČEVIĆ<sup>2</sup>*

<sup>1</sup> Veterinarski fakultet Univerzitet u Sarajevu, Sarajevo, BiH

<sup>2</sup> Laboratorija za kontrolu radioaktivnosti, Veterinarski fakultet UNSA, Sarajevo, BiH

\*Autor za korespondenciju: Lejla Fulurija, lejla.fulurija@student.vfs.unsa.ba

### **Sažetak**

Ovaj rad ima za cilj utvrditi koncentraciju aktivnosti i radijacioni rizik od radioaktivnog izotopa  $^{137}\text{Cs}$  u divljim gljivama, s posebnim fokusom na uzorke namijenjene za izvoz u EU. Za mjerenje nivoa  $^{137}\text{Cs}$  korištena je gama spektrometrija, a godišnja doza ingestije izračunata je na osnovu prosječne konzumacije. Rezultati pokazuju značajne varijacije među vrstama i tipovima uzoraka, pri čemu su najviše koncentracije  $^{137}\text{Cs}$  i najveći radijacioni rizik zabilježeni u osušenim zlatnim lisičarkama, te prelaze zakonski limit. Povišeni nivoi su zabilježeni i u drugim vrstama, ali su uglavnom ostali unutar prihvatljivih sigurnosnih granica. Ovi rezultati naglašavaju potrebu za kontinuiranim radiološkim nadzorom divljih gljiva te ukazuju na potencijalni rizik za javno zdravlje.

*Ključne riječi:*  $^{137}\text{Cs}$ , gljive, gama spektrometrija, aktivnost koncentracije, doza unosa

## 2-O-6

### **Medicinal use of Cannabis - Therapeutic potential and challenges**

Farah KONJHODŽIĆ\* Emilija KOPRIVICA Ilma TELIBEČIROVIĆ

University of Sarajevo, Faculty of Pharmacy, 71 000 Sarajevo, BiH

\*Corresponding author: Farah Konjhodžić, farahkonjhodzic@gmail.com

#### **Abstract**

The growing interest in cannabis and its potential health benefits have made it a key topic for research and discussion. Whether approached for its healing properties or out of interest in its influence on the body and mind, it is essential to first grasp the basic facts about cannabis. Although there are numerous studies supporting the therapeutic effects of cannabis, the use of cannabis for medical purposes is still not allowed in most countries. This paper is designed to show the potential therapeutic and effects of cannabis use with special reference to the treatment of certain diseases, including epilepsy, gastrointestinal disorders and infections of bacterial and viral origin. The aim of this paper is to show the presence and use of cannabis products in the market, focusing on their medical applications and the possible risks that come with their use.

*Keywords: cannabis, cannabis legalization, medical use of cannabis, THC*

#### **Introduction**

Marijuana contains more than 100 phytocannabinoids, substances that act on the endocannabinoid system in the human body. The most well-known active principles are tetrahydrocannabinol (THC) and cannabidiol (CBD). THC is primarily responsible for the psychoactive effects of marijuana, namely euphoria, changes in the perception of space and time, as well as mood changes, while CBD, unlike THC, is non-psychoactive (or significantly less) and has anti-inflammatory, anticonvulsant, anxiolytic properties. (Kopustinskiene et al., 2022)

One of the reasons why growing hemp and marijuana is so popular is due to the variety of uses of its extracts. Specifically, its stem fibers have traditionally been used for paper, textiles, and ropes, and more recently it has been used as reinforcement in construction materials and bioplastics, and its biomass is used to produce solid biofuels, ethanol and biogas. Cannabinoids act through different receptors: CB1 receptors in the central nervous system

and CB2 receptors in the immune system and peripheral tissues. THC is a partial agonist of CB1 and CB2 receptors, meaning it activates them with different affinities, which contributes to the psychoactive effect (CB1) and immunomodulation (CB2). CBD binds CB1 and CB2 less strongly, and acts partly as a negative allosteric modulator, which may alleviate some of the side effects of THC, such as anxiety and psychosis. (Ahmed et al., 2020). Marijuana is used for medical purposes to relieve chronic pain, nausea (e.g., during chemotherapy), muscle spasms (e.g., in multiple sclerosis), and as a treatment for epilepsy (Williamson et al., 2000)

## ***Experimental***

For the purposes of this paper, a literature review was conducted, which included electronically available works related to the use of cannabis and research into areas where its use is legally permitted. To obtain relevant data, medical platforms such as PubMed, Google Scholar, MEDLINE, and the Centers for Disease Control and Prevention were used. The keywords used were: cannabis, cannabis legalization, medical use of cannabis, THC.

## ***Results and Discussion***

### ***Use of cannabis and cannabinoids in pain therapy***

For many years it was assumed that the chemical components of the cannabis plant, cannabinoids, produce analgesia by activating specific receptors throughout the body, in particular CB1, which are found predominantly in the CNS, and CB2, found predominantly in cells involved with immune function. However, recently this picture has become much more complicated, as it has been recognized that cannabinoids, both plant-derived and endogenous, act simultaneously on multiple pain targets within the peripheral and CNS. (Vučković et al., 2018)

Several studies have found that cannabis may be helpful in treating neuropathic pain (a specific type of chronic pain caused by damaged nerves), but that it may also help relieve pain in people with various malignant diseases. These facts have resulted in legalizing cannabis for medical use to manage pain and prevent deaths from opioids for pain management (CDC, 2024)

### ***Use of cannabis in the treatment of bacterial and viral diseases***

Recently published research suggests that cannabinoids exhibit potent antibacterial properties. Five different cannabis constituents have been shown to have potential antimicrobial activity, and cannabinoids are excellent at

slowing the development of resistance in methicillin-resistant *Staphylococcus aureus* (MRSA), a major problem in today's clinical practice. (Goločorbin et al., 2015)

All five major cannabinoids (cannabidiol, cannabichromene, cannabigerol,  $\Delta^9$ -tetrahydrocannabinol, and cannabinol) have shown potent activity against various strains of methicillin-resistant *Staphylococcus aureus* (MRSA) that are currently clinically relevant. All of the listed cannabinoids (cannabidiol, cannabichromene, cannabigerol,  $\Delta^9$ -tetrahydrocannabinol, and cannabinol) can bind to cannabinoid receptors type 1 (CB1) and type 2 (CB2), which are located in the plasma membranes of nerve cells and the immune system. (Coelho et al., 2025)

### ***Use of cannabis in the therapy of gastrointestinal system disorders***

It is important to note that access to cannabinoid-based medicines is increasing around the world. More countries are creating specific rules for medical cannabis. Interest among patients and their families is also rising as information spreads quickly online. Patients with gastrointestinal disorders often seek medical advice and support for using cannabinoids to treat stubborn symptoms or to replace standard medications.

Researchers have studied the endocannabinoid system in the gastrointestinal tract in recent years. It has been known for a long time that functional gastrointestinal disorders and motility disorders lead to high healthcare costs around the world. They also create a heavy burden on everyday gastroenterology practice, affecting more than 40% of people globally and significantly reducing quality of life. According to some of the latest research on this topic, currently less than 13% of patients with gastrointestinal disorders consult with their physician about proper cannabinoid prescribing and optimal medical guidelines. In most cases, patients access illegal or unregulated medicinal cannabis products without any knowledge of dosage, indications and contraindications, potential drug-drug interactions, and possible side effects. (Arboleda et al., 2020)

The use of cannabis is not unfamiliar to many cancer patients, as there is a long history of its use for cancer pain and/or pain, nausea, and cachexia induced by cancer treatment.

There are two US Food and Drug Administration (FDA)–approved delta-9-THC pharmaceutical agents, dronabinol and nabilone, for use in treating nausea and vomiting associated with cytotoxic chemotherapy. Patients with cancer often fearfully anticipate the prospect of many potential negative consequences resulting from cancer chemotherapy. At or near the top of their concerns is chemotherapy-induced nausea and vomiting (CINV). Dronabinol is manufactured as a capsule containing  $\Delta^9$ -tetrahydrocannabinol (THC) in

sesame oil. It was approved by the FDA in 1985 for the treatment of CINV. Similarly, patients often subjectively report improvements in appetite with cannabis use.

It is important to note that of all the antiemetics currently available, cannabis and corticosteroids are the only two options with both antiemetic and orexigenic effects. Balancing risk, benefit, or drug-drug interactions between corticosteroids may limit its use at times, especially in those patients with cancer receiving immunotherapy. (Ward et al. 2021)

### ***Use of cannabis against migraine and epilepsy***

Some research suggests that migraines may result from endocannabinoid deficiencies. The use of cannabis can reduce the frequency of migraines for many patients. It is also useful for common tension headaches. Cannabinoids interact with migraines in several specific ways, similar to conventional drugs. This suggests they may offer comparable benefits. (Backes, 2016)

Studies also have shown the effectiveness of cannabinoids in the treatment of refractory epilepsy. A significant amount of research has been conducted investigating the interactions between cannabinoids and other conventional antiepileptic drugs.

The exact mechanisms by which cannabinoids act to control epileptic seizures remain unclear, and research into these mechanisms continues at a rapid pace. Several preliminary clinical studies have been conducted evaluating the use of CBD in other genetic and developmental epilepsies that are resistant to treatment. (Wilson, 2025)

### ***Use of cannabis for Tourette syndrome***

Tourette syndrome is a neurological disorder characterized by sporadic movements or vocalizations, commonly referred to as tics. Although there is currently no cure, recent research has explored the potential of cannabis to reduce symptoms associated with the condition. Two high-quality systematic reviews have evaluated the use of medical cannabis for Tourette syndrome, both examining the same clinical trials.

The more recent review provides a comprehensive summary of these studies. Specifically, two randomized controlled trials conducted by the same research group compared THC capsules, with a maximum daily dose of 10 mg, to a placebo in a total of 36 patients with Tourette syndrome.

These trials provide the primary evidence regarding the efficacy and safety of THC in managing the symptoms of this disorder. Tic severity, assessed by multiple measures, and global clinical outcomes were improved with THC capsules. On a 0 to 6 severity scale, symptoms were improved by less than 1 point. No clear link has been established between symptoms of Tourette

syndrome and cannabinoid sites or mechanism of action. Two small trials (assessed as being of fair to poor quality) provide limited evidence for the therapeutic effects of THC capsules on tic severity and global clinical outcomes. There is limited evidence that THC capsules are an effective treatment for improving symptoms of Tourette syndrome. (National Academies of Sciences, Engineering, and Medicine, 2017)

### ***Use of cannabis for anorexia and weight loss***

These two terms are common side effects associated with many diseases, particularly cancer. In 1992, the approved indications for dronabinol were expanded to include the treatment of anorexia linked to weight loss in patients with AIDS.

Four randomized controlled trials involving a total of 255 patients were evaluated, all of which were considered to carry a high risk of bias for reasons that were not further detailed. Each study included dronabinol, with one also investigating inhaled cannabis. Three of the trials were placebo-controlled, while one used the progestational agent megestrol acetate as a comparator. In one study, participants experienced significantly greater weight gain on higher doses of cannabis, containing 3.9 percent THC, and on 10 mg of dronabinol compared to lower doses.

In another study with 88 evaluable patients, those receiving dronabinol gained an average of 0.1 kg, whereas participants in the placebo group lost an average of 0.4 kg, a difference that was not statistically significant.

Overall, investigators concluded that current evidence is insufficient to support the efficacy and safety of cannabis and cannabinoids in treating AIDS-associated anorexia.

A Phase III multicenter, randomized, double-blind, placebo-controlled trial in patients with cancer-related anorexia-cachexia syndrome found no significant differences between treatment groups in appetite, quality of life, or adverse effects. Megestrol acetate proved superior to dronabinol for improving both appetite and weight, while combination therapy offered no additional benefit. Pharmacological interventions for anorexia nervosa have similarly shown limited effectiveness.

In studies of dronabinol therapy, participants experienced modest weight gain compared to placebo, yet no significant changes were observed in eating disorder inventory scores. Some evidence suggests that oral cannabinoids can increase weight in patients with HIV-associated wasting syndrome and anorexia nervosa, but no benefit has been demonstrated in cancer-related anorexia-cachexia. Cannabis has historically been believed to have orexigenic properties, stimulating food intake, and there is limited support for its ability to increase appetite and reduce weight loss in HIV/AIDS.



However, overall, there remains insufficient evidence to confirm or refute the effectiveness of cannabinoids as a treatment for cancer-associated anorexia-cachexia syndrome or anorexia nervosa. (National Academies of Sciences, Engineering, and Medicine, 2017)

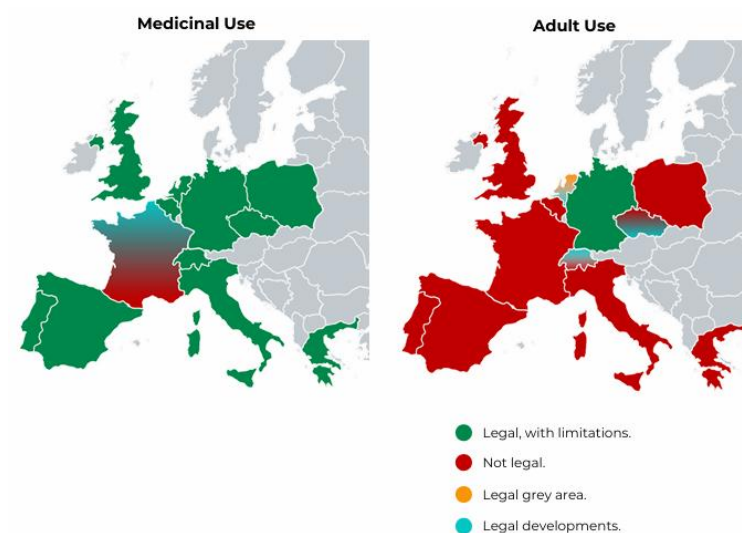
### ***Potential risks of recreational cannabis use***

Acute effects may occur shortly after a single occasion or infrequent cannabis use. Cannabis is used recreationally because of its rewarding effects that are associated with decreased stress reactivity and an enhanced sense of well-being. Rewarding affects can include positive effects e.g., euphoria and the relief of adverse experiences such as anxiety. These effects are linked with the agonist effects of THC at the cannabinoid CB1 receptor that drive THC's modulation of dopaminergic signaling in the nucleus accumbens, the main reward center in brain.

The anxiolytic effects of cannabis are mediated both by THC and CBD in part through their effects in the amygdala. When high THC doses are administered, there is a risk of acute cannabis intoxication, which can manifest as an unpleasant feeling (e.g. irritability, anxiety), distorted perceptions (e.g. paranoid thoughts, short-lived hallucinations, delusions or depersonalization) and dysfunctional behavior. Overdosing and unintentional cannabis use may cause short term psychiatric, gastrointestinal, and cardiovascular problems. (Hoch et al., 2022)

### ***Differences in the market of cannabis products in BiH, and in other countries of Europe and in the world***

Many countries have started medical cannabis programs in the past ten years. Canada launched its program in 2001 and now has nearly 400,000 registered patients. In practice, cannabinoid-based medicines fall into two categories: pharmaceutical or prescription cannabinoids and herbal cannabis or medical cannabis products. Only a few countries have legalized cannabis for medical purposes.



**Figure 1.** Legal status of cannabis in European markets as of the end of 2022 (Prohibition Partners, The Global Cannabis Report (5th edition), 2024)

According to the available data (Figure 1.), it can be seen that the Czech Republic was the first to approve the medical use of cannabis back in 2013, then Poland in 2017, Portugal in 2018, with the fact that in Portugal cannabinoids are approved in the treatment of certain conditions where normal, conventional therapy does not give any results. Medical use of cannabis is also allowed in Belgium and Greece, while a study of 2,000 patients is being conducted in France, and the legal medical use of cannabis is still not allowed in that country. The global legal marijuana market is expected to grow by 20 to 25% over the next five years. (Williamson, Evans, 2000)

## ***Conclusion***

Although there are ongoing efforts to promote the regular use of medical cannabis to treat various ailments, significant barriers still exist. These include complex regulatory restrictions, a lack of high-quality clinical evidence, limitations in research development, social stigma, and insufficient training for health professionals on medical cannabis. As this paper and relevant academic research emphasize, it is clear that cannabis can provide benefits for treating various medical conditions. While some countries, like the Czech Republic, were among the first to legalize cannabis for medical use, Bosnia and Herzegovina still does not allow the sale of medical cannabis preparations. The medical use of cannabis has gained legal support in many countries because it effectively relieves symptoms of chronic pain, epilepsy,

multiple sclerosis, and some types of cancer. A review of the literature shows that the therapeutic effects of cannabis are widely acknowledged; however, more clinical research and strict control of its use are necessary. In Bosnia and Herzegovina, cannabis preparations are currently illegal.

**Author contributions:** Conceptualization, F.K. and E.K.; Methodology, I.T.; Investigation, I.T.; writing—original draft preparation, F.K.; writing—review and editing, E.K.; visualization, E.K.; supervision, I.T. All authors have read and agreed to the published version of the proceeding

**Funding:** This work did not receive funding.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

Ahmed, A. T. M. F., Islam, M. Z., Mahmud, M. S., Sarker, M. E., Islam, M. R. (2020). Hemp as a potential raw material towards a sustainable world: A review. *Heliyon*, 8(e08753).

Appendino, G., Gibbons, S., Giana, A., Pagani, A., Grassi, G., Stavri, M., Smith, E., & Rahman, M. M. (2008). Antibacterial cannabinoids from *Cannabis sativa*: A structure–activity study. *Journal of Natural Products*, 71(8), 1427–1430.

Arboleda, M. F., Prosk, E., Watier, A., Schmulson, M. J. (2020). Cannabinoids in disorders of gut-brain interaction and gastrointestinal motility. *NeuroGastroLatam Review*, 4(3), 171–186.

Backes, M. (2016). *Marijuana as medicine: A practical guide to the use of marijuana for medical purposes*. Zagreb: Mozaik knjiga.

CDC (Centers for Disease Control and Prevention), 2024. Cannabis and public health. Retrieved April 28, 2025, from <https://www.cdc.gov/cannabis/health-effects/chronic-pain.html>

Coelho, M. J., Araújo, M. D., Carvalho, M., Cardoso, I. L., Manso, M. C., Pina, C. (2025). Antimicrobial potential of cannabinoids: A scoping review of the past 5 years. *Microorganisms*, 13(2), 325.

Goločorbin Kon, S., Pavlović, N., Rašković, A., Popović Lalić, M., Milić, N., Milošević, N., Milkov, M. (2015). Application of cannabis in medicine and pharmacy. *Medicinski časopis (Kragujevac)/Medical Journal (Kragujevac)*, 49(4), 130–138.

Hoch, E., Volkow, N. D., Friemel, C. M., Lorenzetti, V., Freeman, T. P., Hall, W. (2022). Cannabis, cannabinoids and health: A review of evidence on risks and medical benefits. *European Archives of Psychiatry and Clinical Neuroscience*, 272(10), 1417–1434. <https://doi.org/10.1007/s00406-022-01427-2>

Kopustinskiene, D. M., Masteikova, R., Lazauskas, R., Bernatoniene, J. (2022). *Cannabis sativa* L. bioactive compounds and their protective role in oxidative stress and inflammation. *Antioxidants (Basel, Switzerland)*, 11(4), 660.

National Academies of Sciences, Engineering, and Medicine. (2017). *The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/24625>.

Vučković, S., Srebro, D., Vujović, K.S., Vučetić, Č., Prostran, M. (2018). Cannabinoids and Pain: New Insights From Old Molecules. *Front Pharmacol*, 9:1259. doi: 10.3389/fphar.2018.01259

Vulfsons, S., Minerbi, A., & Sahar, T. (2020). Cannabis and pain treatment—A review of the clinical utility and a practical approach in light of uncertainty. *Rambam Maimonides Medical Journal*, 11(1), e0002.

Ward SJ, Lichtman AH, Piomelli D, Parker LA. (2021). Cannabinoids and Cancer Chemotherapy-Associated Adverse Effects. *J Natl Cancer Inst Monogr.*, 58:78-85. doi: 10.1093/jncimonographs/lgab007

Williamson, E. M., Evans, F. J. (2000). Cannabinoids in clinical practice. *Drugs*, 60(6), 1303–1314.

Wilson, J. (2025). *Global legal marijuana market: Future trends, insights, and projected 20–25% CAGR by 2029*. Medi-Tech Insights.

## **Medicinska upotreba kanabisa - terapijski potencijal i izazovi**

Farah KONJHODŽIĆ\* Emilija KOPRIVICA Ilma TELIBEČIROVIĆ

Univerzitet u Sarajevu, Farmaceutski fakultet, 71 000 Sarajevo, BiH

\*Autor za korespondenciju: Farah Konjhodžić, farahkonjhodzic@gmail.com

### **Sažetak**

Rastući interes za kanabis i njegove potencijalne zdravstvene koristi učinio ga je ključnom temom za istraživanje i diskusiju. Bilo da se pristupa zbog njegovih ljekovitih svojstava ili iz interesa za njegov uticaj na tijelo i um, bitno je prvo shvatiti osnovne činjenice o kanabisu. Iako postoje brojne studije koje podržavaju terapijske učinke kanabisa, upotreba kanabisa u medicinske svrhe još uvijek nije dozvoljena u većini zemalja. Ovaj rad je osmišljen kako bi prikazao potencijalne terapijske učinke upotrebe kanabisa s posebnim osvrtom na liječenje određenih bolesti, uključujući epilepsiju, gastrointestinalne poremećaje i infekcije bakterijskog i virusnog porijekla. Cilj ovog rada prikazati prisutnost i upotrebu proizvoda od kanabisa na tržištu, uz fokus na njihovu medicinsku primjenu i moguće rizike koji dolaze s njihovom upotrebom.

*Ključne riječi: kanabis, legalizacija kanabisa, medicinska upotreba kanabisa, THC*

**2-O-7**

## **Public health risks of water supply in crisis situations in Bosnia and Herzegovina**

Mirsad MALKIĆ

University of Sarajevo, Faculty of Health Studies, Bosnia and Herzegovina

\*Corresponding author: Mirsad Malkić, [mirsad.malkic@fzs.unsa.ba](mailto:mirsad.malkic@fzs.unsa.ba)

### **Abstract**

Water supply management in crisis situations represents one of the key segments of public safety and sustainable development, particularly in Bosnia and Herzegovina (B&H), a country that in recent decades has faced major natural disasters (floods in 2014 and 2024) and climate change impacts on water resources. This literature review includes works by authors from B&H and the region, supplemented with international research, with the aim of identifying challenges and possible solutions for strengthening the resilience of water supply systems in crisis situations. The analysis showed that the main problems are related to drinking water quality and safety, network losses and insufficient infrastructural resilience, the impact of climate change and extreme weather events, institutional coordination, and awareness of critical infrastructure. The conclusion emphasizes the need for an integrated approach that includes monitoring, preventive measures, infrastructure investment, strengthening institutional cooperation, and the incorporation of international standards such as Water Safety Plans.

*Keywords: water supply, crisis situations, public health*

### ***Introduction***

Safe and continuous access to drinking water represents the foundation of public health and is one of the key indicators of sustainable development. In crisis situations such as floods, droughts, landslides, industrial disasters, or epidemics, water supply systems become highly vulnerable. Contamination or interruptions in supply can lead to a sudden increase in the incidence of waterborne diseases, including acute intestinal infections, viral hepatitis, and poisoning caused by chemical agents. According to the World Health Organization (WHO), in crises, more than 80% of infectious diseases are linked to unsafe water and poor sanitation (WHO 4th ed. Geneva 2017). BiH has a complex administrative structure, and water supply infrastructure in

many municipalities is outdated and fragmented. Analyses show that a significant portion of the network is older than 40 years, which increases the risk of leakage and secondary contamination (Bešić, Obradović, Pašalić, et al., 2013; Ibrahimagić, Bašić, Idrizović, et al., 2018). Crises such as the 2014 and 2024 floods demonstrated that the public health sector and utility companies are not sufficiently coordinated, further increasing risks to population health (Vlaški and Orašanin 2016; Jakovljević 2016). Water supply in BiH, as in many other countries of the region, is a matter of strategic importance. Throughout history, wartime, natural disasters, and climate change have highlighted numerous problems: supply interruptions, infrastructure degradation, microbiological contamination, high operational costs, and weak crisis response (Turčić, Stranjik and Jozić 2018). Managing these systems during crises requires a combination of technical, institutional, resource availability, and preventive measures. Water is a basic resource for life and the foundation of public health, and reliable access to drinking water is a state priority. Interruptions in water supply during crises have immediate and long-term consequences for health, healthcare, and socioeconomic activities (Bonacci, Rubinić and Srdoč 2010; Vidojević, Biondić and Kapelj 2022). B&H, due to its geographical position, hydrological specificities, and complex institutional structure, faces multiple challenges in this field. Water supply management in crises includes risk planning, water quality maintenance, distribution, logistics, and rapid recovery and restoration of infrastructure (Lazić, Jovanović and Milovanović 2024; World Bank, 2023). The global framework of recommendations for water security continuity emphasizes a preventive approach through Water Safety Plans(WSP) and emergency response plans (European Environment Agency, 2020; UNDP Sarajevo, 2019). According to WHO data, more than 2 billion people globally drink water that does not meet minimum safety standards. In crises, this risk increases significantly, and transition countries such as B&H are particularly vulnerable due to insufficient investment in infrastructure and inadequate resource management (WHO 4th ed. Geneva, 2017).

### ***Experimental***

For the purpose of this non-experimental qualitative research, available literature was reviewed electronically across relevant databases (PubMed, Scopus, Google Scholar), along with an analysis of domestic documents, strategies, projects, and reports. The focus was on studies addressing: microbiological and chemical water safety, the impact of climate change and natural disasters on water supply, public health consequences of crisis situations, and institutional and infrastructural challenges in B&H and the region. The search was carried out using keywords related to the topic and

objectives of this paper in English: water supply, crisis situations, climate change, B&H, public health. The goal of this research is to analyze existing studies and sources from B&H and the region, supplemented with international literature, in order to determine the main public health risks and propose recommendations for improving water supply system management in crisis conditions.

## ***Results and Discussion***

Studies conducted in B&H have shown a high incidence of microbiological contamination, especially in rural water systems and wells. Bešić et al. (2013) found that heavy rainfall increases microbiological contamination in water. Ibrahimagić et al. (2018) reported that in 40% of analyzed samples from Zenica-Doboj Canton, the presence of *Escherichia coli* was confirmed. During the 2014 floods, microbiological risks increased further, and the health sector recorded a rise in intestinal infections (Vidojević et al., 2022). In addition to microbiological risks, chemical hazards were also identified. Research in Croatia and eastern B&H indicated that floods and landslides mobilize heavy metals (arsenic, lead, cadmium) and pesticides from polluted soils and industrial zones. Long-term exposure to these contaminants can cause chronic diseases such as cancer or damage to the liver and kidneys (Bonacci et al., 2010). Urban areas have centralized systems, while rural areas rely on local networks without continuous monitoring. Vlaški et al. (2019) point out that the application of international methodologies in B&H is still underdeveloped. Turčić et al. (2018) emphasize that water supply in cities represents critical infrastructure, while the aging of networks increases vulnerability to crises. Challenges in B&H also stem from the complex institutional structure, where responsibilities for water supply are divided between municipalities, cantons, and entities. In crisis situations, this complicates rapid response and alignment with health protocols (European Environment Agency, 2020). Implementation of WSP in B&H is partial, while experiences from Croatia and Serbia show better results in preventing public health consequences. Projects such as the Drina River Basin highlight the need for cross-border risk management. Involving B&H in such initiatives increases capacity to respond to climate and hydrological challenges (Lazić et al., 2024; World Bank, 2023). In crises, microbiological, chemical, infrastructural, and institutional problems combine. Regional experiences show that integrated risk management, crisis planning, and investment in preventive infrastructure reduce health consequences. Necessary measures include: strengthening laboratory capacities and introducing rapid water quality testing, modernizing water supply networks and reducing losses, mandatory implementation of WSP methodology, better



coordination between health institutions, utility companies, and civil protection, and public education on safe use of alternative water sources (UNDP Sarajevo, 2023). Public health risks of water supply in B&H during crises are the result of a combination of factors: climate change, poorly maintained infrastructure, fragmented institutional responsibilities, and weak coordination mechanisms. Experiences from Croatia (Bonacci et al., 2019) and Serbia (Jakovljević 2016) show that integrated risk management models and international standards significantly reduce health consequences.

### ***Conclusion***

The literature review shows that the water supply system in B&H is highly vulnerable to crisis situations due to a combination of microbiological insecurity, high losses, climate change, and weak institutional capacities. It is necessary to: implement WSP in all water companies, modernize infrastructure and reduce water losses, develop crisis plans for floods, droughts, and contaminations, strengthen cooperation between health, civil protection, and utility sectors, and improve cross-border cooperation in water resource management. An integrated approach, based on international standards and local specificities, is crucial for improving resilience to public health risks in water supply crisis situations in B&H.

***Funding:*** This work did not receive funding.

***Informed consent statement:*** Not applicable.

***Conflicts of interest:*** The author declare no conflicts of interest.

### ***References***

- Bešić E, Obradović Z, Pašalić A, Žilić S. (2013). Microbiological composition of untreated water during different weather conditions. *J Health Sci.* 3(1):34-9. DOI: <https://doi.org/10.17532/jhsci.2011.103>
- Bonacci O, Rubinić J, Srdoč D. (2019). Integral management of water resources in Croatia: step towards water security and safety for all. DOI: [https://doi.org/10.1007/978-3-030-22468-4\\_7](https://doi.org/10.1007/978-3-030-22468-4_7)
- European Environment Agency. (2020). Climate change, impacts and vulnerability in Europe 2020. Luxembourg: Publications Office of the European Union. URL: <https://www.eea.europa.eu/en/topics/in-depth/climate-change-impacts-risks-and-adaptation>

Ibrahimagić A, Bašić D, Idrizović A. (2018). Prevalence of *Escherichia coli* in drinking water collected from the local and municipal water supply in Zenica-Doboj Canton, Bosnia and Herzegovina. JSM Clin Cytol Pathol. 3(1):1014. DOI:10.20431/2454-9428.0504002

Jakovljević D. (2016). Assessment of water quality during the floods in May 2014, Serbia. Zb Rad Geogr Inst Jovan Cvijić SANU. 66(1):1-13. DOI: <https://ojs.gi.sanu.ac.rs/index.php/zbornik/article/view/228>

Lazić M, Jovanović N, Milovanović M. (2024). Building reservoirs as protection against flash floods and flood basins management: the case study of the Stubo–Rovni regional water-management system. Water. 16(16):2242.

Turčić I, Stranjik T, Jozić M. (2018). Water supply system as critical infrastructure of a city. Adv Res Sci. 1(1):67-75. URL: <https://ojs.vvg.hr/index.php/adrs/article/view/9>

Vidojević D, Biondić R, Kapelj S. (2022). Assessment of the impact of climate extremes on the groundwater of Eastern Croatia. Water. 14(2):254. URL: <https://www.mdpi.com/2073-4441/14/2/254>

Vlaški D, Orašanin G. (2019). The analysis of the effects of IWA methodology application on water supply systems in Bosnia and Herzegovina. Technical sciences archive. 1(20):47-57. DOI: <https://doi.org/10.7251/afts.2013.0508.041V>

UNDP. (2019). Assessment of disaster risk reduction in the Western Balkans. Sarajevo: UNDP. URL: <https://www.undp.org/bosnia-herzegovina/projects/disaster-risk-reduction-sustainable-development-bosnia-and-herzegovina-phase-ii>

World Bank. (2023). Flood protection and climate adaptation for the Drina River Basin. Washington, DC: World Bank. URL: <https://www.worldbank.org/en/results/2023/08/24/flood-protection-and-climate-adaptation-for-the-drina-river-basin>

WHO. (2017). Guidelines for drinking-water quality. 4th ed. Geneva, World Health Organization. URL: <https://www.who.int/publications/i/item/9789241549950>

# **Javnozdravstveni rizici vodosnabdjevanja u kriznim situacijama u Bosni i Hercegovini**

**Mirsad MALKIĆ**

Univerzitet u Sarajevu, Fakultet zdravstvenih studija, Bosna i Hercegovina

Autor za korespondenciju: Mirsad Malkić, [mirsad.malkic@fzs.unsa.ba](mailto:mirsad.malkic@fzs.unsa.ba)

## **Sažetak**

Upravljanje vodosnabdjevanjem u kriznim situacijama predstavlja jedan od ključnih segmenata javne sigurnosti i održivog razvoja, posebno u Bosni i Hercegovini (BiH), zemlji koja je u posljednjim decenijama suočena s velikim prirodnim nepogodama (poplave 2014. i 2024. godine), kao i klimatskim promjenama koji utiču na vodne resurse. Ovaj pregled literature uključuje radove autora iz BiH i regije, dopunjenih međunarodnim istraživanjima, s ciljem identifikacije izazova i mogućih rješenja za jačanje otpornosti sistema vodosnabdjevanja u kriznim situacijama. Analiza je pokazala da se ključni problemi odnose na: kvalitet i sigurnost pitke vode, gubitke u mreži i nedovoljnu infrastrukturnu otpornost, utjecaj klimatskih promjena i ekstremnih vremenskih događaja, institucionalnu koordinaciju i svijest o kritičnoj infrastrukturi. U zaključku se naglašava potreba za integrisanim pristupom koji podrazumijeva monitoring, preventivne mjere, ulaganja u infrastrukturu, jačanje institucionalne saradnje i uključivanje međunarodnih standarda poput *Water Safety Plans*.

*Ključne riječi: vodosnabdjevanje, krizne situacije, javno zdravlje*

## **Physical hazards in the food chain: Risks to human health and prevention measures**

Emira OSMANOVIĆ ZUKIĆ\* Merima LIGATA Eldina SMJEČANIN

University of Sarajevo, Faculty of Health Studies

\*Corresponding author: Emira Osmanović Zukić, emira.osmanovic@fzs.unsa.ba

### **Abstract**

The presence of physical hazards in the food chain poses a serious public health challenge, as they present a potential risk to consumer health. This paper aims to analyze the frequency of physical hazards in food products based on data from the RASFF (Rapid Alert System for Food and Feed) system, present possible risks of physical hazards to human health, and provide preventive measures. For this paper, data from the RASFF system and relevant scientific literature published in established databases were used. From 2020 to 2025, 96 notifications were recorded, with the most frequently identified contaminants being foreign bodies of unknown origin (27.08%). By product category, the largest number of notifications was for fruit and vegetables (14.58%), cereals and cereal products (12.8%), and nuts, nut products, and seeds (11.48%). Although there is a decrease in the total number of notifications through the RASFF system, the presence of physical hazards still poses a significant risk. Foreign bodies can cause injuries to the gastrointestinal system, including perforations and obstructions, and may lead to permanent psychological trauma for the consumer. Effective risk management requires integrating prerequisite programs and the HACCP system, enabling the identification and monitoring of critical control points at all stages of the production process to ensure a high level of food product safety.

*Keywords: food safety, physical hazards, RASFF system, health, prevention*

### **Introduction**

Food safety is a major public health challenge that significantly affects consumer health and the global economy. Numerous risk factors are associated with food safety, including various types of contaminants such as microbiological and chemical hazards. Although these two types of hazards are most often linked to food safety, physical hazards also have a significant impact on food safety and consumer health. The presence of foreign bodies in

food products is a common reason for consumer complaints to food business operators (FBOs) and competent authorities. Foreign bodies not only cause discomfort and repulsion in consumers but can also lead to physical damage to the gastrointestinal tract or even fatal outcomes (Onyeaka, Jalata, Mekonnen, 2023). Physical hazards can enter food from the external environment, during food processing and handling, during distribution, or, in some cases, may be intentionally added (Nkosi, Bekker, Gower et al., 2022). The most frequently detected physical hazards in the food chain include pebbles, metal parts from equipment and accessories that come into contact with food, nuts, pieces of wood, ropes, glass, fabrics, living or dead parts or whole bodies of pests, paint residues, bones, and other (Djekic, Jankovic, Rajkovic, 2017).

One of the main factors contributing to the presence of physical hazards in food products is the inadequate implementation of control systems and safety measures at all stages of production and distribution. Physical hazards can unintentionally enter the food chain through various means, such as equipment failures, improper handling, non-compliance with sanitary standards by workers, and failure to wear appropriate protective clothing (Onyeaka, Jalata, Mekonnen, 2023). The presence of physical hazards in food poses a serious risk to consumer health. Ingesting foreign bodies can cause injuries to the oral cavity, damage to teeth, perforation of the diaphragm and internal organs, and may lead to secondary infections or death. Additionally, the psychological impact of such incidents can cause long-term trauma for consumers.

In most cases, symptoms appear immediately or shortly after consuming contaminated food (Onyeaka, 2023; Aguiar, Esmerino, Rocha et al., 2018). Previous research has shown that physical and chemical hazards account for approximately 10% of all incidents related to food safety in the European dairy supply chain (Cavalheiro, da Silva, Leite et al., 2020). In addition to direct effects on consumer health, the presence of physical hazards in food products leads to multiple economic consequences for producers, including significant financial losses, damage to business reputation, and an increased risk of legal proceedings and regulatory sanctions, which further burden business viability and competitiveness in the market (Onyeaka, 2023). These factors highlight the need to implement control and preventive measures at all stages of the food production and distribution chain to minimize the presence of physical hazards and ensure the protection of the end consumer. In this context, hazard analysis and critical control points (HACCP), good manufacturing practice (GMP), good agricultural practice (GAP), and standard operating procedures (SOP) are key tools for improving the safety and quality of food products (Aquiar, 2018).

The aim of this paper is to analyze the frequency of physical hazards in food based on data from the RASFF system, to present the risks that physical hazards pose to human health, and to present preventive measures for their mitigation.

### ***Experimental***

For this research, data were obtained from the official EU RASFF (Rapid Alert System for Food and Feed) portal and from scientific literature published in relevant databases using the keywords "food safety," "physical hazards," "RASFF," "health," and "prevention."

### ***Result and discussion***

To analyze the frequency of physical hazards in the food chain, notifications from the Rapid Alert System for Food and Animal Feed (RASFF) were reviewed for the period from 2020 to 2025. To ensure the safety of food and animal feed on the European market, the European Union established the RASFF in accordance with the General Food Law. This system enables the rapid exchange of information on measures related to food safety and food fraud and includes an online database with details of each report, such as the type of hazard, product, date, country of origin, and report (Djekic, 2017).

According to available data from the RASFF portal, a total of 96 notifications related to the presence of physical hazards in food products were recorded during the specified period. The analysis shows that the largest share involved foreign bodies of unknown origin, recorded in 27.08% of cases, followed by insects (16.66%), metal (16.66%), glass (14.58%), and plastic (13.54%). In addition to these contaminants, cases involving stones, wood, fish bones, and shells were also registered. The results of RASFF notifications from 2016 to 2018 indicate a significant increase in reports of physical hazards in food products. During this period, 409 notifications were recorded, with plastic as the most dominant contaminant (24.4%), followed by glass (21.5%), metal (21.3%), and insects (20%). Other contaminants such as rubber, stones, and wood accounted for less than 5% of reported cases. Based on these data, we can conclude that from 2020 to 2025, there was a significant reduction in the presence of plastic fragments in food, which may result from improved food product quality control (Čapla, Zajác, Fikselová et al., 2019).

Regarding the categories of food products in which physical contamination was most often detected from 2020 to 2025, the highest proportion of reports related to fruits and vegetables (14.58%), followed by cereals and cereal products (12.8%), and nuts, nut products, and seeds (11.48%). A comparative analysis with the previous period from 2016 to 2018 reveals a similar pattern:

fruits and vegetables accounted for 24.8% of total reported cases, nuts and seeds 21.1%, and bakery and confectionery products 17.6% of notifications (Čapla, 2019). These data confirm the persistence of certain food categories as dominant sources of physical contamination in the analyzed time frames, and these results align with relevant research conducted in Great Britain and the United States. Research shows that products such as fruits, vegetables, grains, and their products are consistently identified as dominant carriers of the risk of physical contamination, confirming the universality of this problem in different geographical and regulatory contexts (Djekic, 2017). Although the total number of notifications about physical hazards in food products decreased from 2020 to 2025, the presence of foreign bodies in food remains a serious challenge for consumer safety. The fact that the most common contaminants are still objects such as metal, glass, and plastic highlights the need for ongoing monitoring and improvement of preventive measures in the food industry.

Physical hazards in food products can significantly impact human health. Although most foreign bodies (80–90%) that reach the gastrointestinal tract pass through the esophagus and the rest of the digestive system without problems (Onyeaka, 2023), foreign bodies can become lodged in anatomically narrowed regions, such as the cricopharynx, lower esophageal sphincter, ileocecal region, and anus. Such retention can result in various clinical manifestations. Although many cases are asymptomatic, there is a significant risk of developing acute abdominal conditions, including intestinal obstruction and peritonitis, which require immediate medical intervention (Farhadi, Mohtadi, Pakmehr et al., 2024). The severity of the clinical presentation largely depends on the type, size, and shape of the foreign body. Sharp objects or those with larger dimensions can cause serious damage to mucous membranes and tissues, requiring rapid diagnosis and appropriate medical assistance (Jin, Horiguchi, Ma et al., 2023). Physical hazards such as metal and glass often cause cuts in the oral cavity, as well as perforations and injuries throughout the digestive tract. Plastic, wooden fragments, and stones can cause suffocation and damage to teeth and intestines. Insects and other pests, in addition to being potential disease vectors, can cause suffocation and mechanical injuries to consumers (Onyeaka, 2023). Fish bones pose a particular risk to consumer health because their sharp and elongated shapes often lead to intestinal perforation. According to Goh et al., fish bones are most frequently identified as the cause of gastrointestinal perforations (Shahid, Abdalla, Elbakary et al., 2020). Given the seriousness of the potential consequences that physical hazards can have on consumer health, establishing effective prevention measures at all stages of the food chain is essential. Food safety management requires a

systematic and comprehensive approach in which well-defined prerequisite programs (PRPs) play a key role. Prerequisite programs are procedures that establish the basic environmental and operational conditions necessary to produce safe products. These programs provide the fundamental hygienic and technical conditions that must be met before implementing the HACCP system. Key measures of prerequisite programs for preventing physical hazards include good manufacturing practices (GMP), equipment maintenance, workspace control, sanitation, personal hygiene, employee training, and rodent and insect control. Implementing the HACCP system enables effective monitoring and prevention of physical hazards at all stages of the food chain, from raw materials to the final product. A key component of the HACCP system is the identification of critical control points (CCPs)—specific points in the process where measures can be applied to eliminate, prevent, or reduce a hazard to an acceptable level. For physical hazards, the most common CCP tools include metal detectors, sieves, visual inspections, and packaging integrity controls. The combination of properly implemented prerequisite programs and a functional HACCP system establish a multi-level control system that significantly reduces the probability of contamination and ensures a high level of food safety for the end consumer (Šehović A, 2023; Payne, O'Bryan, Marcy et al., 2023).

### ***Conclusion***

Analysis of data from the RASSF system indicates a decrease in notifications about the presence of physical hazards in food products compared to the previous period (2016-2018). However, contamination persists, especially in the fruit, vegetable, grain, and nut categories, with the most common contaminants being metal, glass, and plastic fragments. Physical hazards are an important aspect of food safety because they pose a potential risk to human health. Therefore, continuous improvement of hygienic, sanitary, and technological measures in quality control in the food industry is necessary to ensure food safety and protect consumers.

***Author contribution:*** “Conceptualization, E.O.Z. and M.L.; methodology, E.O.Z and M.L.; investigation, E.O.Z; writing—original draft preparation, E.O.Z. and M.L; writing—review and editing, E.S.; visualization, M.L.; supervision, E.S; All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding.

***Informed Consent Statement:*** Not applicable.

***Conflicts of Interest:*** The authors declare no conflicts of interest.



## ***References***

- Aguiar, R. S., Esmerino, E. A., Rocha, R. S., Pimentel, T. C., Alvarenga, V. O., Freitas, M. Q., ... & Cruz, A. G. (2018). Physical hazards in dairy products: Incidence in a consumer complaint website in Brazil. *Food control*, 86, 66-70. <https://doi.org/10.1016/j.foodcont.2017.11.020>
- Čapla, J., Zájac, P., Fikselová, M., Bobková, A., Belej, L., Janeková, V. (2019). Analysis of the incidence of foreign bodies in European foods. *Journal of microbiology, biotechnology and food sciences*, 9, 370-375.
- Cavalheiro, C. P., da Silva, M. C. A., Leite, J. S. F., da Silva Felix, S. K. R., Herrero, A. M., Ruiz-Capillas, C. (2020). Physical hazards in meat products: Consumers' complaints found on a Brazilian website. *Food Control*, 108, 106892. <https://doi.org/10.1016/j.foodcont.2019.106892>
- Djekic, I., Jankovic, D., Rajkovic, A. (2017). Analysis of foreign bodies present in European food using data from Rapid Alert System for Food and Feed (RASFF). *Food control*, 79, 143-149.
- Farhadi, F., Mohtadi, A., Pakmehr, M., Ghaedamini, H., Shafieian, F., Aminifar, S. A. (2024). This is a successful removal of more than 450 pieces of metal objects from a patient's stomach: a case report. *Journal of Medical Case Reports*, 18(1), 381. <https://doi.org/10.1186/s13256-024-04672-3>
- Jin, S., Horiguchi, T., Ma, X., Yuan, S., Liu, Q. (2023). Metallic foreign bodies ingestion by schizophrenic patient: a case report. *Annals of Medicine and Surgery*, 85(4), 1270-1272.
- Nkosi, D. V., Bekker, J. L., Gower, L. A., Van der Watt, M., Hoffman, L. C. (2022). Physical hazards in *Aepyceros melampus* carcasses killed for meat purposes by aerial and thoracic shots. *Applied Sciences*, 12(14), 6861. <https://doi.org/10.3390/app12146861>
- Onyeaka, H., Jalata, D. D., Mekonnen, S. A. (2023). Mitigating physical hazards in food processing. doi: 10.1002/fsn3.3727
- Onyeaka, H., Jalata, D. D., & Mekonnen, S. A. (2023). Mitigating physical hazards in food processing: Risk assessment and preventive strategies. *Food Science & Nutrition*, 11(12), 7515-7522. <https://doi.org/10.1002/fsn3.3727>
- Payne, K., O'Bryan, C. A., Marcy, J. A., & Crandall, P. G. (2023). Detection and prevention of foreign material in food: A review. *Heliyon*, 9(9).
- Shahid, F., Abdalla, S. O., Elbakary, T., Elfaki, A., & Ali, S. M. (2020). Fish bone causing perforation of the intestine and Meckel's diverticulum. *Case Reports in Surgery*, 2020(1), 8887603. <https://doi.org/10.1155/2020/8887603>

Šehović, A. (2023). HACCP Manual. Investment Foundation Impakt. <https://impakt.ba/wp-content/uploads/2023/12/HACCP-prirucnik.pdf>

## **Fizičke opasnosti u lancu hrane-rizici po zdravlje ljudi i mjere prevencije**

Emira OSMANOVIĆ ZUKIĆ\* Merima LIGATA Eldina SMJEČANIN

Univerzitet u Sarajevu – Fakultet zdravstvenih studija

\*Autor za korespondenciju: Emira Osmanović Zukić, [emira.osmanovic@fzs.unsa.ba](mailto:emira.osmanovic@fzs.unsa.ba)

### **Sažetak**

Prisustvo fizičkih opasnosti u lancu ishrane predstavlja ozbiljan javnozdravstveni izazov, budući da predstavljaju potencijalni rizik za zdravlje potrošača. Cilj rada bio je analizirati učestalost pojave fizičkih opasnosti u prehrambenim proizvodima na osnovu podataka iz RASFF (Rapid Alert System for Food and Feed) sistema, prikazati moguće rizike fizičkih opasnosti po zdravlje ljudi te mjere prevencije. U svrhu izrade rada, korišteni su podaci sa RASFF sistema i dostupna naučna literatura publicirana u relevantnim bazama podataka. U periodu od 2020. do 2025. godine zabilježeno je 96 obavijesti, pri čemu su najčešće identificirani kontaminanti bili strana tijela nepoznatog porijekla (27,08%). U odnosu na kategoriju proizvoda, najveći broj obavijesti zaprimljen je za voće i povrće (14,58%), žitarice i proizvode od žitarica (12,8%), te za orašaste plodove, proizvode od oraštih plodova i sjemenke (11,48%). Iako se bilježi pad ukupnog broja obavijesti putem RASFF sistema, prisustvo fizičkih opasnosti i dalje predstavlja značajan rizik. Strana tijela mogu izazvati povrede gastrointestinalnog sistema, uključujući perforacije i opstrukcije, te potencijalno dovesti do trajnih psiholoških trauma potrošača. Efikasno upravljanje rizicima zahtijeva integraciju preduslovnih programa i HACCP sistema, koji omogućavaju identifikaciju i nadzor kritičnih kontrolnih tačaka u svim fazama proizvodnog procesa, s ciljem osiguranja visoke razine sigurnosti prehrambenih proizvoda.

*Ključne riječi: sigurnost hrane, fizičke opasnosti, RASSF sistem, zdravlje, prevencija*

## Consumer perception and sensory assessment of diluted milk: evaluating awareness and detection limits

Aleksa PAVLIS

<sup>1</sup>University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine,  
Republic of Serbia

Corresponding author: Aleksa Pavlis, aleksapavlis@gmail.com

### Abstract

Milk adulteration by adding water reduces nutritional value, undermines consumer trust, and can pose food safety risks. This study continues the 2024 research and was conducted during the International Student Camp 2025, held in March in Palić, Serbia. Out of 84 participants from Hungary, Romania, Slovakia, and Serbia, 60 took part. A short perception questionnaire was combined with a blinded sensory evaluation. Four coded cow's milk samples were prepared with predetermined, concealed meanings: A – undiluted (0% water), B – 5% water, C – 15% water, and D – 30% water. All dilutions were made using commercially bottled water and pasteurized milk with 2.8% fat from the same production batch.

Participants first completed a demographic and lifestyle section, followed by tasting each sample, describing differences in taste or texture, and finally ranking the samples by perceived dilution or identifying the undiluted one. A consistent pattern was observed: sample A was most often described as natural and recognized as undiluted, while sample D was perceived as watery or thin. The boundary between samples B and C lay near the perceptual threshold and was often misjudged. Strong dilutions were readily detected by taste, while mild ones were not, supporting the need for consumer education and regular market monitoring.

*Keywords: milk dilution, sensory analysis, detectability, consumer perception, food safety*

### Introduction

Milk is a key component of human nutrition, providing essential proteins, calcium, vitamins, and minerals, and its regular consumption across all age groups highlights its public health importance. However, adulteration by dilution with water remains a widespread issue globally. Recent studies show that even with modern spectroscopic and chemometric methods, detecting

low-level dilution remains challenging (Ceniti et al., 2023). Such adulteration lowers nutritional value and may compromise microbial and chemical safety, particularly when poor-quality water or masking additives are used.

This study builds on previous findings from Vojvodina, where a clear gap between awareness and understanding of milk adulteration was identified (Pavlis, 2024). While over 60% of respondents said they would avoid diluted milk, only 35.7% fully understood the term “adulteration,” and 76% supported stricter quality control. To expand on these insights, the current phase adds a blinded sensory component to evaluate detection accuracy across standardized dilution levels (A = 0%, B = 5%, C = 15%, D = 30%), prepared with commercially bottled water and pasteurized 2.8% fat milk. The aim is to determine how reliably untrained participants can detect dilution and to compare sensory findings with their stated beliefs about milk quality and safety. The results are expected to guide consumer education and strengthen dairy quality control practices.

### ***Experimental***

The study combined a short questionnaire with a blinded sensory test to evaluate both stated attitudes and the actual detectability of milk dilution. Participation was anonymous and voluntary. 60 participants provided informed consent and were included in the analysis. Sensory data were based only on those who tasted the samples. Non-tasters were kept in descriptive summaries, with reasons such as intolerance or a preference to drink milk only in mixed form.

Four standardized cow’s milk samples were prepared and coded A, B, C, and D, with a fixed scheme withheld from participants: A undiluted (0% water), B 5% water, C 15% water, and D 30% water. Each dilution was prepared volumetrically using commercially bottled still water and a single batch of pasteurized milk (2.8% fat). Per-liter compositions were as follows: A 1000 mL milk; B 1000 mL milk + 53 mL water (1.053 L total); C 1000 mL milk + 176 mL water (1.176 L); and D 1000 mL milk + 429 mL water (1.429 L). All samples were served in identical cups under the same conditions, with about 30 mL per portion. The procedure began with a short demographic and habit questionnaire, followed by tasting each coded sample and noting perceived differences or descriptors (e.g., “natural,” “watery,” “thin”). Participants then ranked the samples by perceived dilution or marked which sample contained no added water. The code meanings were revealed only after completion. The main objective was to determine recognition accuracy across dilution levels, particularly identification of A as undiluted and D as most diluted, while secondary observations focused on frequent confusions between B and C and recurring sensory descriptions.

## ***Results and Discussion***

The analytic set comprised 60 participants, of whom 56 completed the tasting and four did not. Recorded reasons included intolerance and a preference not to drink plain milk. All sensory findings are therefore based on tasters only. Four coded cow's milk samples were tested under identical conditions: A (0% water), B (5%), C (15%), and D (30%), prepared volumetrically with commercially bottled still water and a single batch of pasteurized 2.8% fat milk.

Demographic data reflected a typical young adult population. Among 49 respondents who reported sex, 73.5% were female ( $n = 36$ ) and 26.5% male ( $n = 13$ ). Year of birth was available for 42 participants, ranging from 1993 to 2007, with a median near 2001–2002. Country of residence was recorded for 40 respondents: Hungary ( $n = 21$ ), Romania ( $n = 15$ ), Serbia ( $n = 3$ ), and Slovakia ( $n = 1$ ). Towns were noted only contextually and not analyzed statistically. Lifestyle and milk-use data ( $n = 41$ ) were used as descriptive context rather than explanatory factors. Their potential influence on sensory perception, particularly the effects of tobacco, alcohol, coffee, and tea habits on taste sensitivity, will be explored in the next research phase.

Sensory analysis showed consistent qualitative patterns. Nineteen tasters completed the ranking task, which revealed frequent confusions between samples B and C, with no participant providing the fully correct sequence A–B–C–D. The “no added water” field was completed by 24 participants, where sample A was consistently identified as undiluted, providing a stable reference. Free-text descriptors confirmed these findings: D was most often described as watery or thin, and A as natural or regular. These results indicate reliable perception at the extremes and an unstable boundary between B and C for untrained assessors.

Overall, the findings are consistent with established sensory literature: strong dilution is easily detected without prior training, while subtle differences near the perceptual threshold require either assessor training, denser reference intervals, or instrumental confirmation. In practice, the A–D setup functions as a rapid screening method for pronounced watering, while finer discrimination should rely on density measurement, freezing-point depression, or other instrumental verification methods. In Serbia, the quality and safety of milk are regulated by the Food Safety Law (Official Gazette of the Republic of Serbia, No. 41/2009; 10/2013) and the Veterinary Law (Official Gazette of the Republic of Serbia, No. 91/2010). These legal frameworks define production, processing, and control standards for milk and dairy products, ensuring compliance with both national and international

safety requirements. Regulations derived from these laws further specify acceptable microbiological and chemical limits, hygiene measures, and procedures for official control, forming a comprehensive system that maintains product integrity and protects consumer health.

### ***Conclusion***

Under blinded conditions, participants reliably detected only the strongest dilution. Sample A (0% water) was consistently identified as undiluted, while D (30% water) was most often described as watery or thin. In contrast, B (5%) and C (15%) were frequently confused, indicating that moderate dilution lies near the perceptual threshold and cannot be reliably detected by taste alone. The A–D setup therefore functions as a rapid sensory screen for clear cases of watering, while borderline samples require instrumental confirmation, such as density or freezing-point analysis. These findings highlight that taste can reveal only major deviations in milk quality and reinforce the need for consumer education and consistent, transparent market control.

***Funding:*** This work did not receive funding.

***Informed Consent Statement:*** Informed consent was obtained from all subjects involved in the study.

***Acknowledgments:*** The author thanks Prof. Dr. Marija Pajić for guidance and support. Deep gratitude to Dr. Csaba Csorba, PhD, President of the Association of Hungarian Veterinarians in Serbia (Udruženje veterinara Mađara Srbije / Magyar Állatorvosok Szerbiai Egyesülete) and to the Association itself for enabling the organization and execution of this study at the International Student Camp 2025.

***Conflicts of Interest:*** The author declares no conflicts of interest.

### ***References***

Ceniti, C., Spina, A. A., Piras, C., Oppedisano, F., Tilocca, B., Roncada, P., ... & Morittu, V. M. (2023). Recent advances in the determination of milk adulterants and contaminants by mid-infrared spectroscopy. *Foods*, 12(15), 2917.

Pavlis, A. (2024). Diluted Milk: Health Threat or Harmless Practice? In *Proceedings of the 9th Student Congress Food–Nutrition–Health (HIZ 2024)*, Sarajevo, Bosnia and Herzegovina, p. 207.

Food Safety Law of the Republic of Serbia. (2009; 2013). *Official Gazette of RS*, 41/2009; 10/2013.

[https://www.paragraf.rs/propisi/zakon\\_o\\_bezbednosti\\_hrane.html](https://www.paragraf.rs/propisi/zakon_o_bezbednosti_hrane.html) (accessed 25/9/2025).

Veterinary Law of the Republic of Serbia. (2010). *Official Gazette of RS*, 91/2010. [https://www.paragraf.rs/propisi/zakon\\_o\\_veterinarstvu.html](https://www.paragraf.rs/propisi/zakon_o_veterinarstvu.html) (accessed 25/9/2025)

## **Percepcija potrošača i senzorna procena razblaženog mleka: procena informisanosti i pragova uočljivosti**

Aleksa PAVLIS

Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za veterinarsku medicinu,  
Republika Srbija

Autor za korespondenciju: Aleksa Pavlis, [aleksapavlis@gmail.com](mailto:aleksapavlis@gmail.com)

### **Sažetak**

Falsifikovanje mleka dodavanjem vode smanjuje njegovu nutritivnu vrednost, narušava poverenje potrošača i može predstavljati rizik po bezbednost hrane. Ovo istraživanje predstavlja nastavak rada iz 2024. godine i sprovedeno je tokom međunarodnog Studentskog kampa 2025, održanog u martu na Paliću. Od ukupno 84 učesnika iz Mađarske, Rumunije, Slovačke i Srbije, u istraživanju je učestvovalo 60 ispitanika. Kratka anketa o percepciji uparena je sa slepom senzornom analizom. Testirana su četiri šifrovana uzorka kravljeg mleka sa unapred definisanim, ispitanicima nepoznatim značenjima: A – nerazblaženo mleko (0% vode), B – 5% vode, C – 15% vode i D – 30% vode. Uzorci su pripremljeni flaširanom vodom i pasterizovanim mlekom sa 2,8% mlečne masti, iz iste serije proizvoda. Ispitanici su najpre popunjavali deo ankete o demografskim podacima, navikama i mogućim alergijama, zatim degustirali uzorke i beležili zapažene razlike. Uzorak A je najčešće opisan kao prirodan i prepoznat kao onaj bez vode, dok je uzorak D najčešće opisan kao vodenast ili razređen. Granica između uzoraka B i C bila je blizu perceptivnog praga i često pogrešno procenjena. Dobijeni rezultati potvrđuju da su veća razblaženja prepoznatljiva ukusom, dok su manja teža za detekciju, što ukazuje na potrebu za edukacijom potrošača i redovnom kontrolom tržišta.

*Ključne reči: razblaživanje mleka, senzorna analiza, percepcija potrošača, uočljivost, bezbednost hrane*

## Aflatoxin: Perspectives of Producers and Consumers

Djordje PEURAČA

University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine,  
Republic of Serbia

Corresponding author: Djordje Peurača, djordje.vaterpolista@gmail.com

### Abstract

Milk is a key component of human nutrition and must meet strict safety and quality standards. One of the major threats to dairy safety is contamination by aflatoxins—highly toxic and carcinogenic compounds produced by *Aspergillus* species, commonly found in animal feed. When consumed by dairy cows, these toxins can appear in milk, particularly as aflatoxin M1 (AFM1). This study explores the level of awareness and practices related to aflatoxins among dairy producers and consumers in Serbia. Data were collected via questionnaires, separately targeting farmers and consumers, to assess knowledge, practices, and attitudes regarding aflatoxin contamination and prevention. Results indicate that while most producers are aware of the issue and some use preventive measures such as mycotoxin binders, gaps still exist, especially among small-scale farms. Consumer awareness remains low, but a majority expressed willingness to pay more for milk guaranteed to be aflatoxin-free. These findings highlight the need for improved education, tighter regulations, and better production practices to ensure safer milk and protect public health.

*Keywords: Aflatoxin M1, Milk safety, Dairy production, Mycotoxins, Animal feed, Consumer awareness, Food regulation*

### Introduction

Milk as one of the most important animal products which is used in human nutrition, must be of exceptionally high quality and completely safe for health. One of the biggest problems in dairy production is caused by mycotoxins in animal feed. The most dangerous toxin that occurs is aflatoxin. Aflatoxin is a collective term for a group of toxic and carcinogenic secondary metabolites produced by some strains of *Aspergillus flavus* and *Aspergillus parasiticus* during growth on animal feed. When feed contaminated with aflatoxin is consumed by dairy cattle, the animals can be affected by the



toxin. Furthermore, milk produced when toxic feed is consumed by the cow can contain aflatoxin (Applebaum, Brackett, Wiseman et al, 1981.) The animal feed that can be contaminated by aflatoxins are corn, corn silage, wheat and the soybean. The occurrence is greater when plants are grown in hot and dry climate regions. The aflatoxins can be found during food production, harvest, storage, and processing. The problem occurs when consuming milk with increased levels of toxins, as such milk can be carcinogenic to humans, immune suppression and can damage the kidneys and liver. (Negash, 2018) The occurrence of aflatoxin AFM1 in milk is result of ingestion of aflatoxin AFB1 in feed .Milk that has an excessively high concentration of aflatoxins can only be safely discarded because the toxins are not destroyed even at high temperatures (neither boiling nor pasteurization of milk reduces the levels). The goal is to raise awareness about this problem and to educate producers with advice on attempting to reduce the levels not only of aflatoxins in food, and consequently in milk, but of all toxins, by using better feed and dietary supplements. (Applebaum et al, 1981) Considering that AFM1 was included in first group by carcinogenicity and milk and its products are consumed daily, most countries have set up maximum residue levels (MRL) of AFM1 in milk. MRL of AFM1 in milk varies from 0.05 µg/kg in EU (European Commission, 2006b) to 0.5 µg/kg established in United States (FDA, 2011), Russia. Regulation for MRL of AFM1 in milk in Serbia (Serbian Regulation, 2011) was recently adopted and harmonized with EU Regulation. However, the problem that occurred in Serbia was presence of AFM1 in milk during January and February 2013 resulted in Regulation changes. During March 2013, relevant authorities changed previously MRL of AFM1 from 0.05 µg /kg to 0.5 µg /kg (Serbian Regulation, 2013; Kos, Lević, Đuragić et al, 2014). This move was made due to poor conditions in agricultural production a year earlier, in order to reduce losses in dairy production. This leads us to question what quality of milk we were drinking at the time and why the limits were increased.

### ***Experimental***

In order to better understand and explore this whole situation, it is necessary to first explain how dairy production generally works in Serbia. It is necessary to consider multiple aspects of dairy production. The important perspectives are those of the producer and the consumer. In milk production, due to poor marketing and product procurement, farmers often try to save in every possible area; unfortunately, these savings manifest directly in the products themselves, often resulting in elevated levels of aflatoxins. One of the problems is saving on the storage of the food itself—people do not treat

grains with products that prevent the growth of fungi and thus toxins. Storage occurs in facilities that are not intended or adapted for this purpose. After that, it is important to see how familiar producers are with certain treatments to reduce the impact of toxins in food and what they specifically think about them. To solving this problem, it is also necessary to communicate with the consumers themselves, to see whether they are aware of this problem in the first place and what they think about it. If they are, do they consider, for example, that store-bought milk is safer than homemade milk or vice versa? Would they be willing to pay more for milk that definitely has low toxin levels or contains none at all? This could, in turn, stimulate the use of certain preparations to reduce toxins and improve the handling of both food products and animals. This research was conducted using a questionnaire approach directed at both producers and consumers, with specific questions designed separately for producers and consumers. The questionnaire conducted with producers consisted of 4 questions: 1. Do they know how aflatoxin appears in milk? a) Yes b) No 2. What do they consider the biggest problem? a) Problem in feed production. b) Problem in feed storage. c) Problem of high costs of feed control. d) Something else: 3. Do they use any preparations aimed at reducing aflatoxins? a) Yes b) No 4. Would they apply all the ministry's recommendations so that their milk could be labeled as AFLATOXIN FREE? a) Yes b) No c) Maybe A different questionnaire was given to consumers. 1. Are they generally aware of the problem of aflatoxin in milk? a) Yes b) No 2. Where they usually buy milk products? a) In store b) in farmers market c) Directly from producers 3. Do they think that domestic milk is safer than store-bought milk? a) Yes b) No 4. Would they be willing to pay more for milk that is AFLATOXIN FREE? a) Yes b) No

### ***Results and Discussion***

In the whole research consisted of 20 farmers raising between 30 and 300 cows. In this particular case notable differences in production practices were observed between small- and large-scale producers. The bigger producers are more responsible and take care a little bit more about the problems with aflatoxin in animal feed and in milk.

With regard to awareness of aflatoxin contamination, 85% of respondents reported being informed about the issue, whereas 15% indicated a lack of knowledge. When asked about the main challenges in production, 50% identified feed production as the primary concern, 35% highlighted storage practices, and 15% cited insufficient control measures as the most significant problem.

Concerning the use of mycotoxin binders (preparations for reducing aflatoxin), 70% of farmers reported employing them in their operations, while 30% did not. Regarding compliance with aflatoxin-free milk regulations, 70% stated that they would strictly adhere to all measures recommended by the Ministry, 15% would not comply, and the remaining 15% would carefully consider implementation before adopting them.

The consumer sample was predominantly male, with an average age of approximately 50 years, although some participants were either younger or older than the average. This may indicate that the awareness of aflatoxins in milk was generally low, with only 35% of respondents reporting familiarity with the issue. However, younger participants demonstrated a higher level of awareness compared to older individuals, indicating generational differences in knowledge and exposure to food safety information. The majority of respondents (80%) reported purchasing milk primarily from retail stores, while 15% sourced their milk from local markets, and only 5% obtained milk directly from producers, typically through familial or personal connections. Moreover, 83% of participants considered store-bought milk to be safer than domestically produced milk and expressed trust in dairy processing companies, further supporting the observed preference for commercially distributed milk. Notably, 66% of respondents indicated a willingness to pay a higher price for milk that complies with regulatory standards and is free from aflatoxins. These findings highlight a generally low level of awareness regarding aflatoxins, but also reveal a strong consumer preference for safer dairy products. This may underscore the need for targeted consumer education and suggests potential opportunities for market strategies focused on food safety assurance.

## ***Conclusion***

Aflatoxins in milk can potentially represent a significant public health concern due to their toxic and carcinogenic properties. This study possibly can reveal weaknesses in Serbia's dairy production, particularly in feed quality control and storage conditions. Although many producers are aware of the issue and apply preventive measures, especially larger farms, smaller producers often lack resources and knowledge. On the consumer side, awareness is relatively low, but there is a clear willingness to pay more for milk labeled as aflatoxin-free, indicating a demand for safer dairy products. Addressing this issue requires coordinated action: educating producers, enforcing stricter regulations, improving storage and feed management, and raising public awareness. From my perspective these steps are essential to reduce contamination and improve milk safety.

**Acknowledgments:** I would to express my gratitude to Professor Marija Pajić for help and support during the preparation of this paper.

## **References**

Applebaum, R.S., Brackett, R.E., Wiseman, D.W., Marth, E.H. (1981). Aflatoxin: Toxicity to Dairy Cattle and Occurrence in Milk and Milk Product. Department of Food Science and the Food Research Institute, University of Wisconsin-Madison, Madison, Wisconsin. Available from: <https://doi.org/10.4315/0362-028X-45.8.752>

European Commission. (2006.). Commission Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs. *Official Journal of the European Union*

Jovanović, R (1998). Ishrana krava., Udžbenik Poljoprivrednog fakulteta u Novom Sadu

Kos, J., Lević, J., Đuragić, O., Kokić, B., Miladinović, I. (2014). Occurrence and estimation of aflatoxin M1 exposure in milk in Serbia, Food Control, 38:41-46, <https://doi.org/10.1016/j.foodcont.2013.09.060>

Negash, Demissie. (2018). A review of aflatoxin: occurrence, prevention, and gaps in both food and feed safety, Journal of Applied Microbiological Research, <https://www.innovationinfo.org/articles/JAMBR-106.pdf>

Serbian Regulation. (2011). Pravilnik o maksimalnim dozvoljenim količinama rezidua pesticida i drugih kontaminanata u hrani. *Službeni glasnik RS*, br. 25/11

Serbian Regulation. (2013). Izmena pravilnika o maksimalno dozvoljenim količinama aflatoksina M1 u mleku. *Službeni glasnik RS*, br. 20/13.

U.S. Food and Drug Administration (FDA). (2011). Compliance Policy Guide – Sec. 527.400 Whole Milk, Lowfat Milk, Skim Milk - Aflatoxin M1.

## **Aflatoksin sa aspekta proizvođača i potrošača**

Djordje PEURAČA

Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za veterinarsku medicinu,  
Republika Srbija

Autor za korespondenciju: Djordje Peurača, djordje.vaterpolista@gmail.com

### **Sažetak**

Mleko je ključna komponenta u ishrani ljudi i mora ispunjavati stroge standarde bezbednosti i kvaliteta. Jedna od najvećih pretnji bezbednosti mleka jeste kontaminacija aflatoksinima – veoma toksičnim i kancerogenim jedinjenjima koje proizvode vrste gljiva iz roda *Aspergillus*, a koje su česte u stočnoj hrani. Kada krave konzumiraju kontaminiranu hranu, aflatoksini mogu dospeti u mleko, najčešće u obliku aflatoksina M1 (AFM1). Ova studija ispituje nivo informisanosti i prakse koje se odnose na aflatoksine među proizvođačima i potrošačima mleka u Srbiji. Podaci su prikupljeni pomoću strukturisanih upitnika koji su posebno bili namenjeni proizvođačima i potrošačima, sa ciljem procene njihovog znanja, stavova i navika u vezi sa kontaminacijom mleka i merama prevencije. Rezultati pokazuju da su proizvođači uglavnom upoznati sa problemom, a deo njih koristi i preventivne mere poput vezivača mikotoksina, ali i dalje postoje značajni nedostaci, naročito kod manjih farmi. S druge strane, svest potrošača o ovom problemu je relativno niska, iako je većina ispitanika izrazila spremnost da plati više za mleko koje je garantovano bez aflatoksina. Ovi nalazi ukazuju na potrebu za dodatnom edukacijom, strožom regulativom i unapređenjem proizvodnih praksi kako bi se obezbedila veća bezbednost mleka i zaštitilo javno zdravlje.

*Ključne reči: Aflatoksin M1, bezbednost mleka, proizvodnja mleka, mikotoksini, stočna hrana, svest potrošača, regulativa u ishrani*

## **The future of cannabis products in Bosnia and Herzegovina**

Nedim TANKOVIĆ\* Iman BISIĆ Sara POPARA Selma VRABAC Hana  
ŽALIĆ Aleksandra POROBIĆ

Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

Corresponding author: Nedim Tanković, nedimtankovic@ffsa.unsa.ba

### **Abstract**

A wide range of cannabis-derived products exists, including inhaled, oral, dermal, and edible preparations, each with distinct pharmacological profiles. While medical formulations such as nabiximols, nabilone, and dronabinol provide therapeutic benefits in pain, chemotherapy-induced nausea, and multiple sclerosis, recreational use is primarily linked to THC's psychoactive properties. Recent trends reveal increasing THC levels and decreasing CBD content in cannabis products, raising concerns about safety and the growing prevalence of cannabis use disorder. Legalization and regulation offer opportunities for improved quality control, medical access, and economic benefits but also pose risks related to misuse, dependence, and mental health. Evidence highlights the critical need for science-based education and strict regulatory frameworks to balance benefits with the minimization of harms.

*Keywords: Cannabis, Cannabis products, Legalization, Regulation, Public health*

### **Introduction**

Cannabis, a plant belonging to the family *Cannabaceae*, has long been the subject of extensive discussions and debates at the global level. The World Health Organization defines cannabis as a generic term used to describe several psychoactive preparations derived from the *Cannabis sativa* plant. The principal psychoactive constituent of cannabis is delta-9-tetrahydrocannabinol (THC). Among the other chemical compounds present, classified as cannabinoids, cannabidiol (CBD) is of particular significance, as it does not exert psychoactive effects but demonstrates numerous potential therapeutic properties. Another commonly used term in many countries is marijuana, which generally refers to the leaves of the cannabis plant or other raw plant material. Unpollinated female plants are commonly used for the

production of hashish (*WHO*, 2025). A broad spectrum of products is derived from cannabis and its constituents, including dried flowers for smoking or vaporization, cannabis oil (CBD/THC oil) for oral or topical application, vaporizers enabling cannabinoid inhalation without combustion and thereby reducing harmful side effects of smoking, as well as edible formulations such as cakes, chocolates, candies, beverages, and drops. Other preparations include tinctures, capsules, pills, concentrates, creams, and balms. It is important to note that these preparations differ in the concentration of psychoactive components with some containing higher, and others lower levels, and therefore may be applied for medical, industrial, or recreational purposes, the latter often involving misuse. In medicine, cannabis has been employed for the alleviation of various forms of pain (chronic, neuropathic, myalgias, etc.), for the treatment of anxiety and depression given the calming effects attributed to CBD, for reducing adverse effects associated with chemotherapy, and for mitigating symptoms of multiple sclerosis, including muscle spasticity and pain.

Recreational use is primarily associated with the psychoactive properties of THC, which induces euphoria, heightened sensitivity to auditory and visual stimuli, and alterations in the perception of time and space. Three principal cannabis species are generally recognized: *Cannabis sativa* (typically a taller and thinner plant, associated with stimulating effects), *Cannabis indica* (a shorter plant with broader leaves, primarily characterized by sedative and relaxing properties, often linked to muscle relaxation and stress reduction), and *Cannabis ruderalis* (a smaller species, less widely known, mainly utilized in industrial applications and in breeding programs to develop varieties that grow and flower more rapidly) (Ryle, S., 2025). Cannabis is a widely cultivated plant that is subject to trade as well as misuse (*WHO*, 2025). With respect to regulatory frameworks, in some countries cannabis use has undergone processes of legalization, whereas in others such measures have not yet been implemented. These aspects will be further elaborated in the continuation of this paper.

## ***Experimental***

This review was conducted through a systematic search of scientific literature across multiple databases. The search strategy focused on publications in English, with no restriction on publication year, in order to capture both historical and recent perspectives. The keywords that were used to identify relevant sources included „cannabis products“, „future of cannabis products“, „regulation“, „legalization“, public health“.

## ***Results and Discussion***

### **Classification of Cannabis Products**

Cannabis products can be classified according to the organ system through which absorption occurs:

- Cannabis products absorbed through the digestive system and consumed in the form of food and beverages;
- Oral cannabis-based preparations, e.g., tablets;
- Cannabis products absorbed through the skin;
- Cannabis products absorbed through the respiratory system, e.g., e-cigarettes, vapes, etc.;
- Cannabis products exhibiting multisystemic absorption.

Within this classification, cannabis products are further divided into twelve subclasses, defined as the medium through which cannabis is introduced into the body and delivered to specific organ systems for absorption. These subclasses include: beverages, concentrates, diffusive and direct inhalation products, plant parts, solid oral preparations, food, topical and transdermal formulations, diverse forms, and others (Nali, M.C., Yang, J.S., Li, Z., 2024). There are four basic types of cannabis preparations:

- *Bhang* – a cannabis preparation consisting of fresh leaves and flowers of marijuana, prepared in the form of a paste using a mortar and pestle.
- Hashish – produced from cannabis trichomes, with THC content varying depending on the preparation method.
- Cannabis oil – obtained through extraction using various solvents.
- Leaves and/or buds – whole plant parts conventionally used by smoking or direct ingestion (Gloss, 2015).

### **Pharmacological Cannabis Preparations**

Cannabis-derived preparations used for medical purposes include:

- Nabiximols – an oromucosal spray used in the treatment of muscle spasms, neuropathic pain, and bladder dysfunction caused by multiple sclerosis.
- Nabilone – a synthetic cannabinoid employed for chemotherapy-induced nausea and vomiting in patients unresponsive to conventional antiemetics.

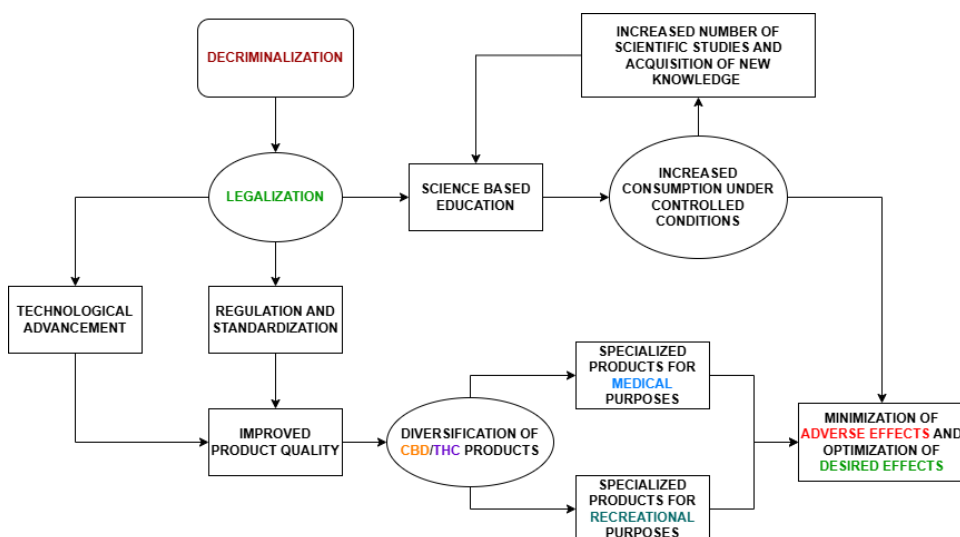


- Dronabinol – a synthetic form of THC used in the treatment of anorexia in AIDS patients, as well as nausea and vomiting in oncology patients (Gloss, 2015).

## Cannabis-Containing Food Products

Cannabis-containing food products, commonly referred to as “edibles,” are currently experiencing substantial popularity. These include cakes, candies, chewing gums, chocolates, and beverages. Such products have gained attention because they are considered a safer alternative that avoids the potentially harmful effects of smoking cannabis. The main distinction between ingestion and inhalation of cannabis products lies in the delayed onset of effects associated with edibles. However, a significant problem arises from consumers often misunderstanding this delayed action, leading them to ingest higher-than-recommended amounts. This frequently results in adverse effects caused by excessive intake of cannabis-containing edibles (Barrus, D.G., Capogrossi, K.L., Cates, S.C., 2016).

## Future of cannabis products



**Figure 1.** Flow chart of the consequences of cannabis product legalization

The future of cannabis products in our market will likely follow global trends, moving toward potential legalization. Numerous consequences accompany such a decision. Decriminalization has already proven effective

in reducing the incidence of severe adverse outcomes, including fatalities associated with hard drug use. Regarding cannabis products, however, most countries have not aimed solely at reducing use, but rather at regulating it (RÊGO, X., Oliveira, M.J., Lameira, C., 2021). Legalization entails the establishment of regulatory frameworks and safety standards, along with inevitable technological advancements. These include the development of more efficient and economical extraction methods such as supercritical fluid extraction, which yields highly pure and high-quality extracts. Nanoencapsulation of cannabinoids enables the development of formulations with high bioavailability, allowing oral administration, precise dosing, and the achievement of stronger therapeutic effects with smaller amounts of active substances. Advances in cannabis cultivation aim to increase yields of specific strains while minimizing environmental contamination. (Kolesarova, M., Simko, P., Urbanska, N., 2023; Gonzalez, R., 2024)

A study conducted between January 1, 1995, and December 31, 2014, analyzing nearly 40,000 cannabis samples, found that THC concentrations increased from 4% to 12%, while CBD levels decreased from 0.28% to <0.15%, raising the THC/CBD ratio from 14:1 to 80:1. Such products are primarily intended for recreational use, and their application in medicine is at best suboptimal, and potentially dangerous due to high THC levels being one of the most important risk factors for cannabis induced psychosis disorder. By diversifying products and ensuring high quality standards, it is possible to minimize adverse effects and optimize therapeutic outcomes of cannabis-based medicines.

In a 16-year observational study, time-dependent associations were identified between increased cannabis potency and first admissions for cannabis use disorder (CUD) treatment (Freeman, T.P., van der Pol, P., Kujipers, W., 2018). Meta-analyses have shown that among cannabis users, 22% (18–26%) develop CUD, 13% (8–18%) cannabis abuse (CA), and 13% (10–15%) cannabis dependence (CD). Cohort studies estimate that the risk of developing CD rises to 33% (22–44%) among young individuals engaged in regular (weekly or daily) cannabis use (Leung, J., Chan, G.C.K., Hides, L., 2020).

We may conclude that education aimed at promoting responsible cannabis use is not at the level it should be, and greater attention is required to prevent it from being reduced to a mere formality. With adequate education, the likelihood of responsible use in controlled settings increases, creating opportunities for scientific research with highly relevant outcomes, thereby further improving public education.

## ***Conclusion***

The legalization of cannabis products carries substantial implications for public health, the economy, and society. Legalization offers benefits such as increased tax revenues and improved access to medical cannabis, while regulation ensures safer markets and reduces black-market risks. However, challenges include potential misuse, mental health risks, dependence, and difficulties in quality control and limiting access to minors. A regulated framework, accompanied by strict oversight and education, could mitigate these risks. The positive and negative experiences of countries that have legalized cannabis provide valuable insights for shaping future policies aimed at maximizing benefits and minimizing harms for society as a whole.

***Author contribution:*** Conceptualization, N.T. and I.B.; methodology, N.T.; investigation, N.T., I.B., S.V., S.P., H.Ž; writing- original draft preparation, N.T., I.B., S.V., S.P., H.Ž; writing-review and editing, N.T. and I.B.; visualization, N.T.; supervision, A.P. All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding.

***Conflicts of interest:*** The authors declare no conflicts of interest.

## ***References***

- Barrus, D.G., Capogrossi, K.L., Cates, S.C., Gourdet, C.K., Peiper, N.C., Novak, S.P., Lefever, T.W., Wiley, J.L. (2016) “Tasty THC: Promises and Challenges of Cannabis Edibles,” Methods report (RTI Press), 2016, p. 10.3768/rtipress.2016.op.0035.1611. Available at: <https://doi.org/10.3768/rtipress.2016.op.0035.1611>.
- Freeman, T.P., van der Pol, P., Kujipers, W., Wisselink, J., Das, R.K., Rigter, S., van Laar, M., Griffiths, P., Swift, W., Niesink, R., Lynskey, M.T. (2018) “Changes in cannabis potency and first-time admissions to drug treatment: a 16-year study in the Netherlands,” Psychological Medicine, 48(14), pp. 2346–2352. Available at: <https://doi.org/10.1017/S0033291717003877>.
- Gloss, D. (2015) “An Overview of Products and Bias in Research,” Neurotherapeutics, 12(4), pp. 731–734. Available at: <https://doi.org/10.1007/s13311-015-0370-x>.
- Gonzalez, R. (2024) “Supercritical CO2 Extraction: Equipment, Process, and Benefits,” 27 August. Available at: <https://www.rootsciences.com/blog/supercritical-co2-extraction-cannabis-oil-guide/> (Accessed: September 29, 2025).

Kolesarova, M., Simko, P., Urbanska, N., Kiskova, T. (2023) “Exploring the Potential of Cannabinoid Nanodelivery Systems for CNS Disorders,” *Pharmaceutics*, 15(1), p. 204. Available at: <https://doi.org/10.3390/pharmaceutics15010204>.

Leung, J., Chan, G.C.K., Hides, L., Hall, W.D. (2020) “What is the prevalence and risk of cannabis use disorders among people who use cannabis? a systematic review and meta-analysis,” *Addictive Behaviors*, 109, p. 106479. Available at: <https://doi.org/10.1016/j.addbeh.2020.106479>.

Nali, M.C., Yang, J.S., Li, Z., Larsen, M.Z., Mackey, T.K. (2024) “Cannabis-Derived Product Types, Flavors, and Compound Types From an E-Commerce Website,” *JAMA Network Open*, 7(10), p. e2440376. Available at: <https://doi.org/10.1001/jamanetworkopen.2024.40376>.

RÊGO, X., Oliveira, M.J., Lameira, C., Cruz, O.S. (2021) “20 years of Portuguese drug policy - developments, challenges and the quest for human rights,” *Substance Abuse Treatment, Prevention, and Policy*, 16, p. 59. Available at: <https://doi.org/10.1186/s13011-021-00394-7>.

Ryle, S. (2025) What Is Cannabis Ruderalis? Leafwell. Available at: <https://leafwell.com/blog/what-is-cannabis-ruderalis> (Accessed: September 27, 2025).

WHO, Cannabis (2025). Available at: <https://www.who.int/teams/mental-health-and-substance-use/alcohol-drugs-and-addictive-behaviours/drugs-psychoactive/cannabis> (Accessed: September 27, 2025).

## **Budućnost proizvoda od kanabisa na tržištu Bosne i Hercegovine**

Nedim TANKOVIĆ Iman BISIĆ Sara POPARA Selma VRABAC Hana  
ŽALIĆ Aleksandra POROBIĆ

Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

Autor za korespondenciju: Nedim Tanković, nedimtankovic@ffsa.unsa.ba

### **Sažetak**

Postoji širok spektar proizvoda izvedenih iz kanabisa, uključujući inhalacione, oralne, dermalne i jestive pripravke, od kojih svaki ima različite farmakološke profile. Dok medicinske formulacije poput nabixsimola, nabilona i dronabinola pružaju terapijske koristi kod bolova, mučnine izazvane hemoterapijom i multiple skleroze, rekreativna upotreba se prvenstveno povezuje s psihoaktivnim svojstvima THC-a. Najnoviji trendovi pokazuju rast nivoa THC-a i smanjenje sadržaja CBD-a u kanabis proizvodima, što izaziva zabrinutost u vezi s bezbjednošću i rastućom prevalencijom poremećaja upotrebe kanabisa. Legalizacija i regulacija nude prilike za poboljšanu kontrolu kvaliteta, medicinski pristup i ekonomske koristi, ali također nose rizike povezane s zloupotrebom, zavisnošću i mentalnim zdravljem. Dokazi naglašavaju ključnu potrebu za obrazovanjem koje se temelji na naučnim spoznajama i strogo regulativnim okvirima kako bi se uravnotežile koristi uz minimiziranje štetnih efekata.

*Ključne riječi: Kanabis, proizvodi od kanabisa, legalizacija, regulacija, javno zdravlje*

## 2-P-1

### **Correlation between nutrition and toxic stress in children: a literature review with emphasis on the role of nutritional deficiencies in exacerbating toxic stress and their long-term consequences**

Malik BURIĆ

University of Sarajevo, Faculty of Health Studies, Bosnia and Herzegovina

Corresponding author: Malik Burić, malik.buric@fzs.unsa.ba

#### **Abstract**

Toxic stress in early childhood and inadequate nutrition (particularly chronic deficiencies in essential macro- and micronutrients, as well as food insecurity) often coexist and mutually reinforce one another. This review synthesizes evidence on the mechanisms through which nutritional deficits may increase a child's vulnerability to toxic stress (via activation of the HPAxis, inflammation, and epigenetic programming), epidemiological data on the association between poor nutrition and adverse developmental outcomes, and findings from interventional and biomarker studies (e.g., hair cortisol measurements). The literature search included PubMed/Medline, Scopus, Web of Science, and relevant review papers up to September 2025; twelve key articles and reviews were selected. A consistent and robust finding is that food insecurity is associated with poorer cognitive and academic outcomes, along with heightened indicators of chronic stress; mechanistic evidence suggests that deficiencies in iron, zinc, and general energy malnutrition may exacerbate HPA-axis dysfunction and contribute to long-term deterioration of mental and metabolic health.

*Keywords: toxic stress; child nutrition; micronutrient deficiency; HPA axis*

#### **Introduction**

The objective of this study is to synthesize the literature on the relationship between nutritional deficiencies and toxic stress in childhood, with a focus on how nutrient insufficiency exacerbates stress-related outcomes and long-term developmental, cognitive, and socio-emotional consequences (Johnson, Riley, Granger et al., 2013). Early experiences of toxic stress encompass chronic social, economic, or familial stressors that can induce enduring alterations in neurobiological pathways and stress regulation, particularly in the absence of adequate emotional support (Center on the Developing Child, n.d., 2025; Johnson et al., 2013). Toxic stress involves persistent exposure to violence, neglect, unpredictable family environments, or chronic food

insecurity, with cumulative effects mediated through HPA-axis activation, inflammation, and epigenetic modifications (Ling, Robbins, & Xu, 2019; Murgatroyd & Spengler, 2011). Prolonged HPA-axis activation can lead to dysfunction in the hippocampus, prefrontal cortex, and amygdala, compromising emotion regulation and cognitive functions (Maniam, Antoniadis, & Morris, 2014; Radlowski & Johnson, 2013).

Three layers of evidence support the link between nutritional status and toxic stress:

**Epidemiological Evidence:** Food insecurity and micronutrient deficiencies, such as iron and zinc, are correlated with poorer cognitive and socio-emotional outcomes in preschool-aged children (de Oliveira, de Almeida, Gubert et al., 2020; Gallegos, Eivers, & Sondergeld, 2021). Food insecurity functions as a chronic stressor rather than merely a marker of poverty (Gallegos et al., 2021).

**Biomarker and Interventional Evidence:** Hair cortisol concentration (HCC) measurements indicate associations between nutritional deficits and elevated stress in children and caregivers (Ling et al., 2019). Randomized micronutrient supplementation studies yield mixed results, suggesting that single-nutrient interventions are often insufficient (Hinnouho, Bernstein, & Barffour et al., 2019).

**Mechanistic Evidence:** Early nutritional deficits modulate the HPA axis, neurotransmission, myelination, and induce epigenetic modifications that increase stress sensitivity (Grantham-McGregor & Ani, 2001; Radlowski et al., 2013; Maniam et al., 2014; Murgatroyd et al., 2011). Perinatal iron deficiency alters the expression of genes controlling glucocorticoid receptors, producing long-term modifications in stress responsivity (Radlowski et al., 2013; Murgatroyd et al., 2011).

Nutritional deficiencies exert both direct effects, by limiting substrates for neurotransmitter synthesis and myelination (Grantham-McGregor et al., 2001), and indirect effects through HPA-axis modulation and epigenetic changes, thereby amplifying the impact of toxic stress (Maniam et al., 2014; Murgatroyd et al., 2011). Deficiencies in zinc, iron, and vitamin D particularly influence inflammation, neurotransmission, and cognitive development (Maniam et al., 2014; Grantham-McGregor et al., 2001). Epidemiological data indicate a synergistic effect of early nutritional deficits and chronic toxic stress, increasing the risk of adverse educational, human capital, metabolic, and mental health outcomes in adulthood (Nelson, Scott, Bhutta et al., 2020). Interventional evidence highlights the importance of combined approaches that integrate nutritional improvement with psychosocial support (Hinnouho et al., 2019; Ling et al., 2019; Johnson et al., 2013).

## ***Experimental***

The search strategy included PubMed/MEDLINE, Scopus, Web of Science, and PsycINFO up to September 2025. Keywords combined terms such as “toxic stress,” “early life stress,” “food insecurity,” “micronutrient deficiency,” “child,” and “infant.” Included were human studies (ages 0–18) reporting developmental, neurocognitive, psychosocial, or biomarker outcomes, as well as relevant animal and molecular studies. This work constitutes a narrative review; for a systematic approach, the PRISMA protocol is recommended.

## ***Results and discussion***

**Epidemiological evidence:** Household food insecurity is associated with developmental difficulties in vocabulary, cognition, and academic skills (de Oliveira et al., 2020; Gallegos et al., 2021). Food insecurity functions not merely as a marker of poverty but as an independent stressor (de Oliveira et al., 2020; Gallegos et al., 2021). Improved longitudinal studies are needed that simultaneously assess nutritional biomarkers and stress indicators (de Oliveira et al., 2020).

**Biomarkers of chronic stress and nutritional status:** hair cortisol concentration (HCC) is a useful biomarker, though it is subject to variability (Ling et al., 2019). Single-nutrient supplementation rarely alters cumulative stress; combined interventions addressing both nutrition and psychosocial support are preferable (Hinnouho et al., 2019).

**Micronutrients, the Brain, and the HPA Axis:** Evidence for the impact of iron deficiency on cognitive development is the most robust (Grantham-McGregor et al., 2001). Deficiencies in zinc, vitamin D, and other micronutrients modulate the HPA axis and inflammatory pathways (Maniam et al., 2014). Epigenetic mechanisms provide a pathway for lasting modifications in stress regulation (Murgatroyd et al., 2011; Maniam et al., 2014).

**Long-term consequences:** Early nutritional deficits and toxic stress act synergistically to increase the risk of adverse outcomes in adulthood, including educational attainment, human capital, and health (Victora et al., 2008; Nelson et al., 2020). Interventions that target nutrition alone are insufficient; integrated solutions are required (Hinnouho et al., 2019).

## ***Conclusion***

Food insecurity and nutritional deficiencies—particularly in iron and zinc—exacerbate the effects of toxic stress through modulation of the HPA axis, inflammatory pathways, and epigenetic programming, thereby increasing the risk of adverse cognitive, behavioral, and metabolic outcomes. Interventions



should be integrated: nutritional support should be combined with psychosocial interventions and policies that reduce chronic family stressors. Enhanced longitudinal and interventional studies are needed that simultaneously assess both biological and socio-environmental factors.

**Funding:** This work was not funded.

**Informed consent statement:** Not applicable.

**Conflicts of interest:** The author declare no conflicts of interest.

## **References**

Center on the Developing Child at Harvard University. (n.d.). Toxic Stress: What is toxic stress? Harvard University, Center on the Developing Child. Accessed 23/09/2025. URL: <https://developingchild.harvard.edu/key-concept/toxic-stress/>

de Oliveira, K.H.D., de Almeida, G.M., Gubert, M.B., Moura, A.S., Spaniol, A.M., Hernandez, D.C., Pérez-Escamilla, R., Buccini, G. (2020). Household food insecurity and early childhood development: Systematic review and meta-analysis. *Maternal & Child Nutrition*, 16(3), e12967.

Gallegos, D., Eivers, A., Sondergeld, P., Pattinson, C. (2021). Food insecurity and child development: A state-of-the-art review. *International Journal of Environmental Research and Public Health*, 18(17), 8990.

Grantham-McGregor, S., Ani, C. (2001). A review of studies on the effect of iron deficiency on cognitive development in children. *The Journal of Nutrition*, 131(2S-2), 649S–666S.

Hinnouho, G.-M., Bernstein, R.M., Barffour, M.A., Arnold, C.D., Wessells, K.R., Ratsavong, K., Bounheuang, B., Kounnavong, S., Hess, S.Y. (2019). Impact of two forms of daily preventive zinc or therapeutic zinc supplementation for diarrhea on hair cortisol concentrations among rural Laotian children: A randomized controlled trial. *Nutrients*, 11(1), 47.

Johnson, S.B., Riley, A.W., Granger, D.A., Riis, J. (2013). The science of early life toxic stress for pediatric practice and advocacy. *Pediatrics*, 131(2), 319–327.

Ling, J., Robbins, L.B., Xu, D. (2019). Food insecurity and hair cortisol in low-income mother–child dyads. *Western Journal of Nursing Research*, 41(12), 1813–1828.

Maniam, J., Antoniadis, C., Morris, M.J. (2014). Early-life stress, HPA axis adaptation, and mechanisms contributing to later health outcomes. *Frontiers in Endocrinology*, 5, 73.

Murgatroyd, C., Spengler, D. (2011). Epigenetic programming of the HPA axis: Early life decides. *Stress*, 14(6), 581–589.

Nelson, C.A., Scott, R.D., Bhutta, Z.A., Harris, N.B., Danese, A., Samara, M. (2020). Adversity in childhood is linked to mental and physical health throughout life. *BMJ*, 371, m3048.

Radlowski, E.C., Johnson, R.W. (2013). Perinatal iron deficiency and the developing brain. *Frontiers in Human Neuroscience*, 7, 585.

### **Povezanost ishrane i toksičnog stresa kod djece: pregled literature s naglaskom na ulogu nutritivnih deficita u pogoršanju toksičnog stresa i njihovim dugoročnim posljedicama**

Malik BURIĆ

Univerzitet u Sarajevu, Fakultet zdravstvenih studija, Bosna i Hercegovina

Autor za korespondenciju: Malik Burić, e-mail adresa: malik.buric@fzs.unsa.ba

#### **Sažetak**

Toksični stres u ranom djetinjstvu i nezadovoljavajuća ishrana (posebno hronični nedostatak odgovarajućih makro- i mikronutrijenata te prehrambena nesigurnost) često koegzistiraju i međusobno se pojačavaju. Ovaj pregled sintetizira dokaze o mehanizmima kojim nutritivni deficiti mogu povećati ranjivost djeteta na toksični stress, kroz aktivaciju Hypothalamic–Pituitary–Adrenal (HPA) osi, upala, epigenetsko programiranje), epidemiološke podatke o povezanosti siromašne prehrane i lošeg razvoja djece, te rezultate intervencijskih i biomarkernih studija (npr. mjerenja kortizola u kosi). Pretraga literature obuhvatila je PubMed/Medline, Scopus, Web of Science i relevantne pregledne radove do septembra 2025. godine; izabrano je 12 ključnih radova i pregleda. Snažan i dosljedan nalaz jest da je prehrambena nesigurnost povezana s lošijim kognitivnim i školskim ishodima te većim indikatorima hroničnog stresa; mehanistički dokazi upućuju da deficiti željeza, cinka i opća energetska pothranjenost mogu pogoršati HPA-disfunkciju i dugoročno pogoršati mentalno i metaboličko zdravlje.

*Ključne riječi:* toksični stres; ishrana djece; mikronutrijentski deficit; HPA-osa

## Detection of *Enterococcus faecalis* in untreated well water

Azra Fočo

Faculty of Health Studies, University of Sarajevo

Corresponding author: Azra Fočo, [azra.foco@fzs.unsa.ba](mailto:azra.foco@fzs.unsa.ba)

### Abstract

In Bosnia and Herzegovina, there is a large percentage of households that use well water, which is untreated with chlorine or other disinfecting agents, for drinking, personal hygiene, space hygiene, and irrigation. This, in turn, puts human health at risk. In this research, *Enterococcus faecalis* was used as the indicator microorganisms. According to the current regulation on the health safety of drinking water in the Canton of Sarajevo (Official Gazette), the permitted reference values for *Enterococcus faecalis* are <1 colony (cfu). Regular microbiological and physicochemical analyses are of great importance in protecting the health of people who consume untreated well water. Unfortunately, there is no legal regulation requiring well owners to conduct mandatory microbiological testing. Pathogenic microorganisms transmitted through drinking water cause several diseases, the most common of which are: cholera, dysentery, diarrhea, hepatitis, etc. This study will conduct a microbiological analysis of untreated well water in the Federation of Bosnia and Herzegovina, aiming to isolate and identify *Enterococcus faecalis*. The study yielded significant data. Between March 2024 and July 2025, a total of 37 samples of untreated well water were collected, of which *Enterococcus faecalis* was identified in 15 samples. Based on the reference values defined in the Regulation on the Health Safety of Drinking Water, these samples are not considered safe for human consumption and should not be used as such. As a conclusion of this study, it can be stated that there is a great need to raise awareness about the importance of regular microbiological monitoring of well water, as well as the need to amend legislation to clearly define this analysis as mandatory, all aimed at protecting public health.

*Keywords: Well water, microbiological analysis, Enterococcus faecalis, pathogenic microorganism, water disinfection.*

### Introduction

As world population rises we are facing growing human needs for resources, with needs for water are leading and the most affected areas are those of still developing countries (Ahmed, Zounmat-Kermani, Scholz, 2020). Two fifths

of overall world population are facing serious problems due to water scarcity and a whole serie of diseases that spread via water sources (Cantor, 1997). Microbic pathogens that can be spread through water sources, such as *Enterococcus faecalis*, cause a vast amount of diseases such as cholera, dysentery, diarrhea, hepatits, thyfus etc. (Udoh, Lawal, Akpan, 2020). *Enterococcus faecalis* is one indicator that show pollution in drinking water and quite often can be detected in natural waters (Yo, Zhang, Ren, 2019). Public health concerns due to contamination of waters are on the rise (Agbasi, Ezguwu, Omeke, 2024). Tracking the sources of fecal pathogenic indicators of water pollution rappresents the best method in order to regulate the quality of water and protection of human health (Field, Samadpour, 2007). The regulation book of drinking water compliance in the Sarajevo county counts as indicators of microbic contamination the following: *Escherichia coli*, coliform bacteria, *Enterococcus faecalis* and aerobic mesophillic bacteria (Official gazette of BiH, 62/17).

### ***Experimental***

37 samples during the period between March 2024 to July 2025 have been tested for this research. Written consent was obtained from well owners for sampling and microbiological analysis of the water samples, as well as for the obtained results for the purpose of scientific research. All the samples have been taken in the Sarajevo county and they are of private possession. Such waters from water well and raw waters, that have not been trated with chlorine or any other disinfection methods is used for drinking, irrigation, personal hygiene and environmental hygiene. The samples have been taken following the standard BAS EN ISO 19 458, taking 0.5 l of water from the well to be put inside sterile bottles marked with the sample password. Samples were collected either using a telescopic sampling rod or directly from the tap, in cases where the well water was supplied through a plumbing system. All of the samples have been immediately transported to the laboratory of Sanitary inspection and Sarajevo water control centre where the samples were tested right away. After obtaining the samples and evidencing them the first step was to control the samples following membrane filtration based on standards of BAS EN ISO 7899-3. from 2025 and with the help of a device for membrane filtration that filters 100 ml of sample through sterile nitrocellulose filter paper using a vacuum pump. For primary analysis a Slanetz- Bartley surface has been used and it was assabmled following the manufacturer instructions. After membrane filtration the sample was saved in a calibered incubator at a temperature of  $36\pm 2^{\circ}\text{C}$   $44\pm 2$  h. When the period of incubation ended we inspected the slides . All of the colonies having a brownish-red coloration rappresent potential colonies of *Enterococcus*

*faecalis*. Filter papers with high amounts of colonies are transferred to a nutrient agar Bil aesculin azid using a sterile forcep and they are incubated for 2 hours at a temperature of 57°C. After the incubation, all black colonies are reported as colonies of *Enterococcus faecalis* and with the help of a calibrated device for counting they are counted and put on an evidence list. All of the samples have been taken in a laboratory that follows the standards of BAS EN ISO 17 025.

### **Results and discussion**

After primary and secondary analysis of collected samples we gathered important data that show that 37 samples of well, raw and untreated waters have 15 samples positive of having *Enterococcus faecalis* pathogen. The percentage is 40,5% that do not meet the standars and criteria of correct waters based on health regulation of water quality of Sarajevo county.

After an epidemic of campylobacteriosis, where more than 2000 people got infected and 76 were hospitalized, Paruch and associates (2019) have been rapidly implementing microbacteriological analysis to well waters where they found and identified pathogenic bacteria and *Enterococcus faecalis*. Beside including DNA analysis as well, other tests have been used in this research (Paruch, Paruch, Sorherm, 2019).

Field and associates (2007) made a microbiological analysis of fecal pathogenics in drinking waters in USA and obtained results that show it is important to increase control monitoring of waters since it contains pathogenic microorganisms. Their conclusions match the conclusions of this work (Field et al, 2007).

Machado and Bordalo (2014) made a microbiological analysis of well waters in Western Africa. The obtained results as the results of this research indicate that we need a more detailed monitoring of well waters aiming for human health protection.

Fahes and associates (2025) have been researching the presence of pathogenic microorganisms in spring water of Lebanon and came to the conclusion that it was not suitable for drinking and it needed disinfection and microbiological control (Fahes, Dib, El Haidari, 2025).

### **Conclusion**

Based on obtained results where 40,5% of the samples showed the presence of *Enterococcus faecalis* we can conclude that there is a big need for changes in lalag regulations that is going to push a more frequent and periodical microbiological analysis of well waters aiming for human health protection. Another thing that is also very important to say is that there is a need for development of awareness for well waters users to implement a safer usage

and well maintenance, that includes regular water disinfection, machanical cleaning a disinfection of water catchment.

**Funding:** This work did not receive funding.

**Conflicts of Interest:** The author declare no conflicts of interest.

## References

Agbasi, J.C., Ezugwu, A.L., Omeke, M.E., Ucheana, I.A., Aralu, C.C., Abugu, H.O., Egbueri, J.C. (2024). More about making profits or providing safe drinking water? A state-of-the-art review on sachet water contamination in Nigeria. *J Environ Sci Health C Toxicol Carcinog.*, 42(4):255-297.

Ahmed, T., Zounemat-Kermani, M., Scholz, M. (2020). Climate Change, Water Quality and Water-Related Challenges: A Review with Focus on Pakistan. *Int J Environ Res Public Health.*, 17(22):8518. doi: 10.3390/ijerph17228518. PMID: 33212957; PMCID: PMC7698392.

Cantor, K.P. (1997). Drinking water and cancer. *Cancer Causes Control*, 8(3):292-308. doi: 10.1023/a:1018444902486. PMID: 9498894.

Fahes, F., Dib, I., El Haidari, R. *et al.* (2025). Chemical, physical and microbiological analyses of different drinking water sources among diverse governorates in Lebanon. *Sci Rep* **15**, 10539; <https://doi.org/10.1038/s41598-025-89048-3>

Field, K., Samadpour, M. (2007). Fecal source tracking, the indicator paradigm, and managing water quality. *Water research*. 41. 3517-38. 10.1016/j.watres.2007.06.056

Machado, A., Bordalo, A.A. (2014). Analysis of the bacterial community composition in acidic well water used for drinking in Guinea-Bissau, West Africa. *J Environ Sci (China)*, 26(8):1605-14.

Paruch, L., Paruch, A., Sørheim, R. (2019). DNA-based faecal source tracking of contaminated drinking water causing a large *Campylobacter* outbreak in Norway 2019. *International Journal of Hygiene and Environmental Health*. 224. 113420. 10.1016/j.ijheh.2019.113420.

Rulebook on sanitary quality of drinking water in Canton Sarajevo, Official gazette of BiH, 62/17

Udoh, A., Lawal, B.K., Akpan, M., Labaran, K.S., Ndem, E., Ohabunwa, U., Tikare, O., Ibrahim, U.I., Amorha, K., Kpokiri, E. (2021). Microbial contamination of packaged drinking water in Nigeria. *Trop Med Int Health*, 26(11):1378-1400. doi: 10.1111/tmi.13672.

Yu, J., Zhang, D., Ren, W., Liu, B. (2019). Transport of *Enterococcus faecalis* in granular activated carbon column: Potential energy, migration, and release. *Colloids Surf B Biointerfaces*, 183:110415.

## **Detekcija *Enterococcus faecalis* u bunarskoj netretiranoj vodi**

Azra Fočo

Fakultet zdravstvenih studija, Univerzitet u Sarajevu

Autor za korespondenciju: Azra Fočo, [azra.foco@fzs.unsa.ba](mailto:azra.foco@fzs.unsa.ba)

### **Sažetak**

U Bosni i Hercegovini postoji veliki postotak domaćinstava koji za piće, održavanje lične higijene, higijene prostora i navodnjavanje koriste bunarsku vodu koja nije tretirana hlorom ili drugim dezinfekcionim sredstvom. Samim tim dovodi se u opasnost ljudsko zdravlje. Ovim istraživanjem *Enterococcus faecalis* je korištena kao ciljna bakterija. Prema važećem Pravilniku o zdravstvenoj ispravnosti vode za piće u Kantonu Sarajevu (Službene novine) dozvoljene referentne vrijednosti *Enterococcus faecalis* su  $< 1$  kolonije (cfu). Veliki značaj u zaštiti zdravlja ljudi koji su konzumenti buraskih netretiranih voda su redovne mikrobiološke i fizičko-hemijske analize. Na žalost ne postoji zakonska regulativa koja nalaže da su vlasnici istih bunara dužni zakonski vršiti redovne mikrobiološke kontrole. Patogeni mikroorganizmi koji se prenose vodom za piće uzrokuju niz oboljenja među kojima su najčešće: kolera, dizenterija, dijareja, hepatitis itd. Ovim istraživanjem će biti mikrobiološki analizirana bunarska netretirana voda na području Federacije Bosne i Hercegovine i potencijalno izolovan i identificiran *Enterococcus faecalis*. Istraživanjem se došlo do značajnih podataka. U periodu od marta 2024. godine do jula 2025. godine uzorkovano je ukupno 37 uzorka bunarske ne tretirane vode, od čega je u 15 uzoraka identificiran *Enterococcus faecalis*. Na osnovu referentnih vrijednosti definisanih u Pravilniku o zdravstvenoj ispravnosti vode za piće ti uzorci nisu zdravstveno ispravni i nebi smjeli kao takvi da se koriste za ljudsku upotrebu. Kao zaključak ovog istraživanja možemo reći da postoji jako velika potreba za razvijanjem svijesti o značaju redovne mikrobiološke kontrole bunarske vode, kao i promjeni zakonske regulative koja će jasno definisati ovu analizu kao obaveznu, a sve u cilju zaštite ljudskog zdravlja.

*Ključne riječi: Bunarska voda, mikrobiološka analiza, Enterococcus faecalis, patogeni mikroorganizmi, dezinfekcija vode.*

## 2-P-3

### **Public health risks of food poisoning in crisis situations in Bosnia and Herzegovina**

Mirsad MALKIĆ

University of Sarajevo, Faculty of Health Studies, Bosnia and Herzegovina

\*Corresponding author: Mirsad Malkić, [mirsad.malkic@fzs.unsa.ba](mailto:mirsad.malkic@fzs.unsa.ba)

#### **Abstract**

Food poisoning represents a significant public health concern during crisis situations, particularly in Bosnia and Herzegovina (B&H), a country that has in recent decades been exposed to natural disasters, armed conflicts, and pandemics. Such circumstances often lead to the deterioration of sanitary conditions, disruptions in supply chains, and an increased risk of food contamination. This paper presents a literature review focused on microbiological, chemical, and physical risks of food poisoning during crises, analyzing experiences from B&H, the broader region, and international sources. The findings indicate that key threats include bacterial pathogens (*Salmonella spp.*, *Escherichia coli*, *Listeria monocytogenes*), mycotoxins, heavy metals, and chemicals that are mobilized during floods and other emergency events. The conclusion emphasizes the need for stronger institutional measures, integrated surveillance systems, and the implementation of international standards such as the Codex Alimentarius and Hazard Analysis and Critical Control Point (HACCP), in order to reduce public health risks during crisis situations in B&H.

*Keywords: food poisoning, crisis situations, public health, food safety*

#### **Introduction**

Food safety represents one of the fundamental issues of public health and a key factor in preserving population health, especially during crisis situations. According to data from the World Health Organization (WHO), around 600 million cases of foodborne illnesses are recorded globally each year, with approximately 420,000 deaths resulting from the consumption of contaminated food. The most vulnerable are developing countries and crisis-affected regions, where preventive and control measures are often limited or entirely disrupted (World Health Organization, 2017). Bosnia and Herzegovina, due to its geographical location, complex political-administrative structure, and vulnerable infrastructure, is particularly exposed to the public health consequences of crisis situations. Experiences from the



armed conflicts of the 1990s, the floods that affected the country in 2014 and 2024, and the global COVID-19 pandemic clearly demonstrated that food safety under crisis conditions represents one of the greatest challenges for public health (Bešić, Obradović, Pašalić, et al., 2013; Ibrahimagić, Bašić, Idrizović, et al., 2018). In such circumstances, disruptions in supply chains, lack of food quality and safety control, use of alternative and often unsafe sources of water and food, as well as reduced capacities of the healthcare system, further increase the likelihood of mass food poisoning. In addition to microbiological contaminants such as bacteria, viruses, and parasites, chemical hazards-including pesticides, heavy metals, mycotoxins, and other harmful substances-also pose significant threats during crisis situations. These substances can enter the food chain as a result of floods, improper storage, or malfunctions in distribution systems. Moreover, physical contamination of food due to damage to facilities and storage areas further complicates the situation (Turčić, Stranjik, and Jozić, 2018). Regional experiences from Croatia, Serbia, and Montenegro show that natural disasters such as floods and earthquakes often cause interruptions in food distribution and controlled processing, leading to an increased risk of food poisoning and outbreaks of foodborne diseases (Lazić, Jovanović, and Milovanović, 2024). Compared to these cases, B&H faces additional challenges due to fragmented institutional authority and a lack of coordinated emergency food safety plans. All of this highlights the critical importance of analyzing public health risks related to food poisoning during crisis situations in B&H. The objectives of this study are to identify the key public health risks of food poisoning, their causes, mechanisms of occurrence, and strategies for prevention and management in crisis conditions in B&H. The research also includes a review of institutional structures, the application of international standards and regulatory frameworks, as well as local and regional practices in managing food safety under crisis conditions.

### ***Experimental***

For the purposes of this literature review, a systematic search of available scientific databases-including PubMed, Scopus, and Google Scholar-was conducted, and the data were analyzed qualitatively. The search focused on studies addressing public health risks related to foodborne illnesses in crisis situations, with particular emphasis on B&H and the broader Southeast Europe region. In addition to international scientific articles, national reports, strategies, guidelines, and projects related to food safety were included, encompassing publications from relevant institutions, the United Nations Development Programme (UNDP), as well as reports from the WHO and the European Food Safety Authority (EFSA). The keywords used in the search

were: *foodborne diseases, crisis situations, public health, and food safety*. The search was limited to works published between 2013 and 2024 to cover contemporary knowledge and experiences; however, older studies providing historical context on crisis situations in B&H and the region were also included. Special attention was given to works by authors from B&H and neighboring countries (Serbia, Croatia) in order to capture the local context, infrastructural and institutional challenges, and to compare regional experiences with international recommendations and standards.

## ***Results and Discussion***

Microbiological contamination of food during crisis situations represents the most prevalent and frequently documented public health risk. The most common foodborne pathogens include *Salmonella spp.*, *Escherichia coli* (particularly enterohemorrhagic strains), *Listeria monocytogenes*, and *Campylobacter spp.* (Bešić et al., 2013; Ibrahimagić et al., 2018). According to reports from B&H, there is a significant increase in the incidence of gastrointestinal infections during flood events, directly linked to the contamination of food and water. Similar experiences were reported in Serbia and Croatia, where the 2014 floods resulted in a rise in cases of diarrhea and suspected foodborne illnesses associated with the consumption of unverified food and water (Lazić et al., 2024). In addition to microbiological risks, chemical hazards pose an equally significant threat during emergencies. Flooding events often lead to the mobilization of pesticides, heavy metals, and industrial pollutants from soil, storage facilities, and plants, which subsequently enter the food chain. In B&H and the surrounding region, cases of increased concentrations of arsenic, lead, and cadmium in agricultural areas have been documented following major flood events (Vlaški & Orašanin, 2019). These contaminants can accumulate in the human body over time, causing chronic diseases such as cancer, cardiovascular disorders, and liver and kidney damage. Reports from Croatia and Serbia also highlight increased levels of mycotoxins in corn and grains following heavy rainfall and floods, directly linked to a heightened risk of food poisoning (Jakovljević, 2016). Physical contamination of food is also common during crisis situations due to damaged infrastructure and disrupted food distribution chains. The presence of foreign bodies such as glass, metal, plastic, or wood in meals-particularly in humanitarian aid packages and large-scale food distributions-has been documented in B&H during the war years, as well as during more recent floods and earthquakes in the region (Ibrahimagić et al., 2018). Reports from public health institutes indicate an increased frequency of food poisoning and gastrointestinal infections in affected areas, especially in rural communities forced to rely on unverified food and water sources

(Bešić et al., 2013). One of the key systemic challenges in B&H is the fragmentation of food safety responsibilities across state, entity, and cantonal institutions. The lack of laboratory capacity, limited implementation of international standards such as the Codex Alimentarius and the HACCP system, and inconsistent controls across different administrative levels further increase the vulnerability of the food safety system (Codex Alimentarius Commission 2020). Experiences from neighboring countries confirm that the implementation of international standards, development of crisis response plans, and strengthened institutional coordination are critical to reducing risks (Turčić et al., 2018). Both the WHO and the EFSA emphasize the importance of integrated monitoring of food and water safety, particularly in crisis settings-an approach that remains insufficiently implemented in B&H (UNDP Sarajevo, 2019; EFSA, 2020).

### ***Conclusion***

The literature review demonstrates that foodborne public health risks during crisis situations in Bosnia and Herzegovina are significant and multifaceted. Microbiological contamination-including bacterial pathogens-chemical contamination from pesticides, heavy metals, and mycotoxins, as well as physical risks such as the presence of foreign objects in food, represent the most prominent threats to public health. An analysis of regional and international experiences indicates that B&H remains particularly vulnerable to foodborne outbreaks during emergencies due to its complex administrative structure, fragmented responsibilities, and limited laboratory capacities. The insufficient implementation of international standards further exacerbates these risks, while experiences from Croatia and Serbia underscore the importance of integrated management, crisis planning, and preventive measures for ensuring food safety. An integrated approach-combining international standards, local expertise, and continuous risk monitoring-can significantly reduce the public health impact of foodborne illnesses in crisis situations and enhance the resilience of the public health system in B&H.

***Funding:*** This work did not receive funding.

***Informed consent statement:*** Not applicable.

***Conflicts of interest:*** The author declare no conflicts of interest.

### ***References***

Bešić, E., Obradović, Z., Pašalić, A., Žilić, S. (2013). Microbiological composition of untreated water during different weather conditions. J Health Sci. 3(1):34-9.

- Codex Alimentarius Commission. (2020). General Principles of Food Hygiene. Rome: FAO/WHO; URL:<http://ngfrepository.org.ng:8080/jspui/handle/123456789/5547>
- European Food Safety Authority (EFSA). (2020). Food safety and crisis management. EFSA Journal;18(6):1-25. DOI:[10.2903/j.efsa.2022.7215](https://doi.org/10.2903/j.efsa.2022.7215)
- Ibrahimagić, A., Bašić, D., Idrizović, A., et al. (2018). Epidemiology of food poisoning in Zenica-Doboj Canton, Bosnia and Herzegovina. JSM Clin Cytol Pathol. 72(4):266-72.
- Jakovljević, D. (2016). Assessment of water quality during the floods in May 2014, Serbia. Geogr Inst Jovan Cvijić SANU. 66(1):1-13. DOI: <https://ojs.gi.sanu.ac.rs/index.php/zbornik/article/view/228>
- Lazić, M., Jovanović, N., Milovanović, M. (2024). Building reservoirs as protection against flash floods and flood basins management: the case study of the Stubo-Rovni regional water-management system. Water. 16(16):2242. URL: <https://www.mdpi.com/2073-4441/16/16/2242>
- Turčić, I., Stranjik, M., Jozić, R. (2018). Food safety risks in crisis situations. Split: University of Split; DOI:10.5772/intechopen.73687
- Vlaški, D., Orašanin, G. (2019). The analysis of the effects of IWA methodology application on water supply systems in Bosnia and Herzegovina. Technical sciences archive. 1(20):47-57. DOI: <https://doi.org/10.7251/afts.2013.0508.041V>
- UNDP (2019). Assessment of disaster risk reduction in the Western Balkans. <https://www.undp.org/bosnia-herzegovina/projects/disaster-risk-reduction-sustainable-development-bosnia-and-herzegovina-phase-ii>
- WHO (2017). Guidelines for drinking-water quality. 4th ed., Geneva, <https://www.who.int/publications/i/item/9789241549950>

# **Javnozdravstveni rizici trovanja hranom u kriznim situacijama u Bosni i Hercegovini**

Mirsad MALKIĆ

Univerzitet u Sarajevu, Fakultet zdravstvenih studija, Bosna i Hercegovina

Autor za korespondenciju: Mirsad Malkić, [mirsad.malkic@fzs.unsa.ba](mailto:mirsad.malkic@fzs.unsa.ba)

## **Sažetak**

Trovanja hranom predstavljaju značajan javnozdravstveni problem u kriznim situacijama, naročito u Bosni i Hercegovini (BiH), zemlji koja je u posljednjim decenijama bila izložena prirodnim katastrofama, ratnim sukobima i pandemijama. U takvim okolnostima dolazi do narušavanja sanitarnih uslova, prekida u lancima snabdijevanja i povećanog rizika od kontaminacije hrane. Ovaj rad predstavlja pregled literature s fokusom na mikrobiološke, hemijske i fizičke rizike trovanja hranom u kriznim situacijama, analizirajući iskustva iz BiH, regiona i međunarodnih izvora. Rezultati pokazuju da ključne prijetnje obuhvataju bakterijske patogene (*Salmonella spp.*, *Escherichia coli*, *Listeria monocytogenes*), mikotoksine, teške metale i hemikalije koje se mobilizuju tokom poplava i drugih kriznih događaja. Zaključuje se da su potrebne jače institucionalne mjere, integrisani sistemi nadzora i implementacija međunarodnih standarda poput *Codex Alimentarius* i Analize opasnosti i kontrole kritičnih tačaka (*Hazard Analysis and Critical Control Point*), kako bi se smanjili javnozdravstveni rizici u kriznim situacijama u BiH.

*Ključne riječi: trovanja hranom, krizne situacije, javno zdravlje, sigurnost hrane*



3. ISHRANA TOKOM ŽIVOTNOG CIKLUSA  
NUTRITION THROUGH THE LIFECYCLE





## **The Importance of Consuming Long-Ripened Cheeses in Human Nutrition**

Sandra BARUDŽIJA\* Mila MILINKOVIĆ Marija STOJANOVIĆ Bojana  
STOJANOVIĆ Radoslava SAVIĆ RADOVANOVIĆ

University of Belgrade, Faculty of Veterinary Medicine

\*Corresponding author: Sandra Barudžija, sandra.barudzija@gmail.com

### **Abstract**

Cheese as a food takes a very important place in human diet. According to definition of the FAO/WHO expert group, cheese is a fresh or matured product obtained from milk after protein coagulation and separation of whey from milk, cream, partially skimmed milk, buttermilk, or a mixture of these semi-products. Cheeses available at local markets in the Republic of Serbia are produced in individual households, either from raw or boiled milk, originating from different geographical regions. In the production of these cheeses, coagulation is achieved by adding rennet to milk, without use of known starter cultures, which implies that ripening process is driven solely by the natural microbiota of milk. In industrial production, starter cultures of lactic acid bacteria and proteolytic enzymes are additionally employed. According to current legislative, cheeses are classified as non-ripened and ripened cheeses in retail.

Ripened cheeses undergo a defined ripening period during which specific biochemical and physical changes occur, resulting in distinctive sensory characteristics. In long-ripened cheeses, bioactive peptides are generated, with their concentration increasing up to two months of ripening, followed by a decline due to hydrolysis. Bioactive peptides are sequences of 5 to 30 amino acids, which may, beyond their nutritional value, exert beneficial effects on human health. These biopeptides have been attributed with antihypertensive, antioxidant, antimicrobial, anticancerogenic, and immunomodulatory activities. The target group of consumers of such cheeses should primarily include adults over the age of thirty, due to their increased predisposition to cardiovascular and other diseases. The continuous effort to improve quality of life is closely linked to the consumption of foods that not only provide nutritional value but also exert a positive impact on health. In this context, the aim of this article is to highlight the role of bioactive peptides in cheese, as specific protein fragments with potentially beneficial biological, biochemical, and/or physiological effects on the human organism.

*Keywords: cheese, bioactive peptides, ripening, nutrition, health*

## ***Introduction***

Milk and dairy products are among the most essential components in human diet. Like eggs, milk meets the complete nutritional requirements of complex organisms and is therefore regarded as a nearly perfect food. Diets containing a significant proportion of these products are rich in nutrients and provide a balanced ratio of essential components required for proper growth, development, and physiological function of the human body. Milk contains high-quality proteins, amino acids, triglycerides, polar lipids, lactose, and oligosaccharides, as well as essential micronutrients such as calcium, phosphorus, magnesium, potassium, and zinc. It also provides fat-soluble vitamins (A, D, E, K) and water-soluble vitamins (C and B complex: B1, B2, B6, and B12). Due to its short shelf life, raw milk is often processed into products such as cheese, allowing the preservation of its highly nutritious and biologically valuable constituents (da Cruz et al., 2009). Considering the balance between cost and nutrient density, milk and dairy products stand out as affordable foods of high nutritional value in developed economies, making them an important part of a healthy and balanced diet (Drewnowski, 2011).

The FAO/WHO commission for Food Standards Programme (Codex Alimentarius Commission) defines cheese as a ripened or unripened product of soft, hard, or extra-hard consistency, in which the ratio of whey proteins to casein does not exceed that of milk. It is obtained through complete or partial coagulation of milk proteins—derived from whole or partially skimmed milk, cream, whey cream, or buttermilk—using rennet or other suitable coagulants, followed by partial whey separation. The remarkable diversity of cheeses, expressed through differences in flavor, texture, and form, results from variations in milk source, starter cultures, fermentation parameters, technological processes, and ripening duration (Chourasia et al., 2020). Because of this complexity, cheese classification is challenging; however, it can be carried out based on physicochemical characteristics, as well as coagulation and ripening methods (da Cruz et al., 2009; Rashidinejad et al., 2017).

According to the regulation and Roolbook of the Quality of Milk Products and Starter Cultures ("*Official Gazette of the Republic of Serbia*", No. 33/2010, 69/2010, 43/2013 and 34/2014), ripened cheeses are chesees with defined aging process during which, under controlled conditions, biochemical and physical changes occur, leading to the development of specific sensory properties. The ripening process may involve molds on the surface or interior of the cheese, as well as surface microflora or brine maturation.

Based on the water content of the fat-free matter, consistency, and structure, cheeses are classified and marketed as extra-hard, hard, semi-hard, or soft.

Depending on fat content in dry matter, cheeses can be categorized as skimmed (<10%), low-fat (10-25%), semi-fat (25-45%), full-fat (45-60%), and extra-fat (>60%).

According to literature data, the average consumption of white cheese in Serbia was approximately 10 kg per person annually between 2012 and 2019, which is higher than the consumption of other dairy products (Đorđević et al., 2023). Considering the widespread use of cheese in the human diet, the presence of traditionally produced cheeses at the market, and consumers preference, this review article aims to highlight the importance of long-ripened cheeses and their bioactive peptides in human nutrition.

### ***Experimental***

Articles and studies were searched in Google Scholar, Pubmed and the Archives of Veterinary Science.

### ***Bioactive Peptides***

Bioactive peptides are released during cheese ripening through the action of proteases and peptidases derived from both starter and non-starter lactic acid bacteria (LAB). The activity of ACE-inhibitory peptides depends on the bacterial strain involved in casein hydrolysis, as each strain possesses distinct proteases and genotypic variants determining cleavage sites and peptide sequences. *Lactobacillus helveticus*—originally used as a starter culture for Swiss-type cheeses—has proven to be an effective culture for producing various cheese types. Strains CP790 and LBK-16 are among the most studied and efficiently generate a wide range of bioactive peptides. Through its proteolytic system, *L. helveticus* produces the antihypertensive peptide derived from  $\beta$ -casein, with the amino acid sequence KVLPPVQ. Starter cultures such as *Lactococcus lactis subsp. lactis* and *Lactococcus lactis subsp. cremoris* significantly contribute to the generation of bioactive peptides, including ACE and DPP-4 inhibitors. They release short peptides exhibiting antihypertensive, antimicrobial, immunomodulatory, and antioxidant activities. These bacteria possess cell-envelope proteinases (CEPs) that initiate casein hydrolysis, followed by intracellular peptidases (endopeptidases and dipeptidyl-peptidases) that further degrade larger peptides into bioactive fragments such as VPP and IPP. *Lactocaseibacillus casei* further breaks down peptides into shorter, functional fragments, enhancing peptide diversity and antioxidant capacity. The formation of bioactive peptides in long-ripened cheeses thus relies on the synergy of multiple bacterial cultures (*L. helveticus*, *L. lactis subsp. lactis*, *L. lactis subsp. cremoris*, and *L. casei*). When combined, their proteolytic systems

complement each other, yielding a broader spectrum of bioactive peptides, including those with antihypertensive potential.

### ***Functional Role of Bioactive Peptides***

In the continuous efforts for improving quality of life, functional foods is increasingly consumed, which—beyond nutritional attributes—exert beneficial effects on human health. Within this context, bioactive peptides, of which cheeses are a major dietary source, have attracted growing attention due to their biological, biochemical, and physiological roles that contribute to the development of functional dairy products (Rangel et al., 2023). These peptides are fragments embedded within the primary structure of milk proteins and remain inactive until released, most notably through proteolytic cleavage by lactic acid bacteria during ripening (Rangel et al., 2023). Their composition and concentration depend on the choice of starter cultures as well as ripening conditions and duration (Rafiq et al., 2020).

Hypertension—a condition of persistently elevated blood pressure—is influenced by genetic predisposition and environmental factors. The renin–angiotensin system (RAS) plays a central role in its pathogenesis. The antihypertensive activity of biopeptides occurs through the inhibition of angiotensin-converting enzyme (ACE), which catalyzes the conversion of angiotensin I to angiotensin II, a potent vasoconstrictor (Rangel et al., 2023).

The peptides VPP (Val–Pro–Pro) and IPP (Ile–Pro–Pro), known for their ACE-inhibitory effects, have been quantified in various long-ripened cheeses, demonstrating a clear relationship between ripening duration and peptide concentration. In a study of 101 samples from ten Swiss cheese varieties, the lowest concentration was found in L’Etivaz (19.1 mg/kg), while the highest was observed in Appenzeller (182.2 mg/kg) (Bütikofer et al., 2008).

Casein hydrolysis by lactic acid bacteria also produces peptides with thrombolytic properties, contributing to the cardiovascular benefits of fermented dairy products (Rafiq et al., 2020). Furthermore, antimicrobial fragments derived from  $\alpha$ s1-,  $\alpha$ s2-,  $\beta$ -, and  $\kappa$ -caseins, as well as  $\alpha$  lactalbumin and  $\beta$ -lactoglobulin, have been identified. Their mechanisms generally involve interactions with microbial membrane lipids, increasing permeability and leading to cell lysis (Rangel et al., 2023).

Excess of free radicals cause oxidative damage to DNA, RNA, and proteins, leading to cellular injury, aging, and degenerative diseases such as cancer and atherosclerosis. The antioxidant activity of biopeptides is linked to amino acids that donate electrons or contain sulfhydryl groups acting as radical scavengers. These peptides usually contain 5–30 amino acids; tyrosine, tryptophan, methionine, lysine, cysteine, and histidine are among those associated with antioxidant function (Rangel et al., 2023).

Moreover, peptides derived from dairy products—especially fermented cheeses—have demonstrated anticancer potential, influencing different stages of carcinogenesis. Notable examples include lactoferricin (LFcin) and casein phosphopeptides (CPPs), which inhibit tumor cell proliferation, induce apoptosis, and modulate gene expression. Epidemiological studies link fermented dairy consumption with reduced cancer risk, with higher efficacy observed in longer ripened cheeses (Rafiq et al., 2020).

### ***Functional Cheeses and Their Role in Hypertension Prevention: Insights from France and Spain***

Modern nutritional science increasingly recognizes the value of functional foods that, in addition to their nutritional value, provide physiological health benefits. Among them, fermented dairy products—particularly cheeses—occupy a prominent place. During ripening, proteolytic activity of lactic acid bacteria produces bioactive peptides that can exhibit multiple biological effects.

Some act as angiotensin-converting enzyme (ACE) inhibitors, granting them potential antihypertensive properties. Thus, cheeses rich in these peptides can be considered functional dairy products that promote cardiovascular health. The best-known examples, Ile–Pro–Pro (IPP) and Val–Pro–Pro (VPP), naturally inhibit ACE, blocking the conversion of angiotensin I to angiotensin II—a strong vasoconstrictor responsible for elevated blood pressure (Lu et al., 2016; Rangel et al., 2023). In addition to antihypertensive effects, these peptides exhibit antioxidant, antimicrobial, immunomodulatory, and opioid-like activities. However, antihypertensive potential remains the most widely studied due to its relevance to cardiovascular disease prevention.

#### ***- Evidence on the Antihypertensive Effects of Cheese***

Laboratory studies have confirmed the presence of ACE-inhibitory peptides in numerous cheese types, including Cheddar, Gouda, Emmental, and Manchego. *In vitro* experiments demonstrate that these peptides can significantly reduce ACE activity (Lu et al., 2016). However, results of clinical studies in humans are not consistent: some report modest reductions in blood pressure among regular consumers of fermented dairy products, while others found no statistically significant effect (Nilsen et al., 2016). This variability is attributed to differences in peptide concentration, ripening duration, consumption quantity, and individual digestion and absorption. Peptides may also be partially degraded during digestion, with bioavailability depending on gastrointestinal stability (Rangel et al., 2023). Despite such limitations, available evidence indicates that cheeses enriched with bioactive

peptides can help maintain normal blood pressure—particularly when integrated into a balanced Mediterranean diet.

#### *- Cheese Consumption in France and Spain*

France is traditionally recognized as one of the world's leading cheese-producing and -consuming nations. According to CNIEL (2023), average annual cheese consumption per capita in France is approximately 27 kg. The country has a long-standing tradition of producing over 1,200 cheese varieties, many belonging to the group of ripened, peptide-rich cheeses.

Interestingly, despite high cheese and saturated fat intake, France records lower cardiovascular mortality rates compared to other European nations—a phenomenon referred to as the “French paradox.” This is attributed to overall dietary patterns characterized by moderate portions, wine consumption, high vegetable intake, and the presence of bioactive compounds from fermented foods.

In Spain, cheese consumption is markedly lower—around 8.9 kg per capita annually (MAPA, 2023). Although Spain has a developed production of cheeses such as Manchego, Tetilla and Idiazabal, they present a smaller part of the total diet compared to other dairy products and Mediterranean foods such as olive oil, fish and vegetables. However, thanks to the traditional Mediterranean diet, the rate of cardiovascular disease in Spain is among the lowest in Europe. Large-scale of epidemiological studies and meta-analyses suggest that moderate cheese consumption is not associated with an increased risk of cardiovascular disease and may even exert protective effects (Qin et al., 2015; Alexander et al., 2016). This paradoxical finding can be explained by the complex composition of cheese: although it contains saturated fats, it also contains calcium, phosphates, peptide components and fermentation products that can neutralize the negative effect of fat on the lipid profile. Bioactive peptides that act as ACE-inhibitors additionally contribute to this effect, especially in mature cheeses. Therefore, moderate consumption of fermented cheeses, especially as part of a balanced diet, can be considered beneficial for the prevention of hypertension and cardiovascular diseases.

#### ***Conclusion***

Cheeses with bioactive peptides represent an interesting example of combination of traditional nutritional practices and modern functional concepts. Thanks to the presence of natural ACE inhibitors, these cheeses may contribute to lowering blood pressure and reducing the risk of cardiovascular diseases. France and Spain, as two European countries with well-developed dairy industries, demonstrate interesting examples of different patterns of cheese consumption and their possible health

consequences. Although the scientific evidence is still insufficient to declare cheeses as a *natural antihypertensive agent*, it is evident that moderate consumption of fermented milk products—particularly long-ripened cheeses—can represent a valuable component of a healthy and functional diet promoting cardiovascular well-being.

**Author contributions:** All authors have contributed equally to the preparation of this manuscript. Conceptualization, methodology and investigation, S.B., M.M., M.S. and B.S.; writing—original draft preparation S.B., M.M., M.S. and B.S.; writing-review and editing, R.S.R.; supervision and visualization of final version, R.S.R.; All authors have read and agreed to the published version of the proceeding.

**Acknowledgment:** This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, under Contract No. 451-03-136/2025-03/200143.

**Conflicts of Interest:** The authors declare no conflicts of interest

## References

Bütikofer, U., Meyer, J., Seiber, R., Walther, B., Wechsler, D. (2008) ‘Occurrence of the angiotensin-enzyme-inhibiting tripeptides Val-Pro-Pro and Ile-Pro-Pro in different cheese varieties of Swiss origin’, *Journal of Dairy Science*, 91(1), pp. 29–38. <https://doi.org/10.3168/jds.2007-0400>

Dairy Products in Global Public Health (2023) *American Journal of Clinical Nutrition*, S0002 9165(23)05072-4. Available at: [https://ajcn.nutrition.org/article/S0002-9165\(23\)05072-4/fulltext](https://ajcn.nutrition.org/article/S0002-9165(23)05072-4/fulltext) (Accessed: 10 October 2025).

Drewnowski, A. (2011) ‘The Contribution of Milk and Milk Products to Micronutrient Density and Affordability of the U.S. Diet’, *Journal of Food Composition and Analysis*, 24(6), pp. xxx–xxx. Available at: <https://www.tandfonline.com/doi/abs/10.1080/07315724.2011.10719986> (Accessed: 10 October 2025).

Đorđević, J., Ledina, T., Kovandžić, M., Bulajić, S. (2023) ‘Production and trade of milk and dairy products in Serbia’, *Meat Technology*, 64(2), pp. 166–170. <https://doi.org/10.18485/meattech.2023.64.2.30>

Effect of Lactobacteria on Bioactive Peptides and Their Sequence Identification in Mature Cheese (2022) *Microorganisms*, 10(10), 2068. <https://doi.org/10.3390/microorganisms10102068>

FAO/WHO Codex Alimentarius Commission (2018) Codex General Standard for Cheese (CODEX STAN 283-1978, Rev. 2018). Food and

Agriculture Organization of the United Nations & World Health Organization, Rome. Available at: <https://www.fao.org> (Accessed: 10 October 2025).

Gobbetti, M., Minervini, F., Rizzello, C.G. (2004) ‘Angiotensin I-converting-enzyme-inhibitory and antimicrobial bioactive peptides’, *International Journal of Dairy Technology*, 57(2–3), pp. 173–188.

Gülhan, A. (2024) ‘The Health Benefits of the Cheese’, in *Global Perspectives on Cheese Tourism*. IGI Global, pp. 149–160. <https://doi.org/10.4018/979-8-3693-3490-4.ch009>

Ministarstvo poljoprivrede, šumarstva i vodoprivrede Republike Srbije (2014) Pravilnik o kvalitetu proizvoda od mleka i starter kultura. „Službeni glasnik RS“, br. 7/2014, 27/2017, 84/2018 i 67/2022. Available at: <https://www.paragraf.rs/propisi/pravilnik-kvalitetu-proizvoda-mleka-starter-kultura.html> (Accessed: 10 October 2025).

Rafiq, S., Gulzar, N., Sameen, A., Huma, N., Hayat, I., Ijaz, R. (2020) ‘Functional role of bioactive peptides with special reference to cheeses’, *International Journal of Dairy Technology*, 73(1), pp. 1–12. <https://doi.org/10.1111/1471-0307.12732>

Rangel, A.H.N., Bezerra, D.A.F.V.A., Sales, D.C., Araújo, E.O.M., Lucena, L.M., Porto, A.L.F., Vêras, Í.V.U.M., Lacerda, A.F., Ribeiro, C.V.D.M., Anaya, K. (2023) ‘An overview of the occurrence of bioactive peptides in different types of cheeses’, *Foods*, 12(23), 4261. <https://doi.org/10.3390/foods12234261>



## **Značaj primene sireva sa dugim zrenjem u ishrani ljudi**

Sandra BARUDŽIJA\* Mila MILINKOVIĆ Marija STOJANOVIĆ Bojana  
STOJANOVIĆ Radoslava SAVIĆ RADOVANOVIĆ

Univerzitet u Beogradu, Fakultet veterinarske medicine

\*Autor za korespondenciju: Sandra Barudžija, [sandra.barudzija@gmail.com](mailto:sandra.barudzija@gmail.com)

### **Sažetak**

Sirevi kao hrana zauzimaju veoma važno mesto u ishrani ljudi. Prema definiciji ekspertske grupe FAO/WHO sir predstavlja svež ili sazreo proizvod, koji se dobija od mleka posle koagulacije proteina i odvajanja surutke iz mleka, pavlake, delimično obranog mleka, mlaćenice, ili mešavine ovih poluproizvoda. Sirevi koji se mogu naći na tržištu gradskih pijaca u Republici Srbiji se proizvode u individualnim domaćinstvima od sirovog ili kuvanog mleka, a poreklom su iz različitih geografskih lokaliteta. U procesu proizvodnje ovih sireva koagulacija se odvija dodavanjem sirila u mleko, bez dodavanja poznatih starter kultura, što znači da u procesu zrenja učestvuje samo prirodna mikrobiota mleka. U industrijskim uslovima proizvodnje dodaju se starter kulture-bakterija mlečne kiseline i preteolitički enzimi. Prema važećoj zakonskoj regulativi sirevi se u promet mogu staviti kao: sirevi bez zrenja i sirevi sa zrenjem. Sirevi sa zrenjem su sirevi, koji moraju imati proces zrenja sa definisanim periodom tokom kojeg se dešavaju odgovarajuće biohemijske i fizičke promene i na taj način nastaju specifične senzorne karakteristike. Kod sireva sa dugim zrenjem stvaraju se bioaktivni peptidi čija koncentracija raste do 2 meseca, a posle toga opada usled hidrolize. Bioaktivni peptidi su peptidi dužine od 5 do 30 aminokiselina, koji osim hranljive vrednosti ispoljavaju i pozitivan uticaj na zdravlje čoveka. Biopeptidima se pripisuje antihipertenzivno, antioksidativno, antimikrobno, antikancerogeno i imunomodulatorno dejstvo. Ciljnu grupu konzumenata ovih sireva bi trebalo da čine odrasle osobe, starije od trideset godine zbog povećane predispozicije ka kardiovaskularnim i drugim oboljenjima. Stalno nastojanje za poboljšanjem kvaliteta života ljudi je usko povezano sa konzumiranjem hrane, koju pored hranljive vrednosti karakteriše i pozitivan uticaj na zdravlje. U kontekstu ovih nastojanja cilj rada je da se istakne delovanje bioaktivnih peptida u siru, kao specifičnih fragmenata proteina sa mogućim potencijalnim pozitivnim biološkim, biohemijskim i/ili fizičkim efektima na organizam.

*Ključne reči: sir, biaktivni peptidi, zrenje, ishrana, zdravlje*

**Napomena:** Rad je podržan sredstvima Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor broj 451-03-136/2025-03/200143).

### 3-O-2

#### **Mindful eating – concept, approach, and assessment tools**

Jasmina BEGIĆ\* Edna ČOSIĆ Ilhana ČOSIĆ Ilma HALILOVIĆ Fatima  
MURATOVIĆ Jasmina ĐEDIBEGOVIĆ

University of Sarajevo -Faculty of Pharmacy, Department of bromatology and nutrition,  
Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Jasmina BEGIĆ, [jasminabegic@ffsa.unsa.ba](mailto:jasminabegic@ffsa.unsa.ba)

#### **Abstract**

The aim of this paper is to explore the concept of mindful eating, focusing on its core principles, connection to mindfulness techniques, and the assessment tools used to evaluate eating behaviors. A comprehensive literature review was conducted, analyzing studies on the effectiveness of mindful eating in improving dietary habits, reducing emotional eating, and promoting physical and emotional well-being. Results indicate that mindful eating enhances awareness of hunger and satiety cues, supports weight management, and alleviates maladaptive eating patterns. Assessment instruments such as the Mindful Eating Questionnaire (MEQ) and Intuitive Eating Scale (IES) provide valuable insights into eating behaviors and emotional triggers. Overall, mindful eating emerges as a scientifically validated, holistic approach that not only improves nutritional outcomes but also fosters a healthier relationship with food, emphasizing presence, awareness, and enjoyment during the eating process.

**Keywords:** *Mindful eating, Emotional eating, Dietary habits, Eating behavior assessment*

#### **Introduction**

The modern lifestyle, characterized by a fast pace, stress, and the easy availability of high-calorie foods, has led to unhealthy dietary habits and a growing prevalence of nutrition-related diseases. In this context, mindful eating has emerged as a relevant concept offering an alternative approach to the relationship with food. Mindful eating emphasizes presence, awareness, and attention during the eating process, helping reduce impulsive eating and overeating. Its goal extends beyond weight control, aiming at a deeper understanding of personal eating patterns, emotional triggers, and internal signals of hunger and satiety. Grounded in mindfulness techniques, mindful eating focuses on non-judgmental awareness of the present moment. Research has demonstrated its effectiveness in improving eating behaviors,

alleviating symptoms of eating disorders, and enhancing overall quality of life. Although rooted in Buddhist teachings, the concept gained therapeutic application in the late 1970s, when Jon Kabat-Zinn developed the eight-week Mindfulness-Based Stress Reduction (MBSR) program to help individuals cope with stress and illness. This approach later evolved into Mindfulness-Based Cognitive Therapy (MBCT) for depression and anxiety, now endorsed by the UK's National Institute for Health and Care Excellence (NICE) (Tapper, 2022).

The aim of this paper is to explore and understand the concept of mindful eating, with a focus on defining its core principles and linking this approach to mindfulness techniques. Special emphasis will be placed on identifying and describing assessment instruments for mindful eating, such as questionnaires, and their role in both research and clinical contexts. Furthermore, the paper will evaluate the scientific evidence supporting the effectiveness of mindful eating in improving health and modifying dietary behaviors, while considering the potential for implementing this concept in everyday life. Through a comprehensive literature review and analysis of practical applications, the aim is to contribute to the scientific discourse on mindful eating and highlight its potential to enhance individual and public health.

### ***Experimental***

For the preparation of this paper, scientific articles and publications available through the PubMed database were used, along with other relevant journals in the fields of nutrition, psychology, and medicine. Literature searches were conducted using keywords such as “mindful eating,” “mindfulness,” “dietary habits,” “emotional eating,” and “weight regulation.” Additionally, terms such as “assessment tools,” “mindful eating questionnaire,” and “health impact” were employed to ensure a comprehensive search.

The selection of literature focused on studies published within the last ten years, emphasizing recent research, systematic reviews, and meta-analyses exploring the application of mindful eating in various contexts, including eating disorders, obesity, and health promotion. Special attention was given to studies investigating the validation and application of instruments such as the Mindful Eating Questionnaire for assessing dietary habits, as well as studies analyzing the effectiveness of mindful eating in clinical and everyday practice.

Data collected from these sources were synthesized and critically analyzed to provide a comprehensive overview of the concept of mindful eating, its methods, and assessment tools. In addition to PubMed, sources from leading journals such as *Mindfulness* were consulted. The analysis specifically

focused on identifying key aspects of mindful eating, its practical implications, and its potential to enhance individual health and food-related behaviors.

## ***Results and Discussion***

### **Concept of Mindful Eating**

The practice of mindful eating has helped thousands of individuals develop skills necessary for managing chronic pain, illnesses, depression, sleep disturbances, and anxiety. Mindful eating, defined as paying attention to food moment by moment, is an approach that emphasizes individuals' sensory awareness of food and their eating experience. This concept is less concerned with calories, carbohydrates, fats, or proteins, and more focused on helping individuals fully enjoy the present moment and the act of eating, fostering complete presence during the eating experience. In this sense, mindfulness is process-oriented rather than outcome-oriented, and it is grounded in the individual's moment-to-moment experience. Many practitioners of mindful eating, along with a growing number of healthcare professionals, increasingly believe that mindful eating can make a significant difference for example, in supporting individuals with diabetes to modify their eating habits. Ultimately, mindful eating involves bringing full awareness to every plate and every bite. Mindful eating is a practice that requires a commitment to behavioral change, similar to the dedication required for any diet or nutritional plan. At its core, mindful eating emphasizes the need for attention and conscious engagement with food (Nelson, 2017).

### **Benefits of the Mindful Eating Concept**

Although mindful eating can be incorporated into various diets, it emphasizes the eating process rather than the specific foods consumed, without strict rules. The first step involves noticing all senses, flavors, smells, and textures of the food. The second is recognizing habitual behaviors, such as eating while multitasking. The third step is knowing when to stop eating. Mindful eating has been linked to numerous benefits. A 2014 study found a significant positive relationship between mindful eating and mental well-being, measured using the Mindful Eating Questionnaire in a sample of 309 participants ( $r = .291$ ,  $p < 0.05$ ) (Khan, Zadeh, 2014).

A 2019 randomized crossover study of 25 participants aged 18–30 suggested that mindful eating may enhance satiety signals and could serve as an effective intervention for regulating food intake (Bamford, Gonzalez, Lalla, 2019).

A 2024 systematic review and meta-analysis, "*Mindful Eating Approaches and Cardiometabolic Risk Factors*," analyzed 14 randomized controlled

trials (sample sizes 18–194; interventions duration 4–24 weeks) assessing outcomes such as body weight, BMI, waist circumference, serum glucose, glycated hemoglobin, and C-reactive protein. Results indicated that mindful eating was as effective as other interventions and, in many cases, more effective in reducing cardiometabolic risk factors and food-related distress (Idelson, D'Elia, Strazzullo, 2024).

**Table 1.** Studies that investigated the benefits of the mindful eating concept

STUDY	STUDY TITLE	RESULTS
Study 1. Khan et al (2014)	"Mindful Eating and Its Relationship with Mental Well-Being"	The results showed a significant positive relationship between overall mindful eating and mental well-being.
Study 2. Bamford et al (2019)	"Effects of Mindful Eating Education on Increasing Satiety"	The results indicate that mindful eating may potentially be used as an intervention to enhance satiety signals.
Study 3. Idelson et al (2024)	"Mindful Eating Approaches to Cardiometabolic Risk Factors: Systematic Review and Meta-Analysis of Intervention Studies"	In many cases, it was more effective in reducing risk factors that may compromise cardiovascular health.

### **The relationship between mindful and emotional eating**

Mindful eating and emotional eating are closely linked, as *mindfulness* helps individuals recognize and overcome patterns of emotional overeating. Emotional eating occurs when food is used to cope with emotional states such as stress, sadness, boredom, or euphoria, rather than to satisfy physical hunger. This behavior often leads to unhealthy eating habits, increased caloric intake, and compromised physical and emotional health. Mindful eating, as a mindfulness-based approach, offers an effective strategy for addressing this challenge, helping individuals distinguish between physical and emotional hunger. A 2023 study examined the relationship between emotional and mindful eating, aiming to assess the effectiveness of a "mindful eating" program in reducing emotional eating in patients with overweight or obesity. The results showed that mindful eating significantly decreases emotional eating (Morillo-Sarto, López-Del-Hoyo, Pérez-Aranda, et al, 2023).

Emotional eating often arises from impulses, while mindful eating slows decision-making and clarifies the body's true needs. By increasing awareness of internal hunger and satiety cues, it reduces overeating as well as feelings

of guilt and shame often associated with emotional eating. Thus, mindful eating is a powerful tool for managing emotional eating.

## **ASSESSMENT TOOLS**

### **Mindful Eating Questionnaire**

The Mindful Eating Questionnaire (MEQ) is a standardized tool for assessing key aspects of mindful eating. It helps researchers and healthcare professionals analyze eating patterns and understand how individuals relate to food. The MEQ measures mindfulness and attention during meals, as well as attitudes toward eating habits. It includes several subscales and typically 28–30 items rated on a 1–5 Likert scale, where respondents indicate their agreement with statements reflecting their eating behaviors.

The advantages of this tool include its simplicity, coverage of key aspects of mindful eating, and use across different demographic and clinical settings. However, it may be limited by the subjectivity of responses, as results depend on participants' honesty and self-perception. The MEQ is often combined with other measures, such as food diaries or physiological indicators (e.g., BMI, blood glucose), to provide a comprehensive view of eating patterns and to evaluate programs like Mindfulness-Based Eating Awareness Training (MB-EAT) (Clementi, Casu, Gremigni, 2017).

### **Eating Behavior Questionnaire (EBQ)**

Alongside the Mindful Eating Questionnaire (MEQ), other tools assess aspects of mindful eating and related behaviors, such as the Eating Behavior Questionnaire (EBQ). This tool measures the relationship between mindful eating and dietary patterns. It focuses on awareness of physical and emotional states during meals and assesses tendencies toward impulsive or emotional eating in daily situations (Cebolla, Barrada, van Strien, Oliver, Baños, 2014).

### **Intuitive Eating Scale (IES)**

The Intuitive Eating Scale (IES) assesses intuitive eating, which emphasizes responding to natural signals of hunger and satiety, freeing oneself from external dietary rules, and developing a healthy relationship with food. Intuitive eating is similar to mindful eating but focuses more on self-regulating intake by listening to the body's needs. The IES has been validated in various populations, including adolescents and adults, and provides a comprehensive view of intuitive eating. It helps examine links between diet, mental health, and body weight. Limitations include potential subjectivity, as it relies on self-reporting, and cultural and social factors may influence responses. IES-2 and mindful eating are often used together in research, as both emphasize food awareness and connection to bodily signals. While

mindful eating focuses on attention during meals, IES-2 emphasizes internal cues and emotional reasons behind food choices (Hawks, Merrill, Madanat, 2004).

### **Mindful Eating Journal**

Participants keep a diary recording everything they eat, meal times, and emotions and feelings during eating. These diaries help researchers track eating patterns and identify triggers for emotional eating.

A food diary adapted to the concept of mindful eating serves as a tool for increasing awareness of eating habits and the emotional triggers that influence food choices. Unlike traditional food diaries, which focus on calorie or macronutrient intake, a mindfulness-based diary provides space for introspection, reflection on emotions, and the relationship with food (Mindful Eating, 2024).

### **Conclusion**

- Mindful eating is not just a trend but a scientifically validated approach offering significant health and emotional benefits. It helps individuals develop a healthy relationship with food, overcome unhealthy patterns, and fully enjoy each bite.
- The essence of mindful eating is awareness the ability to recognize physical signals of hunger and satiety while reducing the impact of emotional triggers on eating habits.
- Research shows that mindful eating contributes to weight management, reduces emotional overeating, supports a healthy diet, and improves blood glucose regulation in individuals with diabetes.
- Mindful eating is particularly compelling for its holistic approach. It is not only about proper nutrition but also about focusing on the present moment appreciating the aroma, taste, and texture of food. Food thus becomes a source of pleasure rather than merely fuel.
- Tools like the Mindful Eating Questionnaire (MEQ) and Intuitive Eating Scale (IES) allow evaluation of mindful eating patterns, emotional eating, and bodily responses to hunger and satiety. They are used in research, clinical practice, and interventions to better understand factors influencing eating behaviors and emotional well-being.

**Author Contributions:** Conceptualization, I.Č. and J.B; methodology, F.M.; investigation, I. H.; writing original draft preparation, E. Č.; writing review and editing, F. M. and I. H.; supervision: J. Đ. All authors have read and agreed to the published version of the proceeding.

***Conflict of interest:*** The authors declare no conflicts of interest.

## ***References***

Bamford A, Gonzalez E, Lalla S, The Effects of Mindful Eating Education on Increasing Satiety Signals, (2019). Loma Linda University Research Reports.

Cebolla A, Barrada JR, van Strien T, Oliver E, Baños R. Validation of the Dutch Eating Behavior Questionnaire (DEBQ) in a sample of Spanish women. *Appetite*. 2014 Feb;73:58-64. doi: 10.1016/j.appet.2013.10.014. Epub 2013 Oct 28. PMID: 24177441.

Clementi C, Casu G, Gremigni P, An Abbreviated Version of the Mindful Eating Questionnaire, *Journal of Nutrition Education and Behavior*, Volume 49, Issue 4, 2017, Pages 352-356.e1.

Hawks, Steven, Ray M. Merrill, and Hala N. Madanat. "The intuitive eating scale: Development and preliminary validation." *American Journal of Health Education* 35.2 (2004): 90-99.

Idelson P.I, D'Elia L, Strazzullo P, Mindful Eating Approaches to Cardiometabolic Risk Factors: Systematic Review and Meta-Analysis of Intervention Studies, *Dietetics*. 2024; 3(3):271-288.

Khan Z and Zadeh Z.F/ Mindful Eating and It's Relationship with Mental Well-Being, *Procedia - Social and Behavioral Sciences* 159 ( 2014 ) 69 – 73.

Mindful eating [Internet]. [cited 2024 Nov 18]. Available from: <https://www.bda.uk.com/resource/mindful-eating.html>.

Morillo-Sarto H, López-Del-Hoyo Y, Pérez-Aranda A, et al. 'Mindful eating' for reducing emotional eating in patients with overweight or obesity in primary care settings: A randomized controlled trial. *Eur Eat Disord Rev*. 2023;31(2):303-319.

Nelson JB. Mindful Eating: The Art of Presence While You Eat. *Diabetes Spectr*. 2017 Aug;30(3):171-174.

Tapper K, Mindful eating: what we know so far, *Nutrition Bulletin*. 2022;47:168–185.



## **Svjesno jedenje – koncept, pristup i alati za testiranje**

Jasmina BEGIĆ\* Edna ČOSIĆ Ilhana ČOSIĆ Ilma HALILOVIĆ Fatima  
MURATOVIĆ Jasmina ĐEDIBEGOVIĆ

<sup>1</sup>Univerzitet u Sarajevu – Farmaceutski fakultet, Katedra za bromatologiju i nutricionizam,  
Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Jasmina BEGIĆ, [jasminabegic@ffsa.unsa.ba](mailto:jasminabegic@ffsa.unsa.ba)

### **Sažetak**

Cilj ovog rada je istražiti koncept svjesnog jedenja, fokusirajući se na njegove osnovne principe, povezanost s tehnikama mindfulness-a i alate za procjenu koji se koriste za evaluaciju prehrambenog ponašanja. Proveden je sveobuhvatan pregled literature, analizirajući studije o efikasnosti svjesnog jedenja u poboljšanju prehrambenih navika, smanjenju emocionalnog jedenja i promovisanju fizičkog i emocionalnog blagostanja. Rezultati pokazuju da svjesno jedenje povećava svijest o signalima gladi i sitosti, podržava regulaciju tjelesne težine i ublažava neprimjerene obrasce u ishrani. Instrumenti za procjenu, kao što su Upitnik o svjesnom jedenju (MEQ) i Skala intuitivnog jedenja (IES), pružaju vrijedne uvide u prehrambeno ponašanje i emocionalne okidače. Sveukupno, svjesno jedenje se pokazuje kao naučno potvrđen, holistički pristup koji ne samo da poboljšava nutritivne ishode, već i podstiče zdraviji odnos prema hrani, naglašavajući prisutnost, svjesnost i uživanje tokom procesa jedenja.

*Ključne riječi: svjesno jedenje, emocionalno jedenje, prehrambene navike, procjena prehrambenog ponašanja*

### 3-O-3

#### **Relative energy deficiency in sport: future challenges in physiotherapy**

Meliha ČOLPA\* Maja KRSTIĆ Demir DŽAFEROVIĆ

University of Sarajevo, Faculty of Health Studies, Physiotherapy Program, Bosnia and Herzegovina

\*Corresponding Author: Meliha Čolpa, meliha.colpa@fzs.unsa.ba

#### **Abstract**

Relative Energy Deficiency in Sport (RED-S) represents a syndrome caused by chronic low energy availability, where calorie intake is insufficient to meet the demands of training and basic body functions. RED-S occurs in both males and females and has widespread effects on multiple physiological systems, including hormonal, metabolic, cardiovascular, immune, and skeletal systems. RED-S clinically manifests as chronic fatigue, decreased athletic performance, frequent injuries, menstrual irregularities in women, and reduced testosterone levels in men. Of particular concern is its impact on bone mineral density, increasing the risk of stress fractures and long-term orthopedic complications. Although the cause may be related to eating disorders, RED-S often develops as a result of unintentional low energy availability due to intensive training combined with inadequate nutrition. The purpose of this study is to analyze the impact of low energy availability on athletes' health and performance. Based on a review of the scientific literature from relevant databases such as Google Scholar, PubMed, and Web of Science, although research is still limited, available data indicate that early detection and correction of energy imbalance can significantly reduce the risk of health complications and improve athletic performance. Today, RED-S is recognized as one of the key challenges in sports medicine and physiotherapy, and prevention and management require collaboration among athletes, nutritionists, physiotherapists, and psychologists, along with education of athletes and coaches on proper energy balance.

*Keywords: Relative Energy Deficiency in Sport (RED-S), Low Energy Availability (LEA), physiotherapy, nutrition, health*

## ***Introduction***

The female athlete triad, defined by the American College of Sports Medicine (ACSM) in the 1990s, included eating disorders, amenorrhea, and osteoporosis. This concept was expanded in 2007 to include low energy availability (LEA), menstrual dysfunction, and low bone density. Over time, it has been recognized that the presence of all elements is not necessary for diagnosis, and in 2014, the broader term Relative Energy Deficit in Sport (RED-S) was introduced, which emphasizes a holistic approach and the impact of energy imbalance on various physiological functions (Coelho et al., 2023).

RED-S can cause hormonal, bone, immunological, and cardiovascular disorders, as well as reduced athletic performance (Cabre et al., 2022).

Although the concept is gaining importance in sports medicine, clinical evidence confirming a direct causal effect of low energy availability is still limited (Jeukendrup et al., 2024).

The key physiological mechanism underlying RED-S syndrome is energy availability (EA), which represents the amount of energy available for optimal functioning of the organism after subtracting the energy expended during exercise. Energy availability is expressed as the number of kilocalories per kilogram of fat-free body mass per day (kcal/kg FFM/day) and is crucial for maintaining homeostasis of various body systems (Mountjoy M, Ackerman KE et al., 2023).

When energy availability is chronically reduced, low energy availability (LEA) occurs, which can have adaptive or pathological consequences. While adaptive LEA can lead to benign and reversible changes in the short term, problematic LEA causes disorders of the endocrine, bone, immune and reproductive systems, thereby increasing the risk of injury and reduced sports performance. The severity of the consequences is additionally influenced by moderating factors such as gender, age and genetics, which can mitigate or amplify the effects of low energy availability (Mountjoy M, Sundgot-Borgen JK et al., 2018).

Nonpharmacological intervention is the preferred primary approach and often leads to successful outcomes in most cases. Calcium and vitamin D have shown important benefits in decreasing the risk of stress fractures, as well as in recovery, with supplementation recommended (Coelho et al., 2023). The treatment of RED-S should include a multifaceted approach, taking into account the complexity and individual variability in nutritional needs and recovery processes, and it is crucial to recognize the root cause of RED-S. Dietary, behavioral, and lifestyle changes are the mainstay of treatment; however, pharmacological interventions may be considered, especially in

selected cases related to the treatment of specific symptoms associated with LEA (Angelidi AM, Stefanakis K et al., 2024).

### ***Experimental***

The purpose of this study is to analyze the impact of low energy availability on athletes' health and performance. The analysis is based on a comprehensive review of the scientific literature retrieved from relevant databases, including Google Scholar, PubMed, and Web of Science, using keywords such as “Relative Energy Deficiency in Sport (RED-S)”, “Low Energy Availability (LEA)”, “physiotherapy”, “nutrition”, and “health”. The inclusion criteria were studies published between 2018 and 2025, written in English, and focused on physiological, psychological, and performance-related outcomes associated with RED-S. This paper analyzed randomized controlled trials, systematic reviews, and qualitative studies in order to provide a multidisciplinary understanding of the effects of low energy availability on both male and female athletes.

### ***Results and Discussion***

Relative Energy Deficiency in Sport (RED-S) represents a multifactorial syndrome that affects physiological functions, health, and athletic performance due to chronic low energy availability (LEA). While originally recognized among female athletes, recent research highlights its prevalence and impact on male athletes as well. RED-S manifests through disruptions in metabolic, endocrine, and psychological domains, ultimately impairing training capacity, recovery, and overall performance. Understanding both the physiological mechanisms and lived experiences of athletes affected by RED-S is crucial for developing targeted prevention and rehabilitation strategies. The following studies provide insights into the qualitative and quantitative dimensions of RED-S, emphasizing both psychological and physiological outcomes across genders and sport types.

This study aimed to explore the subjective, lived experiences of RED-S in endurance athletes using a qualitative approach. The research was conducted over three years (2018–2021) by the first author, following an interpretivist framework to understand athletes' experiences within their specific sporting cultures. Participants were recruited via social media and workshops after obtaining ethical approval (Ref. 0805). Inclusion criteria included age between 18 and 40 years, self-identification as being in recovery or recovered from RED-S, and engagement in endurance sports for  $\geq 150$  minutes per week during the period of RED-S. Study 1 involved 12 athletes (10 females, 2 males), while Study 2 included 8 female athletes who maintained four-week wellbeing diaries. Semi-structured interviews, conducted face-to-face or

online, explored RED-S onset, behaviors, and perceived effects, whereas wellbeing diaries captured psychological experiences and energy management. An abductive analytical approach combining deductive and inductive strategies was employed. Coding was performed by the primary researcher, discussed with supervisors acting as ‘critical friends,’ and iteratively developed into sub-themes and overarching themes. This reflexive process allowed for a deep interpretation of identity-related experiences and the psychosocial impact of RED-S within sporting contexts (Langbein-Stott R, Allen-Collinson J et al., 2025).

In addition to qualitative perspectives, quantitative evidence underscores the physiological consequences of RED-S. A systematic review of 10 cross-sectional studies involving 308 male participants demonstrated that low energy availability was associated with a reduction in resting metabolic rate, elevated cortisol levels, and impaired athletic performance. However, findings regarding bone mineral density, testosterone, triiodothyronine, and insulin-like growth factor 1 were inconsistent. These variations indicate potential differences in male physiological responses and highlight the need for further research to determine sex-specific energy thresholds and clarify the long-term health and performance implications of RED-S (Valiño-Marques A, Jurado-Castro JM et al., 2025).

Furthermore, experimental studies on female athletes have provided direct evidence of the effects of LEA on skeletal muscle protein synthesis. One randomized controlled trial investigated the impact of LEA on daily muscle protein synthesis in trained females. Thirty eumenorrheic women were randomly divided into two groups: a low energy availability group (LEA;  $25 \text{ kcal} \cdot \text{kg FFM}^{-1} \cdot \text{day}^{-1}$ ) and an optimal energy availability group (OEA;  $50 \text{ kcal} \cdot \text{kg FFM}^{-1} \cdot \text{day}^{-1}$ ). Both groups followed a controlled protein intake ( $2.2 \text{ g} \cdot \text{kg lean mass}^{-1} \cdot \text{day}^{-1}$ ) and a standardized 10-day exercise program combining resistance and cardiovascular training. Muscle protein synthesis was measured using deuterium oxide ( $\text{D}_2\text{O}$ ), alongside assessments of body composition, resting metabolic rate, and blood biomarkers. Results revealed that LEA led to significant reductions in myofibrillar and sarcoplasmic protein synthesis, lean mass, nitrogen balance, free androgen index, thyroid hormone concentrations, and resting metabolic rate. Conversely, OEA maintained or enhanced these parameters. Additionally, LEA increased the cortisol/insulin ratio, indicating metabolic stress. These findings confirm that inadequate energy availability compromises muscle adaptations and metabolic health, emphasizing the necessity of sufficient energy intake to support optimal physiological function and athletic performance in females (Oxfeldt M, Phillips SM et al., 2025).

Collectively, these studies highlight the complex and multifaceted nature of RED-S. Qualitative data underline the personal, cultural, and identity-related challenges athletes face during energy deficiency and recovery, while quantitative research elucidates the biological mechanisms underlying reduced performance and metabolic disturbances. Together, these insights reinforce the need for an integrated, multidisciplinary approach involving physiotherapists, sports nutritionists, psychologists, and coaches to ensure early detection, effective management, and prevention of RED-S among both female and male athletes.

### ***Conclusion***

The findings from the reviewed studies emphasize that Relative Energy Deficiency in Sport (RED-S) is a complex condition that extends beyond simple nutritional imbalance, encompassing physiological, psychological, and social dimensions that collectively impair athletes' health and performance. Qualitative evidence highlights the deep personal and identity-related struggles experienced by athletes, reflecting how sporting culture and performance pressures can contribute to the development and persistence of RED-S. Quantitative findings, on the other hand, demonstrate clear physiological consequences of low energy availability, including hormonal imbalances, reduced metabolic rate, impaired muscle protein synthesis, and diminished performance outcomes.

These results underscore the necessity of recognizing RED-S as a multifactorial syndrome requiring a comprehensive and individualized management approach. Preventive strategies should prioritize early detection through education, monitoring of energy availability, and collaboration among healthcare and sport professionals. Furthermore, the integration of physiotherapy, sports nutrition, and psychological support is essential to ensure full recovery and sustainable performance in both male and female athletes. Future research should aim to establish sex-specific diagnostic criteria, energy thresholds, and long-term outcomes to optimize prevention and treatment strategies for RED-S across diverse athletic populations.

***Author contribution:*** conceptualization, D. DŽ.-; methodology, D. DŽ., research: M.Č., M.K.; preparation of the original draft, M.Č., M.K.; revision and editing: M.Č.; visualization by M.Č.; supervision, D.DŽ.; all authors agreed with the final version of the paper and contributed to its quality and accuracy.

***Funding:*** This work was not funded.

***Informed consent statement:*** Not applicable.

**Conflicts of interest:** The authors declare no conflicts of interest.

## **References**

- Angelidi AM, Stefanakis K, Chou SH, Valenzuela-Vallejo L, Dipla K, Boutari C, et al. (2024). Relative energy deficiency in sport (REDs): endocrine manifestations, pathophysiology and treatments. *Endocr Rev.*, 45(5):676–708. doi:10.1210/endrev/bnae011.
- Cabre HE, Moore SR, Smith-Ryan AE, Hackney AC. (2022). Relative Energy Deficiency in Sport (RED-S): Scientific, clinical, and practical implications for the female athlete. *Dtsch Z Sportmed.*, 73(7):225–234. doi:10.5960/dzsm.2022.546.
- Coelho AR, Cardoso G, Brito ME, Gomes IN, Cascais MJ. (2021). The female athlete triad/relative energy deficiency in sports (RED-S). *Rev Port Endocrinol Diabetes Metab.*, 16(2):94–100. doi:10.1055/s-0041-1730289.
- Jeukendrup AE, Areta JL, Van Genechten L, et al. (2024). Does relative energy deficiency in sport (REDs) syndrome exist? *Sports Med.*, 54:2793–2816. doi:10.1007/s40279-024-02108-y
- Langbein-Stott R, Allen-Collinson J, Martin D, Jackman P. (2025). Relative energy deficiency in sport (REDs) and identity work in endurance athletes. *Eur J Sport Soc.*, 1–17. doi:10.1080/16138171.2025.2498200.
- Mountjoy M, Ackerman KE, Bailey DM, Burke LM, Constantini N, Hackney AC, et al. (2023). International Olympic Committee's (IOC) consensus statement on relative energy deficiency in sport (RED-S). *Br J Sports Med.*, 57:859–878. doi:10.1136/bjsports-2023-106994.
- Mountjoy M, Sundgot-Borgen JK, Burke LM, Ackerman KE, Blauwet C, Constantini N, et al. (2018). IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sports Med.*, 52(11):687–97.
- Oxfeldt M, Phillips SM, Andersen OE, Johansen FT, Bangshaab M, Risikesan J, et al. (2024). Low energy availability reduces myofibrillar and sarcoplasmic muscle protein synthesis in trained females. *J Physiol.*, 602:1453–1470.

Valiño-Marques A, Jurado-Castro JM, Domínguez-Balmaseda D, Ranchal-Sánchez A, Carrera-Bastos P, Veiga-Herreros P, et al. (2025). Relative energy deficiency in sport (REDs) and its effect on health and performance in men: a systematic review of cross-sectional studies. Research Square [preprint], 1–23. doi:10.21203/rs.3.rs-5571836/v1.

## **Relativna energetska deficijencija u sportu: budući izazovi u fizioterapiji**

Meliha ČOLPA\* Maja KRSTIĆ Demir DŽAFEROVIĆ

Univerzitet u Sarajevu, Fakultet zdravstvenih studija, Studijski program Fizioterapija, BiH

\*Autor za korespondenciju: Meliha Čolpa, meliha.colpa@fzs.unsa.ba

### **Sažetak**

Relativna energetska deficijencija u sportu (REDs) predstavlja sindrom uzrokovan hroničnim nedostatkom energije kada unos kalorija nije dovoljan da pokrije potrebe treninga i osnovnih tjelesnih funkcija. REDs se javlja kod oba spola i utiče na niz fizioloških sistema, uključujući hormonalni, metabolički, kardiovaskularni, imunološki i skeletni. Klinički simptomi REDs-a manifestuju se kroz hronični umor, pad sportske performanse, učestale povrede, menstrualne nepravilnosti kod žena i smanjen nivo testosterona kod muškaraca. Poseban značaj ima uticaj na mineralnu gustinu kostiju, što povećava rizik od stres fraktura i dugoročnih ortopedskih komplikacija. Iako uzrok može biti povezan s poremećajima u ishrani, REDs se često razvija kao posljedica nesvjesnog energetskog deficita usljed intenzivnog treninga i nedovoljne ishrane. Svrha ovog istraživanja je analizirati uticaj niske energetske dostupnosti na zdravlje i performanse sportista. Na osnovu pregleda naučne literature iz relevantnih baza podataka Google Scholar, PubMed i Web of Science, iako su istraživanja još uvijek ograničena, dostupni podaci ukazuju da pravovremeno prepoznavanje i korekcija energetske neravnoteže mogu značajno smanjiti rizik od zdravstvenih komplikacija i poboljšati sportske performanse. REDs je danas prepoznat kao jedan od ključnih izazova u sportskoj medicini i fizioterapiji, a prevencija i tretman zahtijevaju saradnju ljekara, nutricionista, fizioterapeuta i psihologa-uz edukaciju sportista i trenera o pravilnoj energetskoj ravnoteži.

*Ključne riječi: Relativna energetska deficijencija u sportu (REDs), niska energetska dostupnost (LEA), fizioterapija, ishrana, zdravlje*



## **Market analysis and attitudes of goat milk producers in the Novi Sad area**

Iva DUKIĆ

University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine,  
Republic of Serbia

Corresponding author: Iva Dukić, ivaloladukic@gmail.com

### **Abstract**

Goat milk is a valuable nutrient for humans, particularly for children and individuals with lactose intolerance. Compared to cow's milk, it is more easily digestible, has distinct alkalinity and several therapeutic properties relevant to medicine and nutrition. Goat milk is lower in lactose and contains an average of 12.2% total solids, comprising 3.8% fat, 3.5% protein, 4.1% lactose, and 0.8% ash. To obtain data on the production and availability of goat milk, as well to conduct an interview with local producers, a detailed market survey in the city of Novi Sad was conducted. The results revealed a limited number of producers involved in goat milk production and sales, indicating the relatively low local representation of this sector. Respondents' attitudes demonstrated consumer interest, which was selective and varied throughout the year. Furthermore, the findings highlighted a high level of producer awareness regarding product quality, food safety, and control measures.

*Keywords: goat milk, producers, market, interview*

### **Introduction**

The importance of goats in human nutrition has probably been recognized since the early stages of domestication (ALKaisy, Al- Saadi, AL- Rikabi et al., 2023). Goat milk is an important nutrient for humans, especially for young ones, and those who have problem of lactose intolerance. It differs from cow or human milk in higher digestibility, distinct alkalinity, higher buffering capacity, and certain therapeutic values in medicine and human nutrition. Compared to cow's milk, goat's milk is lower in lactose. (Getaneh, Mebrat, Wubie, et al., 2016). Its products, besides protein and fat, are high source of phosphate and calcium (Malau-Aduli, Eduvie, Lakpini, et al., 2001). Goat's milk contains different protein fractions such as casein, whey proteins, and minor proteins, each with unique properties and functions (Dhasmana, Das and Shrivastava, 2022). According to other (Park, 2010)

reports that goat's milk contains an average of 12.2% total solids, consisting of 3.8% fat, 3.5% protein, 4.1% lactose, and 0.8% ash. Goat's milk contains 25% more vitamin B6, 47% more vitamin A and 13% more calcium than cow's milk (Getaneh et al., 2016). Research has shown that goat milk proteins offer multiple health benefits including immunomodulatory, anti-inflammatory, antioxidant, antimicrobial, and anticancer effects (ALKaisy et al., 2023). Although the demand for goat milk products has been growing, they still have lower consumer acceptability than products derived from bovine milk (Paskaš, Miočinović, Lopičić-Vasić, et al., 2020). A possible problem of "goaty" and "mutton" flavour in goat milk and products can pose a challenge, such as that products from goat milk are more expensive and difficult to find than similar products derived from bovine and ovine milk (Haenlein, 1993). Raynal-Ljutovaca, Lagriffoulb, Paccardb, et al., (2008) stated in their study that there is a lack of knowledge and inability to utilize milk in forms conducive to human consumption in a wide variety of circumstances. Therefore, the aim of this study was to examine the market and identify the approximate number of producers of goat-based products, with a particular emphasis on goat milk, in order to conduct interviews and collect data concerning production and sale of goat milk within the territory of the city of Novi Sad. The interview sought to explore, from the producers' perspective, the level of consumer interest in goat milk, the reasons for their interest or lack thereof, as well as the accessibility of goat milk to consumers depending on the number of producers operating within the territory of the City of Novi Sad.

### ***Experimental***

In order to collect relevant data on the production and availability of goat's milk, as well as to conduct an interview with producers, a detailed search of the market in the territory of the city of Novi Sad was conducted. The research process included a multi-phase approach to data collection, which included an internet search of potential producers, direct contact via e-mail and telephone, as well as field information gathering by visiting local trade chains and markets. Special attention was paid to analyzing the offer collected at the four largest city markets — Limanska, Riblja, Futoška and Detelinara markets.

### ***Results and Discussion***

The results of the conducted research indicated that in the area of the city of Novi Sad there is a limited number of producers engaged in the production and sale of goat's milk, which testifies to the relatively low level of representation of this branch of livestock production at the local level. After

applying all the mentioned search methods, contacts were made and interviews were conducted with a total of eight producers, which represents the final number of respondents included in this phase of the research. Through an internet search, we found three producers, whom we contacted by phone and e-mail address. During the field tour of the largest markets in the city, the establishment of direct contact with producers at two of the key locations was especially noted. Two producers of goat products were interviewed at the "Limanska" market, while contact was established with the remaining three producers at the "Riblja" market. These findings show the presence of producers in the city's central markets, highlighting the limited number of active entities in this sector and providing a basis for a more detailed investigation. In contrast, during the field tour of the "Futoška" and "Detelinara" markets, although among the largest markets, the presence of goat milk producers was not observed. Such results show that they are absent in the goat milk sales sector. In this way of searching the market, it is possible to obtain domestic goat's milk, while a tour of larger trade chains such as "Idea", "Maxi", "Univerexport" shows the possibility of purchasing commercially packaged milk.

After this phase of research and the detailed analysis and search of the market, the phase of interviewing the producers was carried out. Interviews followed a survey format, collecting both structured responses and additional informal insights, which enhanced understanding of producers' perceptions, experiences and attitudes towards the production and distribution of goat's milk. On average, each interview lasted approximately 15 minutes, although in some cases, where the discussion extended into broader topics, the duration ranged from 20 to 25 minutes. One of the respondents indicated that goat milk production at their facility had been discontinued, which is the reason why their responses were not included in the subsequent phase of the research, encompassing statistical analysis and data reporting. During the initial part of the conversation, the emphasis was placed on consumers' interest in goat milk, where we tried to collect data on regular sales of milk, as well as to create an insight into whether consumers are the ones trying to get the milk, or producers trying to establish contact with customers. Analyzing the views of the producers, where 100% of the respondents answered the same, showed that consumers are interested in goat milk, and that they are the ones who put in the effort to get the product. Most of the customers are regular and constant consumers, which indicates the existence of a stable base that is continuously looking for this product. Additionally, during the interview, one of the respondents pointed out that new customers often come when they are faced with health problems, while the most important thing is to consume milk preventively, in order to prevent

the onset of diseases. Such insights and responses provide a better understanding of the producer's perception and emphasize the importance of preventive use of goat's milk. In response to the question about the availability of goat milk and whether it is available at all times, the majority of respondents (71.42%) stated that milk is most available in the season, until November, before the beginning of the drying period, while it is almost non-existent in the winter period, with slight variations depending on the year. One of the interviewees pointed out that milk is not available now, while the remaining two interviewees emphasized that milk can be available during the winter period, but in a much smaller quantity. One of them additionally explained to us that such results are not achieved naturally, but by using the estrus synchronization method, which allows them to plan and organize work on the farm more efficiently. These insights indicate the seasonal oscillation of goat milk availability and the application of specific methods to optimize production throughout the year. The analysis of producer responses regarding consumer awareness of goat milk highlighted a high level of prior knowledge among buyers. Most consumers reportedly approach the purchase already informed, often based on medical or pediatric recommendations, and seldom seek additional advice at the point of sale. This suggests a proactive consumer profile characterized by self-initiated information gathering. According to all respondents, consumers are generally well aware of the nutritional and functional value of goat milk. A common observation was that parents frequently seek goat milk or related products for infant supplementation following pediatric guidance. All producers stated that goat milk is primarily recommended for children, while 42.85% of respondents specified that consumers often mention direct pediatric recommendations involving goat milk or whey-based products. The same proportion reported that mothers prefer goat milk due to its compositional similarity to human milk and its lower tendency to cause bloating compared to powdered milk. Most producers (85.71%) indicated that consumers typically use goat milk as a substitute for cow's milk due to allergic reactions. Additionally, all respondents emphasized its recommendation for individuals with health issues, as well as for improving immunity and maintaining a balanced digestive microbiota. Preventive consumption was repeatedly identified as a key factor in its perceived health benefits. Furthermore, 28.57% of respondents mentioned the use of whey as an effective natural aid in managing liver disorders. Overall, these findings suggest that consumers demonstrate a strong level of nutritional awareness and a targeted demand for goat milk and related products, primarily driven by health considerations and preventive dietary behavior. The majority of respondents (71.42%) pointed out that consumers increasingly prefer domestic goat's milk, while a smaller

part (28.58%) stated that they encountered cases in which consumers switch to store-bought milk due to its practicality. During the final part of the conversation, the emphasis was placed on the control and safety of milk and products. Analysis of producers' attitudes regarding the safety of goat products showed that the majority of respondents (71.42%) believe that the primary responsibility for product safety rests with the producer. Two respondents pointed out that control and responsibility is shared by the competent inspection, while one of the producers additionally emphasized that everything starts from the farm itself and the producer, with strict control at all levels of the production chain. These results indicate a good awareness of the manufacturer about the importance of responsibility for product quality and safety, as well as the need for systematic control during the entire production process. Three respondents spontaneously pointed out that the unpleasant smell of milk is not the result of poor nutrition or the quality of the milk itself, as consumers often assume, but rather the result of unhygienic and poor-quality milking conditions. These comments indicate a high level of awareness of producers regarding the safety and quality of milk, as well as their willingness to further educate consumers about the factors that affect product properties. When asked about potential contributions from professionals such as veterinarians, livestock experts, and food technologists, including students in these fields, all respondents provided similar answers emphasizing the importance of education and public awareness. According to their views, while regular consumers already possess a basic level of knowledge, the wider population remains insufficiently informed about the health and nutritional benefits of goat milk. In this regard, they consider the continuous expansion of knowledge and awareness of the advantages of this product as the most effective approach for improving and strengthening the goat's milk market in Novi Sad.

### ***Conclusion***

Based on the obtained results, it can be concluded that the presence of goat milk producers in the central parts of the city market, throughout the year, is the most developed, despite the fact that the total number of goat milk producers in this sector remains limited. The attitudes of the respondents indicate the existence of consumer interest, which is shown to be selective and variable depending on the period of the year. Also, the results indicate a high awareness of quality, control and food safety from the point of view of producers. At the same time, it was observed that educating and informing the population about the importance of preventive consumption and the health benefits of goat's milk is equally important. Furthermore, the respondents expressed, through their answers, a clear interest in continued

education and professional training aimed at improving their knowledge and practices in goat milk production and market development.

**Funding:** This work did not receive funding.

**Acknowledgments:** I would like to express my sincere gratitude to my mentor, prof. dr Marija Pajić, for her invaluable guidance, support, and expert advice throughout the preparation of this research work.

## **References**

- ALKaisy, Q. H., Al-Saadi, J. S., Al-Rikabi, A. K. J., Altemimi, A. B., Hesarinejad, M. A., & Abdelmaksoud, T. G. (2023). Exploring the health benefits and functional properties of goat milk proteins. *Food science & nutrition*, 11(10), 5641-5656. <https://doi.org/10.1002/fsn3.3531>
- Dhasmana, S., Das, S., & Shrivastava, S. (2021). Potential nutraceuticals from the casein fraction of goat's milk. *Journal of Food Biochemistry*, 46(6). <https://doi.org/10.1111/jfbc.13982>
- Getaneh, G., Mebrat, A., Wubie, A., & Kendie, H. (2016). Review on goat milk composition and its nutritive value. *Journal of Nutrition and Health Sciences*, 3(4), 1-10. <https://doi.org/10.15744/2393-9060.3.401>
- Haenlein, G. F. W. (1993). Producing quality goat milk. *International Journal of Animal Science*, 8, 79–84.
- Malau-Aduli, B.S., Eduvie, L.O., Lakpini, C.A.M., and Malau-Aduli, A.E.O. (2001). Effect of supplementation on the milk yield and composition of Red Sokoto does. In: *Proceedings of the Annual Conference of the Nigerian Society for Animal Production* (26) pp. 353-356. <https://hdl.handle.net/102.100.100/491016>
- Park, Y. W. (2010). Goat milk: composition, characteristics. In W. G. Pond & N. Bell (Eds.), *Encyclopedia of animal science* (2nd ed., pp. pp. 474-477)
- Paskaš, S., Miočinović, J., Lopčić-Vasić, T., Mugosa, I., Pajić, M., & Becskei, Z. (2020). Consumer attitudes towards goat milk and goat milk products in Vojvodina. *Mljekarstvo*, 70(3), 171-183. <https://doi.org/10.15567/mljekarstvo.2020.0304>
- Raynal-Ljutovaca, K., Lagriffoulb, G., Paccardb, P., Guillet, I., Chilliard, Y. (2008 ). Composition of goat and sheep milk products: An update. *Small Ruminant Research*, 2008, 79 (1), pp.57-72. <https://doi.org/10.1016/j.smallrumres.2008.07.009>

## **Analiza tržišta i stavova proizvođača kozjeg mleka na području Novog Sada**

Iva DUKIĆ

Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za veterinarsku medicinu,  
Republika Srbija

Autor za korespondenciju: Iva Dukić, ivaloladukic@gmail.com

### **Sažetak**

Kozje mleko predstavlja vredan nutritivni resurs za ljude, posebno za decu i osobe sa intolerancijom na laktozu. U poređenju sa kravljim mlekom, lakše se vari, odlikuje se specifičnom alkalnošću i poseduje nekoliko terapijski značajnih svojstava relevantnih za medicinu i ishranu. Kozje mleko sadrži manju količinu laktoze i prosečno ima 12,2% ukupnih suvih materija, od čega 3,8% čini mast, 3,5% proteini, 4,1% laktoza i 0,8% pepela. Kako bismo prikupili podatke o proizvodnji i dostupnosti kozjeg mleka, kao i kako bismo obavili intervju sa lokalnim proizvođačima, sprovedena je detaljna analiza tržišta na teritoriji grada Novog Sada. Rezultati su pokazali da postoji ograničen broj proizvođača koji se bave proizvodnjom i prodajom kozjeg mleka, što ukazuje na relativno nisku zastupljenost ove grane stočarstva na lokalnom nivou. Stavovi ispitanika ukazali su na postojanje potrošačkog interesovanja, koje je selektivno i varira tokom godine. Pored toga, rezultati su pokazali visok nivo svesti proizvođača o kvalitetu proizvoda, bezbednosti hrane i merama kontrole.

*Ključne riječi: kozje mleko, proizvođači, tržište, intervju*

### **Mindful eating as a method for body weight control**

Amina ĐONKO\* Anida JUSIĆ Lajla KAHRIĆ Aiša KOMARICA Ajna  
MUHAREMOVIĆ Jasmina ĐEĐIBEGOVIĆ

University of Sarajevo – Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

\* Corresponding author: Amina Donko, aminadonko@ffsa.unsa.ba

#### **Abstract**

Many studies and researches recently emphasize mindful eating as a very good method for body weight control. It represents a simple approach to nutrition that focuses on awareness at the moment of eating, recognizing the signals of hunger and fullness, and what represents the biggest problem, reducing emotional eating. This method of weight control focuses on careful food consumption. Numerous studies have shown that mindful eating potentially contributes to maintaining a healthy body mass, reducing impulsive eating and generally improving the relationship to food, and this is what we will focus on through this seminar work. The negative correlation between mindful eating and body mass index (BMI) suggests that people who practice this method more often gain, achieve and maintain a healthy body mass. Practicing conscious nutrition is not necessarily easy and requires practice, but it can be achieved by applying proper steps and consulting appropriate literature with clear guidelines on how to plan meals. The goal of conscious eating is not to lose weight - but to truly experience food and develop healthy eating habits that become part of the lifestyle. However, such practice often helps people in body weight control.

*Keywords: mindful eating, body weight, BMI, eating habits*

#### **Introduction**

Obesity is recognized today as one of the leading global public health challenges. It results from an imbalance between energy intake and expenditure, but is also influenced by psychosocial factors and genetic predispositions. According to the World Health Organization (WHO), more than one billion individuals worldwide live with overweight or obesity (Okunogbe et al., 2022). Beyond being an aesthetic concern, obesity significantly increases the risk of cardiovascular disease, type 2 diabetes mellitus, musculoskeletal problems, and diminished quality of life, such as impairments in sleep or mobility. The modern food environment has



amplified this epidemic: foods are increasingly energy-dense, highly processed, and nutrient-poor. Moreover, food has gained new roles as a form of self-expression and as a coping mechanism for stress (Goens et al., 2023). One particularly concerning factor is emotional overeating, where food is consumed in response to emotions rather than physiological hunger. Episodes of emotional eating are often characterized by a loss of control and the rapid consumption of large amounts of food. Traditional weight-loss approaches frequently overlook the emotional dimension of eating, relying instead on restrictive diets and intensive exercise programs that may not provide sustainable solutions (Nelson, 2017).

### *Mindful Eating and Body Weight Control*

Against this backdrop, mindful eating emerges as an increasingly relevant alternative strategy. It enables individuals to recognize and manage emotions while cultivating a healthier relationship with food. By fostering awareness of hunger and satiety signals, mindful eating reduces impulsive consumption and emotional eating, making it a promising tool in addressing obesity and disordered eating. This approach is rooted in mindfulness practices, which emphasize being fully present in the moment without judgment (Olson & Emery, 2015).

Key characteristics of mindful eating include:

- Awareness of hunger and satiety cues—distinguishing true physical hunger from emotional or situational triggers;
  - Reduction of impulsive and stress-related eating—decreasing food intake as a response to emotions, thus restoring a natural eating rhythm;
  - A sustainable approach to weight management—unlike restrictive diets, mindful eating emphasizes long-term balance;
  - Enhancement of psychological well-being—reducing guilt and increasing satisfaction with meals;
  - Eating without distractions—focusing attention exclusively on the act of eating;
  - Practices such as food journaling and pre-meal meditation—supporting stress reduction and mindful awareness of food (Katterman et al., 2014).
- While its effects on weight loss are comparable to conventional diets, mindful eating offers greater psychological benefits, providing a holistic approach to health by balancing physical and emotional well-being (Godsey, 2013).

The aim of this paper is to explore the concept of mindful eating as a potentially effective strategy for body weight control, to highlight the importance of cultivating a careful relationship with food, and to encourage the adoption of healthy eating patterns.

## ***Experimental***

The paper was prepared using appropriate research methods to ensure accurate formulation and academic quality. The applied research methods included:

- Data collection from secondary sources;
- Descriptive method;
- Analytical method.

Data were gathered from secondary sources, including textbooks and scientific databases such as:

- PubMed;
- Google Scholar;
- BMC (BioMed Central);
- Sci-Hub, among others.

## ***Results and discussion***

### *The Impact of Mindful Eating on Body Weight and Eating Behaviors*

Findings from numerous studies indicate that mindful eating has significant effects on body weight management. Systematic review and meta-analysis of 10 good quality randomized controlled trials (RCTs) involving 706 participants and published between 2008 and 2017 have demonstrated that mindful eating leads to weight reduction, comparable to outcomes from conventional energy restricted diet programs, but without strict restrictions. . The analyzed studies were from United States of America, United Kingdom, and New Zealand with high percent (63-100%) of women participants (Fuentes Artiles et al., 2019).

In another review paper Olson and Emery (2015) analyzed 13 randomized controlled trials and 6 observational studies evaluating the effects of mindfulness-based interventions on weight among individuals attempting weight loss. Although a significant weight loss was reported in 13 of 19 studies (including 6 of 8 RCTs) with total of 1036 mostly obese participants of both genders, the authors could not conclude to what degree the mindfulness was the underlying mechanism of the reported effect due to methodological variability and weaknesses across studies.

In one study, following an eight-week intervention (weekly educational sessions on healthy eating + mindful eating), adult Brazilian participants of different race (57.3% females) diagnosed with obesity and binge eating disorder (n=82) experienced an average weight reduction of 3 kg, as well as decreases in BMI and waist circumference, suggesting improved fat distribution. Although no specific restrictions were included in the intervention, caloric intake was reduced by an average of 350 kcal per day,

accompanied by increased water consumption. Dietary changes included greater consumption of fresh, minimally processed foods such as fruits, vegetables, legumes, whole grains, and lean proteins, while intake of ultra-processed and refined foods declined. Participants also reported preparing and eating meals at home more frequently, contributing to healthier eating habits overall (Minari et al., 2024).

The assessment of the effect of mindful eating (seven monthly mindfulness-based 90-minutes sessions), moderate caloric reduction (deficit of 500 kcal/day with individualized food plan) or the combination of both was conducted among 138 obese Brazilian women (70 completed the study) who were followed for 6 months. Significant weight loss was found in all three groups, with no significant between-group differences. Mindful eating intervention was superior in reduction in uncontrolled eating (vs. caloric reduction) and in reduction in emotional eating (vs both other interventions). No other variables differ significantly between groups. The main limitation of the study was a high dropout rate, which was attributed to long (1 month) period between successive sessions. The attrition rate was higher in the exclusively mindful eating approach, indicating greater difficulty in adhering to this type of strategy (Pepe et al., 2023).

#### *Long-Term Advantages and Emotional Benefits of Mindful Eating*

Unlike traditional diets that prescribe rigid rules about what and how much to eat, mindful eating centers attention on the act of eating itself. By tuning into internal signals of hunger and fullness, individuals are less prone to impulsive eating (Nelson, 2017). This approach helps avoid the negative consequences of restrictive diets, such as the yo-yo effect and psychological stress caused by prohibitions and limitations (Fuentes Artiles et al., 2019). A key contributor to the success of mindful eating is its emphasis on emotional satisfaction and the development of a positive relationship with food.

Participants often report greater enjoyment of meals and reduced feelings of guilt associate with eating (Nelson, 2017). Nevertheless, existing studies face certain limitations, such as relatively short intervention durations (typically up to 12 months) and participant groups dominated by women from developed countries.

Future research should therefore include more diverse populations and investigate the long-term impact of mindful eating on healthy weight maintenance and overall health outcomes. Ultimately, the strength of mindful eating lies in its holistic nature, balancing physical and emotional health, making it a sustainable choice for the prevention and management of obesity.

## ***Conclusion***

Given the growing interest in the relationship between dietary approaches and weight management, individuals often turn to invasive or highly restrictive methods that lack sustainability. In this context, mindful eating presents itself as a valuable alternative, even though adopting such a lifestyle requires commitment and adjustment. It is important, however, not to view mindful eating as a universal or permanent solution, as scientific evidence remains insufficient to confirm its ultimate effectiveness. Instead, mindful eating should be considered as a strategy for promoting balanced nutrition, enhancing quality of life, and improving anthropometric indicators such as BMI. Further research is needed to substantiate its role and establish mindful eating as a reliable method for weight control in the future.

Special care must be taken to adequately assess mindfulness and control for any possible cofactors not specific to mindfulness. Studies providing evidences for establishing clear mechanism of mindfulness-based interventions are also needed. Finally, almost all of the published studies involves adults while mindfulness-based interventions could potentially be both safe and effective in children as well.

***Author contributions:*** Conceptualization, A. J. and A.K.; methodology, A.M. and A. Đ.; Investigation, L. K. and A.M.; writing-original draft preparation, A. J. and L. K.; writing-review and editing, A. Đ.; visualization, A. Đ. and A. K.; supervision, J. Đ.

***Funding:*** This work did not receive funding.

***Conflicts of interest:*** The authors declare no conflicts of interest.

## ***References***

Fuentes Artiles, R., Staub, K., Aldakak, L., Eppenberger, P., Rühli, F., Bender, N. (2019). Mindful eating and common diet programs lower body weight similarly: Systematic review and meta-analysis. *Obesity Reviews*, 20(11), 1619-1627.

Godsey, J. (2013). The role of mindfulness-based interventions in the treatment of obesity and eating disorders: an integrative review. *Complementary Therapies in Medicine*, 21(4), 430-439.

Goens, D., Virzi, N.E., Jung, S.E., Rutledge, T.R., Zarrinpar, A. (2023). Obesity, chronic stress, and stress reduction. *Gastroenterology Clinics of North America*, 52(2), 347-362.

Katterman, S.N., Kleinman, B.M., Hood, M.M., Nackers, L.M., Corsica, J.A. (2014). Mindfulness meditation as an intervention for binge eating, emotional

eating, and weight loss: a systematic review. *Eating Behaviors*, 15(2), 197-204.

Minari, T.P., Araújo-Filho, G.M., Tácito, L.H.B., Yugar, L.B.T., Rubio, T.A., Pires, A.C., Vilela-Martin, J.F., Cosenso-Martin, L.N., Fattori, A., Yugar-Toledo, J.C. (2024). Effects of mindful eating in patients with obesity and binge eating disorder. *Nutrients*, 16(6), 884.

Nelson, J.B. (2017). Mindful eating: The art of presence while you eat. *Diabetes Spectrum*, 30(3), 171-174.

Okunogbe et al. (2022). The economic impacts of overweight and obesity: 2nd edition with estimates for 161 countries. World Obesity Federation.

Olson, K.L., Emery, C.F. (2015). Mindfulness and weight loss: a systematic review. *Psychosomatic Medicine*, 77, 59–67.

Pepe RB, Coelho GS de MA, Miguel F da S, et al. Mindful eating for weight loss in women with obesity: a randomised controlled trial. *British Journal of Nutrition*. 2023;130(5):911-920

## **Svjesno jedenje kao metod za kontrolu tjelesne mase**

Amina ĐONKO\* Anida JUSIĆ Lajla KAHRIĆ Aiša KOMARICA Ajna  
MUHAREMOVIĆ Jasmina ĐEDIBEGOVIĆ

Univerzitet u Sarajevu – Farmaceutski fakultet

\*Autor za korespondenciju: Amina Đonko, aminadonko@ffsa.unsa.ba

### **Sažetak**

Mnoge studije i istraživanja u posljednje vrijeme potenciraju svjesno jedenje kao jako dobar metod za kontrolu tjelesne mase. Predstavlja jednostavan pristup prehrani koji se fokusira na svjesnost u trenutku jedenja, prepoznavanje signala gladi i sitosti, i ono što predstavlja najveći problem, reduciranje emocionalnog jedenja. Ovakva metoda u kontroli tjelesne mase se fokusira na pažljivo konzumiranje hrane. U mnogobrojnim istraživanjima došlo se do saznanja da svjesno jedenje potencijalno doprinosi održavanju zdrave tjelesne mase, smanjenju impulsivnog jedenja i generalnom poboljšanju odnosa prema hrani a kroz ovaj seminarski rad na to ćemo se i fokusirati. Negativna korelacija između svjesnog jedenja i indeksa tjelesne mase (engl. body mass index, BMI) sugerira da osobe koje prakticiraju ovu metodu češće podižu postišu i održavaju zdravu tjelesnu masu. Prakticiranje svjesne ishrane nije jednostavno i zahtjeva praksu ali uz pravilno poduzimanje koraka i pristup odgovarajućoj literaturi sa jasnim smjernicama kako planirati obroke. Cilj svjesnog jedenja nije gubitak težine – već uistinu doživjeti hranu i razviti zdrave prehrambene navike koje postaju dio životnog stila. Ipak, osobe koje prakticiraju svjesno jedenje nerijetko imaju i bolju kontrolu svoje tjelesne mase

*Gljučne riječi: svjesno jedenje, tjelesna masa, BMI, prehrambene navike*

## **Dietary risk factors for Noncommunicable diseases among the adult population in Bosnia and Herzegovina**

Hana KUSTURA\*

University of Sarajevo, Faculty of Agriculture and Food Sciences, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Hana Kustura, hana.kustura@outlook.com

### **Abstract**

Noncommunicable diseases are the leading cause of death worldwide, and their prevalence in Bosnia and Herzegovina (BiH) continues to rise. Cardiovascular diseases account for over 50% of all deaths, while the rates of type 2 diabetes and diet-related cancers are increasing. More than half of the adult population is overweight or obese. The main goal of this paper is to highlight the crucial role of nutrition in the development of risk factors for noncommunicable diseases and to assess how dietary habits affect the health of adults in BiH. The research relies on statistical yearbooks, analytical studies, and WHO policies aimed at reducing noncommunicable diseases. Poor nutrition, combined with high rates of smoking, overweight, and hypertension, has a measurable negative impact on public health. Inadequate intake of fruits, vegetables, and unsaturated fatty acids contributes to premature mortality and increases disease risk. Public health interventions are essential to improve food supply, promote supplementation and food fortification, and raise awareness of healthy eating. These efforts should aim to increase the intake of omega-3 fatty acids, fibre, vitamins, and minerals, while reducing the consumption of added sugars and saturated fats.

*Keywords: noncommunicable diseases, nutrition, health*

### **Introduction**

Noncommunicable diseases (NCDs) are the major cause of morbidity and mortality across the globe, representing a considerable public health concern for both developed and developing countries. In Bosnia and Herzegovina (BiH), chronic noncommunicable diseases have been on the rise, and cardiovascular diseases account for more than half of all deaths (Zavod za javno zdravstvo Federacije Bosne i Hercegovine, 2025; JZU Institut za javno zdravstvo Republike Srpske, 2023). Alongside this, type 2 diabetes, hypertension, and nutrition-related cancers have increased significantly, mirroring global trends associated with unhealthy diet, lack of physical

activity, and population ageing. More than half of the adult population of BiH is now overweight or obese, reflecting the widespread influence of unhealthy nutrition and lifestyle determinants of health status.

The national food consumption surveys conducted throughout the past several years provide valuable data on the nutrition situation and dietary habits of the Bosnian population (Arar, Brenjo and Hajrić, 2021; Gičević, Kremic and Fung, 2019). The first-ever complete dietary survey, developed in collaboration with the national Institute for Statistics, demonstrated the feasibility of nutritional surveillance and revealed alarming trends that consisted of low intakes of vegetables, fruits, fibre, and omega-3 fatty acids, and high intakes of saturated fat, sodium, and refined carbohydrates (Gičević, Gaskins and Fung, 2019).

Additional research confirmed that diet quality is poor in most adults, particularly the young and those from lower socioeconomic backgrounds (Gičević, Gaskins and Fung, 2019). Studies conducted in type 2 diabetic subjects in Banja Luka also pointed to the strong correlation of poor diet with high anthropometric parameters such as body mass index and waist circumference (Šibarević, Malinović Pančić and Dojčinović, 2025; Čano Dedić, Pašalić and Papić, 2024).

These findings emphasise the urgent need for multifaceted nutrition-specific interventions aimed at improving dietary behaviour and reducing the NCD burden in BiH. The primary aim of this study is to analyze the data on dietary habits as risk factors for common noncommunicable diseases among the adult population of Bosnia and Herzegovina. By bringing together data from dietary surveys, statistical yearbooks, and public health policy reports, this research seeks to emphasise the role of nutrition as a chronic disease determinant that can be modified and to aid in the development of evidence-based public health interventions.

### ***Experimental***

This review is a narrative assessment judging dietary habits and their interaction with noncommunicable diseases (NCDs) among adults in Bosnia and Herzegovina (BiH). Systematic gathering and analysis of scientific articles, national food surveys, public health reports, and statistics were employed within the review. Information sources were PubMed, Scopus, Google Scholar, and the databases of the World Health Organisation, the BiH Agency for Statistics, and the Federation of BiH, Republika Srpska, and Brčko District institutions of public health. All publications up to October 2025 were included in the search using keywords including Bosnia and Herzegovina, diet, nutrition, noncommunicable diseases, cardiovascular disease, obesity, diabetes, and dietary survey.



Only studies and reports that focused on the adult population of BiH were examined, while publications with no proper dietary or health data were excluded to avoid inappropriate analysis. Data were yielded on study design, sample, method of dietary assessment, nutrient consumption, and health status. Because of the heterogeneity of data sources, the findings were synthesised narratively rather than statistically. Findings were coded under broad themes: patterns of diet, adequacy of nutrients, socio-economic determinants, and public health consequences. As this study is based on published and publicly available literature only, ethical approval was not required.

### ***Results and Discussion***

The reviewed literature continues to verify that the adult population of Bosnia and Herzegovina has severe nutrition-related health issues. The research establishes that dietary patterns are characterised by insufficient intake of fruits, vegetables, whole grain foods, nuts, and fish, and excessive intakes of refined grains, processed meat, saturated fat, and salt. These are strongly associated with rising overweight, obesity, hypertension, cardiovascular diseases, and type 2 diabetes.

Evidence shows that diet quality scores in Bosnia and Herzegovina are low, particularly among young adults, singles, and individuals in the southern regions of the country. Socioeconomic status also plays a role, where those from low-income families have lower dietary variety and poorer nutrient intake. A deficiency of omega-3 fatty acids, fibre, vitamins, and minerals, and excessive sodium and saturated fat intake cause cardiovascular and metabolic disorders. (Gičević et al., 2019)

These findings align with the World Health Organisation reports declaring unhealthy diet, physical inactivity, and smoking as leading modifiable risk factors for noncommunicable diseases in Bosnia and Herzegovina (Zavod za javno zdravstvo Federacije Bosne i Hercegovine, 2025; JZU Institut za javno zdravstvo Republike Srpske, 2023). These studies have accentuated the need for short-term public health measures to improve food habits and minimise nutritional risks (Arar et al., 2021; Gičević et al., 2019). These measures ought to form nutrition education, food fortification of available supplies, promotion of consumption of local fruits and vegetables, and food promotion and labelling control.

Further, it is also essential to establish short-term arrangements for a national diet surveillance system to track dietary habits periodically and enable evidence-based policy making (Gičević et al., 2019).

More broadly, the evidence suggests that improving the nutritional health of the Bosnian population will require a multisectoral approach that aligns

policy across health, education, and sustainable food systems. Greater promotion of well-balanced diets with high levels of plant-based foods and essential nutrients is potentially an essential first step in averting the danger of chronic noncommunicable disease and maximising long-term population well-being.

## **Conclusion**

This review emphasises the central role of dietary habits in the aetiology and prevention of noncommunicable diseases within Bosnia and Herzegovina. The review of national data and associated research confirms that a poor diet with low intake of fruits, vegetables, and unsaturated fats and high intake of sugar, salt, and saturated fats is a major determinant of the rising rates of cardiovascular diseases, diabetes, and obesity (Gičević et al., 2019; Šibarević et al., 2025). Public health is achieved through combined measures directed at promoting balanced nutrition, imposing food fortification programs, and upgrading public awareness about healthy dietary intake. Overall, improved nutrition is not only an effective disease prevention strategy but also a fundamental element of healthy and sustainable disease prevention and health development in Bosnia and Herzegovina.

**Informed Consent Statement:** Not applicable

**Conflicts of Interest:** The author declares no conflicts of interest.

## **References:**

- Arar, K., Brenjo, D., Hajrić, D., Odak, L. (2021). *The study of Bosnia-Herzegovinian dietary survey of adolescents, adults and pregnant women (B&H MENU)*. Food Safety Agency of Bosnia and Herzegovina. *EFSA Supporting Publications*, 18(12), EN-6993. <https://doi.org/10.2903/sp.efsa.2021.EN-6993>
- Čano Dedić, L., Pašalić, A., Papić, E., Begagić, E., Šečić Selimović, S., Gazibarić, M., Šegalo, S. (2024). Evaluation of indirect indices in the insulin resistance assessment in patients with different body mass index. *Journal of Health Sciences*, 14(2), 108–113. <https://doi.org/10.17532/jhsci.2024.899>
- Gičević S, Gaskins AJ, Fung TT, Rosner B, Sabanovic E, Gurinovic M, Kadvan A, Kremic E, Willett W. (2019). Fueling an epidemic of non-communicable disease in the Balkans: a nutritional survey of Bosnian adults. *Int J Public Health.*, 64(6):873-885. doi: 10.1007/s00038-019-01222-3.
- Gičević S, Gaskins AJ, Fung TT, Rosner B, Sabanovic E, Milesevic J, Kadvan A, Kremic E, Willett W. (2019). Demographic and socio-economic

predictors of diet quality among adults in Bosnia and Herzegovina. *Public Health Nutr.*, 22(17):3107-3117. doi: 10.1017/S1368980019001988.

Gičević S, Kremic E, Fung TT, Rosner B, Sabanovic E, Willett WC. (2019). Feasibility and sustainability of dietary surveillance, Bosnia and Herzegovina. *Bull World Health Organ.*, 97(5):349-357. doi: 10.2471/BLT.18.227108.

JZU Institut za javno zdravstvo Republike Srpske. (2023). *Zdravstveno stanje stanovništva Republike Srpske, 2022*. Banja Luka: JZU Institut za javno zdravstvo Republike Srpske.

Šibarević, M., Malinović Pančić, J., Dojčinović, T., Roljić, R., & Hadžiahmetović Jurida, E. (2025). Eating habits and certain anthropometric characteristics among individuals with type 2 diabetes mellitus in Banja Luka (Bosnia and Herzegovina). *Journal of Health Sciences*, 15(1), 17–23. <https://doi.org/10.17532/jhsci.2025.906>

Zavod za javno zdravstvo Federacije Bosne i Hercegovine. (2025). *Zdravstveno statistički godišnjak Federacije Bosne i Hercegovine 2024*. Zavod za javno zdravstvo FBiH. [https://zzjzfbih.ba/wp-content/uploads/2025/09/Godisnjak\\_ZZJZ\\_2024.pdf](https://zzjzfbih.ba/wp-content/uploads/2025/09/Godisnjak_ZZJZ_2024.pdf)

## **Faktori rizika u ishrani za nezarazne bolesti među odraslom populacijom u Bosni i Hercegovini**

Hana KUSTURA\*<sup>1</sup>

Univerzitet u Sarajevu, Poljoprivredno - prehrambeni fakultet, Sarajevo, BiH

\*Autor za korespondenciju: Hana Kustura, hana.kustura@outlook.com

### **Sažetak**

Nezarazne bolesti su glavni uzrok smrti širom svijeta, a njihov broj u Bosni i Hercegovini raste iz godine u godinu. Kardiovaskularne bolesti čine više od 50% svih smrtnih slučajeva, dok stope dijabetesa tipa 2 i karcinoma povezanih s ishranom rastu. Više od polovine odraslih osoba je prekomjerne tjelesne mase ili gojazno. Cilj rada je istaknuti ključnu ulogu prehrane u razvoju faktora rizika za nezarazne bolesti i procijeniti uticaj prehrambenih navika na zdravlje odraslih u BiH. Korišteni su statistički godišnjaci, analitička istraživanja i WHO politike za smanjenje nezaraznih bolesti. Nedostaci u prehrani, zajedno s visokom prevalencijom pušenja, prekomjerne mase i hipertenzije, imaju značajan negativan uticaj na zdravlje. Nizak unos voća, povrća i nezasićenih masnih kiselina doprinosi povećanom riziku od bolesti i prijevremene smrtnosti. Javne zdravstvene intervencije su potrebne kako bi se poboljšala opskrba hranom, promoviralo suplementiranje i obogaćivanje hrane te podigla svijest o zdravim prehrambenim navikama. Poseban fokus treba biti na povećanju unosa omega-3 masnih kiselina, vlakana, vitamina i minerala, uz smanjenje dodanog šećera i zasićenih masnih kiselina, kako bi se smanjio rizik od nezaraznih bolesti i unaprijedilo zdravlje populacije.

*Ključne riječi: nezarazna oboljenja, ishrana, zdravlje*

## **The Problem of Obesity Among 4th and 5th Grade Elementary School Students**

Ema MUJEZINOVIĆ Elvira Nikšić

University of Sarajevo – Faculty of Education

Corresponding author: Ema Mujezinović, ema.tiro99@hotmail.com

### **Abstract**

Obesity is an increasingly prevalent health issue today that significantly affects public health, especially in childhood. The research was conducted on a sample of N=290 students from the 4th and 5th grades of elementary school. This study aimed to determine the prevalence of obesity among these students and to examine whether there are significant differences between genders. Measurements of body weight and height were taken, based on which the Body Mass Index (BMI) was calculated. Using BMI values, the nutritional status of the participants was determined. Statistical data analysis was performed using Excel. The results showed that in the 4th and 5th grades, most girls had normal body weight (71; 48%), while 42 (28%) were overweight, 32 (22%) were obese, and only 3 (2%) were underweight. Among boys, the majority also had normal body weight (48; 34%), while 46 (32%) were overweight, 46 (32%) were obese, and 2 (2%) were underweight. The analysis indicated that the number of underweight and normal-weight girls was higher compared to boys, whereas boys showed significantly higher numbers in both the overweight and obesity categories. It can be concluded that proper nutrition and regular physical activity are key factors in preventing childhood obesity.

*Keywords: eating habits, physical activity, nutritional status, obesity, 4th and 5th grade students*

### **Introduction**

Nutrition plays a key role in growth and development, because improper nutrition, along with reduced physical activity, leads to excessive accumulation of body weight. Overweight denotes moderate excess fat, while obesity is a more serious condition that can lead to the development of many diseases, especially cardiovascular diseases. The causes of obesity include poor nutrition, lack of physical activity, behavioral and genetic factors. Increased intake of high-calorie foods and reduced physical activity leads to the accumulation of excess energy, which is converted into adipose tissue. Obesity has become a serious health threat that affects many organs and systems in the body, increasing the risk of serious diseases (Prskalo and

Sporiš, 2016). Vučemilović (2010) states that the obesity among children population in developed countries is becoming one of the most prominent problems, with serious health implications. It is worrying that childhood obesity often continues into adulthood. Westcott (2006) states that adolescents who are overweight have a 70% greater chance of facing the same problem in adulthood. This cycle of obesity leads to the development of metabolic syndrome, which manifests itself through a number of health problems, including cardiovascular disease, type 2 diabetes, musculoskeletal disorders, and others (Westcott, 2006). Overweight and obesity are not just aesthetic problems, but also represent a serious health challenge. The World Health Organization (WHO) predicts that by 2025, as much as 50% of the world's population will have a problem with overweight or obesity, which is classified into three categories: overweight, obesity, and morbid obesity (Alić-Partić et al., 2017). Obesity also has serious long-term consequences. At the Second Croatian Congress on Obesity in 2006, it was emphasized that obesity is no longer just a risk factor for other diseases, but also a disease that can lead to increased mortality (Krnić, 2008). Parents play a key role in the development of children's eating and physical habits. Children adopt the eating habits of their parents, so if a healthy diet is promoted in the family, the child is likely to maintain these healthy habits into adulthood. Given the fast-paced lifestyle and the decreasing time that parents have to prepare meals, they often resort to fast food. This type of diet can influence the development of excess body weight in children (Vučemilović, 2010).

Physical inactivity is one of the key causes of obesity and many other diseases. A number of health problems in today's society, including obesity, can be linked to a lack of physical activity. Children today are less physically active than previous generations, and the influence of television and video games takes away time that could be used for play and physical activity. Statistics show that children under 10 years of age spend twice as much time watching television as they do actively play, and the more television they watch, the more likely they are to be obese (Bralić, 2005).

Childhood obesity leads to numerous health problems that appear early in life, from impaired mobility to serious metabolic disorders. Overweight children face an increased risk of developing insulin resistance, type 2 diabetes, fatty liver, hypertension, glomerulosclerosis, accelerated growth and bone maturation, and various hormonal disorders such as ovarian hyperandrogenism in girls and gynecomastia in boys (Montignac, 2025). Obese children may also have a reduced quality of life due to physical problems, reduced self-esteem, and increased stress that come with obesity (Ille, 2008).

Obesity also causes low self-esteem, especially in girls and adolescents, who feel unhappy about their appearance. Over 70% of extremely obese adolescents meet criteria for at least one psychological disorder, with the most common problems being depression, anxiety, and social phobia. Such problems have long-term consequences, as excess body weight can worsen emotional functioning and quality of life. Research shows that obesity can be a predictor of the development of anxiety and depressive disorders in adulthood, especially in women (Šekerija, Ajduković, & Poljičanin, 2008). Parental education should include advice on proper nutrition, such as consuming seasonal fruits and vegetables, using healthy fats such as olive or pumpkin oil, and preparing healthy meals at home.

Parents should also limit the time their children spend in front of the TV or computer and encourage them to engage in daily physical activity. Family activities, such as shared meals or physical recreation, not only help prevent obesity, but also strengthen mutual relationships and communication (Bralić, 2005). The influence of parents on the development of children's eating habits and body weight is extremely important. Factors such as the duration of breastfeeding or the introduction of solid food can affect the risk of obesity in early childhood. If children have access to healthy food in the family and see their parents practicing a healthy lifestyle, it is more likely that they will develop similar habits themselves (Stipančić, 2004).

## ***Experimental***

### *Sample/participants*

Survey included pupils (N=290) in 4th and 5th grade of elementary school, 149 (51%) and N=141 (49%), respectively. Three elementary schools in the municipality of Hadžići participated in the research: OŠ „6. mart“ Hadžići (46 pupils from 5th grade and 60 pupils from 4th grade), OŠ „9. maj“ Pazarić (57 pupils from 5th grade, 35 pupils from 4th grade) and OŠ „Hilmi ef. Šarić“ Tarčin (38 pupils from 5th grade, 54 pupils from 4th grade).

### *Measurements*

Anthropometric variables used in this study were: height, weight and body mass index (BMI).

### *Experimental design*

Anthropometric measures were taken using a standardized, internationally recognized protocol established by the International Society for the Advancement of Kinanthropometry (ISAK). BMI was calculated using formula:  $[BMI = BH \text{ (kg)} / BW \text{ (cm)}^2]$ . Values of BMI for both

subgroups were classified in 4 main categories, according to Center for Disease Control and Prevention, 2000. (Kuczmarski i sar., 2000).

### *Statistical Analysis*

Descriptive statistics were used to summarize the data, with frequencies and percentages being the specific calculations performed. Microsoft Excel was used as the tool for data processing

### **Results and discussion**

In Table 1. are presented values of calculated BMI for pupils from 4th and 5th grade of elementary school, in order to assess their nutritional status.

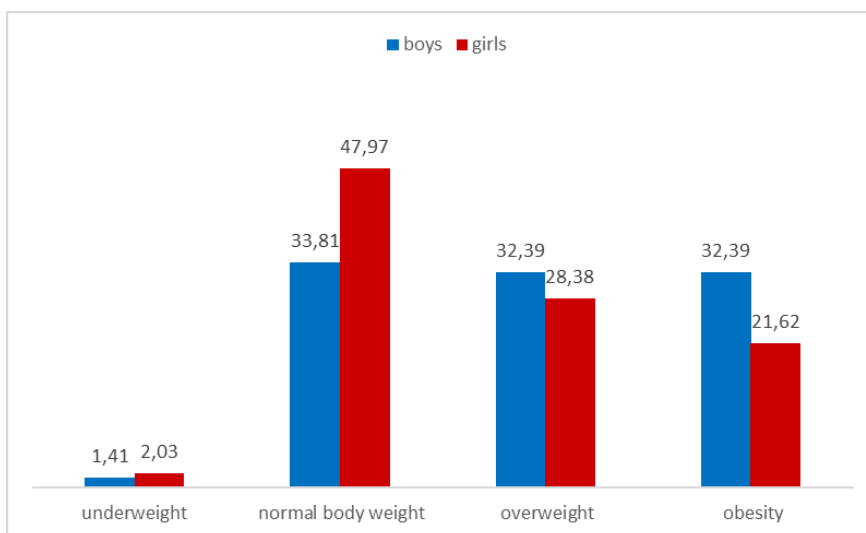
**Table 1.** Frequencies and percentages of BMI by category among boys and girls in 4th and 5th grade of elementary school – Descriptive statistics

<b>Nutritional status</b>	girls	Percentile	%	boys	Percentile	%
Obesity	32	≥95	21,62	46	≥95	32,39
Overweight	42	85-95	28,38	46	85-95	32,39
Normal body weight	71	5-85	47,97	48	5-85	33,81
Underweight	3	<5	2,03	2	<5	1,41
<b>Total</b>	148		100,00	142		100,0

Looking at boys and girls in grades 4 and 5 separately, it can be seen that obesity and overweight are more prevalent in boys than in girls, while normal weight and underweight are more prevalent in girls than in boys. 71 (48%) girls have a normal weight, 42 (28%) are overweight, 32 (22%) are obese, and only 3 (2%) are underweight. The largest number of boys have a normal weight, namely 48 (34%), 46 (32%) boys are overweight, 46 (32%) boys are obese, and only 2 (2%) boys are underweight.

Anthropometry is used to determine the degree of nutrition. Anthropometric methods represent the most important procedures in assessing the nutritional status of children, involving measurement of various body dimensions using recommended tools and standardized techniques. The most important and most commonly used anthropometric measurements are: body height-length, body mass, thickness of subcutaneous fat tissue above the triceps or scapular angle, upper arm circumference, waist circumference, etc. (Krebs et al. 2007).





**Graph 1.** Classification of nutritional status of boys and girls from 4th and 5th grade

There are differences between children, which in most cases depends on their lifestyle habits. Any sports activity affects the maintenance of normal body mass, but also leads to a certain transformation of morphological and motor status. The most important thing is to adapt a certain sports activity to the age of the child, so that the activity affects the transformation of the student (Rašidagić et al., 2000). Different lifestyle habits of children can affect the level of nutrition. Such results are also influenced by the environment, physical activity of children (Carlos et al., 2014). Modern society is characterized by significantly reduced motor activity, improper nutrition and an increasing number of people whose lifestyle can be described as sedentary. It is necessary to act preventively by more frequent monitoring and analysis of the correctness of growth and development and by motivating young people to actively or recreationally engage in sports (Nikšić et al., 2020a).

It is necessary to monitor, measure and analyze all segments of the anthropological status of students on a daily basis, in order to act preventively in the fight against obesity, as the leading epidemiological health problem of today (Nikšić et al., 2021). Ekelund et al. (2004) on a sample of 1292 children aged 9 to 10 from Denmark, Portugal, Norway and Estonia present data that, considering the centile values for BMI, 85.22% of children have normal body mass, while 11.76% are overweight and 3.02% are obese.

Data for Zagreb show that 26% of children aged 6 to 12 and 20% of adolescents were overweight (Poljičanin and Benjak, 2013). Obesity of

primary school children in the Sarajevo Canton, based on the results of the research, in which a total of 33,200 students participated, an exceptionally large number of children with increased body mass were recorded (Abazović et al., 2016). Of the total 44.5% of children (822) who had a deviation from normal body mass, 19.46% (8.7% of the total sample) were underweight, 26.16% (11.6% of the total sample) were moderately underweight, 27.01% (12% of the total sample) were overweight and 27.37% (12.2% of the total sample) were obese (Kovačević et al., 2018).

### ***Conclusion***

Proper nutrition and physical activity are key to preventing obesity among children. Unfortunately, in today's society, parents often neglect the importance of a healthy diet and proper meal preparation for children, often relying on fast food, snacks and sweets instead of fruits and healthy meals. Also, physical activity plays a crucial role in the growth and development of children, and an improper diet and lack of physical activity can lead to a number of health problems, including obesity. The results of the study also show several key findings: improper nutrition significantly contributes to childhood obesity, parents have the greatest influence on their children's eating habits, children often bring unhealthy foods such as snacks and sweets for snacks, stress, such as poor school grades, reduces children's motivation to participate in physical activities, improper nutrition and physical inactivity can cause obesity, which causes numerous health complications. The most important role in educating children about healthy habits is played by parents and schools. Parents should be responsible for preparing healthy meals for children, while school, as a place where children spend their daily time, should actively participate in promoting healthy eating habits.

### ***References***

Abazović, E., Hasanbegović, S., Kovačević, E., Okanović, I., Kazazović, E., Ademaj, Z., Lakota, R., Mekić, A. (2016). *Pretilost djece osnovnih škola Kantona Sarajevo: Prikaz rezultata istraživanja provedenog na 33 200 djece*. Ministarstvo za obrazovanje, nauku i mlade Kantona Sarajevo; Ministarstvo zdravstva Kantona Sarajevo. Sarajevo.

Alić-Partić, M., Cipruković, E., Sinanović, A. i Devedžić, S. (2017). *Pretilost i regulisanje tjelesne težine*. Tuzla: Fakultet za tjelesni odgoj i sport Univerziteta u Tuzli.

Bralić, I. (2005). Roditeljski utjecaj na prehrambene navike djece. *Zdravstvena istraživanja*, 32(4), 158-167.

Carlos, M., Marinho, D., Casanova, N., Fonseca, T., Vila-Chã, C., Jorge, B., Izquierdo, M., Esteves, D., Marques, M. (2014). Utjecaj spola na intervenciju u školi u prepubertetskom naletu rasta. *Journal of Human Kinetics*, 12(43): 159-167.

Ekelund, U., Sardinha, L.B., Anderssen, S. A., Harro, M., Franks, P. W., Brage, S., Cooper, A. R., Andersen, L. B., Riddoch, C., & Froberg, K. (2004). Associations between objectively assessed physical activity and indicators of body fatness in 9- to 10-y-old European children: a population-based study from 4 distinct regions in Europe (the European Youth Heart Study). *Am J Clin Nutr*, 81 (6), 1449–50.

Ille, J. (2008). Metabolički sindrom u djece i adolescenata. *Paediatrica Croatica*, 52, 52-56.

Kovačević, E., Abazović, E., Filipović- Hadžiomerađić, A., Vilić-Švraka, A., Kazazović, E., Has.anbegović, S., Vrcić, M., Maksić, H., Ademaj, Z., Čongo, J., Mašala, A., Lakota, R., Mekić, A. (2018). Pretilost djece u predškolskim ustanovama Kantona Sarajevo: Prikaz rezultata istraživanja provedenog na 1850 djece. Ministarstvo za obrazovanje, nauku i mlade Kantona Sarajevo; Ministarstvo zdravstva Kantona Sarajevo. Sarajevo.

Krnić, B. (2008). Pretilost kao javnozdravstveni problem. *Hrvatski časopis za javno zdravstvo*, 4(16).

Kuczmarski, R., Kuczmarski, MF., Roche, AF. 2000 CDC Growth Charts: Background for Clinical Application. *Top Clin Nutr*. 2002; 17(2): 15- 26.

Kumar, M. D., Kelly A. S., (2017). Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment. *Mayo Clinical Proceedings* 92, 2: 251–265.

Maffeis, C., Talamini, G., & Hirst, M. (1996). The role of physical activity and dietary habits in the development of obesity in children. *Acta Paediatrica*, 85(7), 825-830. <https://doi.org/10.1111/j.1651-2227.1996.tb14445.x>

Montignac, M. (2025). *Dječja pretilost*. Zagreb: Naklada Zadro.

Nikšić, E., Beganović, E., Mekić, A. (2020). Razlike u nutritivnom statusu i tjelesnom sastavu učenika 6. i 7. razreda u Bosni i Hercegovini. *Journal of Physical Education and Sport*; 20(5): 2787-2795.

Nikšić, E., Joksimović, M., Beganović, E., Gardašević, N. (2021). Razlike u stepenu uhranjenosti i tjelesnoj građi dječaka i djevojčica pubertetskog uzrasta. *Pedagogy of Physical Culture and Sports*; 25(1): 4-9.

Poljičanin, T., Benjak, T. (2013). Hrvatski zdravstveno-statistički ljetopis 2012. Zagreb: Hrvatski zavod za javno zdravstvo.

Prskalo, I., Sporiš, G. (2016). *Kinezologija*. Zagreb: Školska knjiga.

Rašidagić, F., Nurković, N., Imamović-Turković, Dž., Hadžibulić–Nurković, H., Nikšić, E. & Kapo, A. (2000). Differences between morphological characteristics and motoric capabilities of physically active and inactive female students. *Pedagogy, psychology, medical-biological problems of physical training and sports*, (24)1: 21–26.

Stipančić, G. (2004). Zašto se djeca debljaju? *Vaše zdravlje*, 2-34.

Škerija, M., Ajduković, D., Poljičanin, T. (2008). Debljina mladih - problem današnjice ili budućnosti. *Hrvatski časopis za javno zdravstvo*, 4 (16).

Vučemilović, Lj. (2010). Dijete, vrtić, obitelj-Kko se broiti s pretilošću djece? *Časopis za odgoj i naobrazbu predškolske djece namijenjen stručnjacima i roditeljima*, 27-28.

Westcott, W. L. (2006). Childhood Obesity. *Strength Cond. J.* Position statement about childhood obesity.

## **Problem pretilosti kod učenika 4. i 5. razreda osnovne škole**

Ema MUJEZINOVIĆ Elvira Nikšić

Univerzitet u Sarajevu – Pedagoški fakultet

\*Autor za korespondenciju: Ema Mujezinović, ema.tiro99@hotmail.com

### **Sažetak**

Pretilost je sve prisutniji zdravstveni problem današnjice koji značajno utiče na javno zdravlje, naročito u dječijoj dobi. Istraživanje je sprovedeno na uzorku od ukupno N=290 učenika 4. i 5. razreda osnovne škole. Cilj ovog istraživanja bio je utvrditi zastupljenost pretilosti kod učenika 4. i 5. razreda osnovnih škola, te da li postoje značajne razlike prema spolu. U ovom istraživanju izvršena su mjerenja tjelesne težine i visine, na osnovu kojih je izračunt indeks tjelesne mase (ITM), a na osnovu tjelesne mase utvrđen je stepen uhranjenosti. Statistička analiza podataka vršila se u programu Excel. Istraživanje je pokazalo da u 4. i 5. razredima većina djevojčica ima normalnu tjelesnu masu, odnosno 71 (48%), 42 (28%) ima prekomjernu tjelesnu masu, 32 (22%) su pretile, a svega 3 (2%) su pothranjene. Najveći broj dječaka ima normalnu tjelesnu masu, odnosno 48 (34%), 46 (32%) učenika ima prekomjernu tjelesnu masu, 46 (32%) dječaka su pretila, a svega 2 (2%) dječaka su pothranjena. Analizom rezultata stanja uhranjenosti utvrđeno je da je broj pothranjenih djevojčica i djevojčica sa normalnom tjelesnom težinom veći nego broj dječaka sa istim, a kada govorimo o prekomjernoj tjelesnoj težini i pretilosti, dječaci imaju znatno veću brojnost od djevojčica. Pravilna ishrana i fizička aktivnost ključni su za prevenciju pretilosti među djecom.

*Ključne riječi: prehrambene navike, fizička aktivnost, stepen uhranjenosti, pretilost, učenici 4. i 5. razreda.*

### 3-O-8

#### **Donkey milk as a potential alternative to mother's milk in children - nutritional and medical aspects**

Branislava PANTIĆ\* Marija PAJIĆ

University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine,  
Republic of Serbia

\*Corresponding author: Branislava Pantić, pantibranislava1@gmail.com

#### **Abstract**

Donkey milk has recently attracted huge attention in human nutrition and veterinary science due to its biochemical similarity to human milk. It is low in casein and fat and rich in lactose, and it also contains bioactive compounds such as lysozyme and lactoferrin, making it a trustworthy alternative for children with cow's milk protein allergy (CMPA). This paper is an overview of current scientific evidence on the nutritional quality, digestibility, and health implications of donkey milk, and consumers' perceptions of its use in Vojvodina. Literature data were gathered via international databases, with a comparative review of cow's and human milk. It is deduced from the findings that donkey milk possesses high digestibility, low allergenicity, and a beneficial nutrient content that enhances immune maturation and intestinal health. The regional questionnaire survey conducted in Vojvodina showed poor public availability and awareness of donkey milk, yet parents already using it confirmed its positive impact on the digestion and immunity of children with CMPA. These findings reflect the greater potential of donkey milk as a functional food and suggest more research and economic development to make it accessible for wider consumer use.

*Keywords: donkey milk, human milk substitute, CMPA, low allergenicity*

#### **Introduction**

In the past few decades, donkey milk has drawn more interest from the scientific and professional community in the areas of veterinary medicine, human nutrition, and nutritional analysis. Since it comes from a monogastric species, its nutritional and chemical characteristics are very similar to those of human milk, which suggests that it could be used as an alternative for infant nutrition in situations where breast milk is not available (Pehlivanoglu H, Aksoy A). Particularly notable is the favorable ratio of casein to whey proteins, where whey proteins make up over half of the protein fraction, much like in mother's milk. Compared to cow's milk, the most popular

substitute and the leading source of allergic reactions, this composition helps to lower the allergenic potential (Pehlivanoglu H, Aksoy A). Donkey milk's nutritional profile and potential applications in a variety of animal husbandry and food industry fields demonstrate its significance from a veterinary perspective. In addition to their traditional use as working animals, donkeys are increasingly being used to produce milk for human consumption and cosmetics, where the nutritional value of the milk is especially valued (Vincenzetti, S., Santini, G. et al.). In comparison to cow's milk, it has a higher lactose content, less protein and ash, and bioactive proteins like lactoferrin and lysozyme that have immunomodulatory and antimicrobial qualities (Pehlivanoglu H, Aksoy A; Altomonte, I., Salari, F. et al.). It is precisely these aspects which point to a potential application in nutrition and health protection, which is meaningful for veterinary science as well. Although in the literature donkey milk is to be placed into consideration in a mention of human medicine and allergy of childhood the most often, it is to be emphasized that its nutritional value and bioactivity form the basis for additional research in veterinary practice. In addition to the nutritional characteristics, quality control and control of compositional heterogeneity affect donkey milk to have a better estimation of its nutritional value and commercial potentialities (Vincenzetti, S., Santini, G. et al; Altomonte, I., Salari, F. et al.). Thus, donkey's milk is an authentic and valuable product which, from the veterinarian's point of view, can become an outstanding substitute for mother's milk, precisely because of its unusual composition and bioactive compounds.

### ***Experimental***

This study uses a survey research method to examine the possibility of using donkey milk as an alternative to breast milk in children. Scientific papers and expert articles published in international and domestic journals were analyzed. The studies deal with the nutritional properties of donkey milk and its comparative composition with cow's and breast milk, as well as its use in children with cow's milk protein allergy. The data collected are systematized and show the possible benefits but also limitations of donkey milk as an alternative to breast milk.

### ***Result and discussion***

Donkey milk has been thought of as a substitute for human milk due to the composition that is very similar to human milk. Compared to cow's milk casein, the major protein fraction, occurs in very low concentrations making donkey milk more digestible and hypoallergenic (Pehlivanoglu H, Aksoy A., 2023; Altomonte, I., Salari, F., Licitra, R., & Martini, M., 2018). Similarly to

human milk, donkey milk contains high levels of serum proteins and biologically active compounds such as lysozyme and immunoglobulins, which are protective against bacterial and viral infections and help mature the infant immune system (Kovandžić, M., Ledina, T., Lončina, J., & Bulajić, S., 2025). Donkey milk is also high in lactose, about the same as human milk, which facilitates the absorption of calcium and guarantees the growth and development of the child (Vincenzetti, S., Santini, G. et al., 2023). Donkey milk also has lower fat and casein than cow's milk but has the same percentage of unsaturated to saturated fatty acids, making it readily digestible and suitable for sensitive children. It also contains minerals such as sodium, potassium, calcium, and magnesium in similar amounts to human milk, although vitamin C is present in levels approximately equal to human milk (Vincenzetti, S., Santini, G. et al., 2023).

**Table 1.** The Components Of Breast Milk And Alternative Types of Milk (Pehlivanoglu H, Aksoy A., 2023.)

<b>Component</b>	<b>Breast milk</b>	<b>Donkey milk</b>	<b>Cow's milk</b>	<b>Goat milk</b>
<b>Lactose (%)</b>	6.9	6.9	4.7	4.1
<b>Total dry matter (%)</b>	12.4	9.53-8.84	12.7	12,3
<b>Ash (%)</b>	0.20-0.22	0.41-0.39	0.70	0.8
<b>Fat (%)</b>	4.0	0.4	3.6	3.8
<b>Protein (%)</b>	1.2	1.7	3.2	3.4
<b>Casein/whey</b>	40/60	120/107	80/20	80/20
<b>Energy (kcal/100 ml)</b>	68	37	69	70

Donkey milk's unique composition renders it a worthy promising substitute for infant feeding, especially for children who have cow's milk protein allergy (CMPA) (Altomonte, I., Salari, F., Licitra, R., & Martini, M., 2018). Donkey milk contains low levels of casein and high levels of bioactive proteins such as lysozyme and immunoglobulins that exhibit reduced allergenicity and increased digestibility and are tolerated well in children who cannot be given cow's milk (Vincenzetti, S., Santini, G. et al., 2023). Donkey milk also exhibits prebiotic activity due to its lactose content that encourages the growth of beneficial gut microbiota, *Lactobacillus* and *Bifidobacterium* species, and maintains intestinal integrity and reinforces nutrient absorption (Polidori, Paolo; Vincenzetti, Silvia, 2013). Its immunomodulatory effect by bioactive peptides, lactoferrin, and lysozyme supports stimulation of the development of the infant's immune system and prevention from infection and perhaps symptom relief of inflammation (Kovandžić, M., Ledina, T.,



Lončina, J., & Bulajić, S., 2025; Nayak, C. M., Ramachandra, C. T., Nidoni et al. 2017). Parental reports and clinical trials in Serbia have reported effective use of donkey milk in CMPA infants with growth improvement, removal of allergic reaction, and increased gastrointestinal tolerance over cow's milk preparations (Polidori, Paolo; Vincenzetti, Silvia, 2013). The evidence suggests donkey milk as a possible source of nutrition for sensitive children, providing macro- and micronutrients similar to human milk and a beneficial role in immune status.

A study in Vojvodina showed that a large portion of parents are still unfamiliar with donkey milk products, while those who have tried it most often reported using it for its potential health benefits, such as strengthening the immune system and improving digestion in children with cow's milk protein allergy (Pantić, B., 2024).

Despite its nutritional and health benefits, the widespread use of donkey milk in Serbia and the Balkans is hampered by many restrictions. It is scantily available, and as such, its market price becomes unaffordable to many households (Pehlivanoglu H, Aksoy A., 2023; Polidori, Paolo; Vincenzetti, Silvia, 2013). Additionally, there is little research on donkey milk in the region, and minimal clinical studies on its safety, efficacy, and long-term effects in children and infants (Polidori, Paolo; Vincenzetti, Silvia, 2013). These factors indicate the need for further scientific research and the development of economically favorable production methods to convert donkey milk into a more viable alternative for infant feeding.

## ***Conclusion***

Donkey milk is a product rich in nutrients and very similar to breast milk in terms of protein and lactose content, which makes it a suitable alternative for children with cow's milk protein allergy. The low content of casein and bioactive proteins (lysozyme and lactoferrin) facilitates digestion and contributes to the development of immunity. In addition to its use in child nutrition, its antimicrobial and antioxidant activity indicates its use in the food and pharmaceutical industries in the future. On the other hand, what puts this product on a low level in the market is its high price, poor availability and insufficient awareness among people. Because of this, the consumption of donkey milk in the Balkans and worldwide is very limited. The results in Vojvodina show that demand is growing among consumers who know about its alleged health benefits, especially for infants. To make it more relevant, more research needs to be conducted on safety, nutrition and economic production models and improved collaboration between science, industry and health authorities needs to be encouraged.

**Author contribution:** Conceptualization, methodology, investigation, writing—original draft preparation, B.P.; writing— review and editing, supervision, M.P.; All authors have read and agreed to the published version of the proceeding.

**Funding;** This work did not receive funding.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Conflict of interest:** The author declares no conflicts of interest.

## **References**

- Pehlivanoglu H, Aksoy A. (2023). *Is donkey milk an alternative for newborn and infant nutrition?* In: 5<sup>th</sup> International New York Conference on Evolving Trends in Interdisciplinary Research & Practices. New York: NY Conference, 104.
- Vincenzetti, S., Santini, G., Polzonetti, V., Pucciarelli, S., Klimanova, Y., Polidori, P. (2023). *Vitamins in human and donkey milk: Functional and nutritional role.* School of Biosciences and Veterinary Medicine, University of Camerino; School of Pharmacy, University of Camerino.
- Altomonte, I., Salari, F., Licitra, R., Martini, M. (2018). *Donkey and human milk: Insights into their compositional similarities.* International Dairy Journal, 87, 1–10.
- Kovandžić, M., Ledina, T., Lončina, J., Bulajić, S. (2025). *Mleko magarica kao 186lternative formulama za odgojad.* Symposium on health care and milk from domestic donkeys – Symposium POTECTDonkey. University of Belgrade, Faculty of Veterinary Medicine, Department of Hygiene and Technology of Foods of Animal Origin, Belgrade, Serbia.
- Nayak, C. M., Ramachandra, C. T., Nidoni, U., Hiregoudar, S., Naik, N., Ram, J. (2017). *Composition, characteristics, nutritional value and health benefits of donkey milk: A review.* Dairy Science & Technology.
- Polidori, Paolo; Vincenzetti, Silvia . (2013). *Use of Donkey Milk in Children with Cow's Milk Protein Allergy.* Foods, 2(2), 151–159
- Pantić, B. (2024). *Consumer attitudes towards donkey milk in Vojvodina* [Unpublished manuscript]. University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine.

## **Magareće mleko kao potencijalna alternativa majčinom mleku kod dece- nutritivni i medicinski aspekti**

Branislava PANTIĆ\* Marija PAJIĆ

Univerzitet u Novom Sadu, Poljoprivredni fakultet, Odeljenje za veterinarsku medicinu,  
Republika Srbija

\*Autor za korespondenciju: Branislava Pantić, pantibranislava1@gmail.com

### **Sažetak**

Magareće mleko je nedavno privuklo veliku pažnju u ljudskoj ishrani i veterinarskoj nauci zbog svoje biohemijske sličnosti sa ljudskim mlekom. Ima malo kazeina i masti, a bogato je laktozom, a sadrži i bioaktivna jedinjenja poput lizozima i laktoferina, što ga čini pouzdanom alternativom za decu sa alergijom na proteine kravljeg mleka. Ovaj rad je pregled trenutnih naučnih dokaza o nutritivnom kvalitetu, svarljivosti i zdravstvenim implikacijama magarećeg mleka, kao i o percepciji potrošača o njegovoj upotrebi u Vojvodini. Podaci iz literature prikupljeni su putem međunarodnih baza podataka, sa uporednim pregledom kravljeg i ljudskog mleka. Iz nalaza se zaključuje da magareće mleko poseduje visoku svarljivost, nisku alergenost i koristan sadržaj hranljivih materija koje poboljšavaju imuno sazrevanje i zdravlje creva. Regionalno istraživanje sprovedeno u Vojvodini pokazalo je lošu dostupnost i svest javnosti o magarećem mleku, ali roditelji koji ga već koriste potvrdili su njegov pozitivan uticaj na varenje i imunitet dece sa Hroničnom mikobakterijskom anemijom (HMPA). Ovi nalazi odražavaju veći potencijal magarećeg mleka kao funkcionalne hrane i sugerišu dalja istraživanja i ekonomski razvoj kako bi se ono učinilo dostupnim široj potrošačkoj upotrebi.

*Ključne reči: magareće mleko, zamena za ljudsko mleko, HMPA, niska alergenost*

### 3-O-9

#### **The genome as a basis for creating personalized nutrition**

Sara POPARA\* Selma VRABAC Hana ŽALIĆ Iman BISIĆ Nedim  
TANKOVIĆ Jasmina ĐEDIĆBEGOVIĆ

Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Sara Popara, sarapopara@ffsa.unsa.ba

#### **Abstract**

The paper aimed to explore the role of the genome in creating personalized nutrition, with an emphasis on the interactions between genetics, nutrition, and health. The basic concepts of nutrigenomics and nutrigenetics, biomarkers of nutrition and health, and available analysis methods including the OMICS approach, metabolomics, and nutrigenetic testing were analyzed. Special attention was paid to ethical issues, such as privacy protection and misuse of genetic information. The results show that genes significantly influence the way the body responds to nutrients, while at the same time nutrition can modulate gene expression. Based on these findings, it is possible to develop nutritional guidelines tailored to individual needs, which represents a potential for the prevention of chronic diseases and the improvement of health. However, it is concluded that personalized nutrition is still in development, that there are methodological and ethical limitations, and that standardization and advances in technologies are needed in order for this concept to become a reliable and widely applicable practice.

*Keywords: genome, nutrigenomics, nutrigenetics, personalized nutrition*

#### **Introduction**

Personalized nutrition (PN) is an emerging field that tailors dietary recommendations to the genetic, phenotypic, and biochemical characteristics of an individual. The “one-size-fits-all” approach to nutrition is becoming a thing of the past, and the spotlight is on PN, which aims to mitigate the risks of chronic diseases such as diabetes and cardiovascular disease. This approach, now much more precise, is based on nutrigenomics, the study of how diet affects gene expression, and nutrigenetics, the study of how genetic variations influence the body’s response to specific nutrients (Ferrario *et al.*, 2021; Cross *et al.*, 2025). Although appealing, this concept has not yet been sufficiently researched to be widely accepted as standard practice in healthcare. The aim of this paper is to present the current applicability of

genetics in personalized nutrition that improves individual health, as well as the basic limitations and future perspectives in this field.

### ***Experimental***

The search criteria included relevant scientific databases, including Web of Science and Scopus, with an emphasis on works dealing with nutrigenomics, nutrigenetics, and personalized nutrition. The search was conducted using keywords such as “genome and nutrition,” “nutrigenomics,” “nutrigenetics,” “personalized nutrition,” and “biomarkers of nutrition and health.” Works published between 2007 and the present were included, with most of the information being taken from sources published within the last five years, to ensure the data was up-to-date. Papers published between 2007 and 2012 were used solely for the purpose of providing a theoretical and historical overview of the development of this field. As an additional limitation, only works available in English were considered, while all sources were reviewed in full text to check their relevance to the topic.

### ***Results and Discussion***

The genome is the foundation for understanding food-body interactions. Nutrigenomics studies the impact of bioactive compounds from food on gene expression, while nutrigenetics examines how genetic variations determine individual responses to nutrition. Research confirms that polymorphisms in genes such as *MTHFR* and *TCN2* significantly affect folate and vitamin B12 metabolism, demonstrating the importance of a personalized approach to nutrition (Bahou, 2024). Similar results are shown by other studies, where glycemic responses to food are predicted based on genetic and microbiota characteristics. However, additive genetic factors even in twins explained 30% of the variance in glucose response to food, whereas only minimal effects were observed for variance in postprandial triglyceride and insulin rise, and genetic variances in insulin and C-peptide rise were close to zero (Berry *et al.*, 2020).

Biomarkers of nutrition and health, such as the omega-3 index or urinary metabolites, offer reliable indicators of nutritional status and disease risk. Static and functional analyses contribute to a better understanding of metabolic flexibility, while OMICS technologies (genomics, proteomics, metabolomics) enable an integrated approach to uncovering links between diet and disease. According to studies, OMICS approaches are key in the development of nutritional guidelines (Singar *et al.*, 2024).

Although personalized nutrition promises significant benefits, a number of ethical issues arise, including privacy protection and the quality of commercially available genetic tests. European guidelines emphasize the

need for regulation and standardization, as the use of unreliable databases can lead to erroneous recommendations (Kohlmeier *et al.*, 2016).

DNA analyses, as well as techniques such as RT-PCR and metabolomic analysis, are increasingly available due to the reduction in sequencing costs. “Online kits” allow for home testing, but the interpretation and clinical utility of the results are still limited.

In the last 20 years, advances in nutrigenomics have brought new knowledge about the impact of diet on gene expression and the development of chronic diseases. The development of biomarkers and the use of stem cells in research open up the possibility of more precise prevention and early detection of disorders. However, standardization of methodology and validation of results are still lacking, as confirmed by recent meta-analyses (Cross *et al.*, 2025). Nevertheless, the available data indicate that further technological development will strengthen personalized nutrition as a valuable tool in health preservation and disease prevention.

Finally, any dietary advice or intervention must be implemented by individuals in order to give results. It is worth noting that Food4Me European randomized controlled trial shows that including phenotypic or phenotypic plus genotypic information didn't enhance the effectiveness of the PN advice in comparison to PN advice based on the individual's baseline diet alone. However, the PN advice was more effective than conventional (non-personalized) healthy eating advice (Celis-Morales *et al.*, 2017).

## **Conclusion**

Genetic variations influence the body's responses to nutrients, while diet can modulate gene expression, confirming that the genome can be the basis for creating personalized nutrition. Nutrigenomics and nutrigenetics enable the development of recommendations tailored to individual needs, with the aim of preserving health and reducing the risk of chronic diseases. Although available analyses and OMICS technologies offer significant potential, the field is still developing, with methodological and ethical challenges. Further progress in standardization and technology is essential for the full application of this concept in practice.

**Author contributions:** Conceptualization, S.P. and S.V.; methodology, S.P.; investigation, S.P., S.V., I.B., N.T., and H.Ž.; writing – original draft preparation, S.P., S.V., I.B., N.T., and H.Ž.; writing – review and editing, S.P. and S.V.; visualization, S.P.; supervision, Prof. dr. Jasmina Đedićbegović. All authors have read and agreed to the published version of the proceeding.

**Funding:** This work did not receive funding.

**Informed Consent Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

Bahou, C. *Understanding nutrigenomics: Examples, risks, and more* (2024). Available at: <https://www.medicalnewstoday.com/articles/nutrigenomics> (Accessed: September 27, 2025).

Berry, S.E. *et al.* (2020) “Human postprandial responses to food and potential for precision nutrition,” *Nature Medicine*, 26(6), pp. 964–973. Available at: <https://doi.org/10.1038/s41591-020-0934-0>.

Celis-Morales, C. *et al.* (2017) “Effect of personalized nutrition on health-related behaviour change: evidence from the Food4Me European randomized controlled trial,” *International Journal of Epidemiology*, 46(2), pp. 578–588. Available at: <https://doi.org/10.1093/ije/dyw186>.

Cross, V. *et al.* (2025) “Do Personalized Nutrition Interventions Improve Dietary Intake and Risk Factors in Adults With Elevated Cardiovascular Disease Risk Factors? A Systematic Review and Meta-analysis of Randomized Controlled Trials,” *Nutrition Reviews*, 83(7), pp. e1709–e1721. Available at: <https://doi.org/10.1093/nutrit/nuae149>.

Ferrario, P.G. *et al.* (2021) “What is the promise of personalised nutrition?,” *Journal of Nutritional Science*, 10, p. e23. Available at: <https://doi.org/10.1017/jns.2021.13>.

Kohlmeier, M. *et al.* (2016) “Guide and Position of the International Society of Nutrigenetics/Nutrigenomics on Personalized Nutrition: Part 2 - Ethics, Challenges and Endeavors of Precision Nutrition,” *Journal of Nutrigenetics and Nutrigenomics*, 9(1), pp. 28–46. Available at: <https://doi.org/10.1159/000446347>.

Singar, S. *et al.* (2024) “Personalized Nutrition: Tailoring Dietary Recommendations through Genetic Insights,” *Nutrients*, 16(16), p. 2673. Available at: <https://doi.org/10.3390/nu16162673>.

## **Genom kao osnova za kreiranje personalizirane prehrane**

Sara POPARA\* Selma VRABAC Hana ŽALIĆ Iman BISIĆ Nedim  
TANKOVIĆ Jasmina ĐEDIĆBEGOVIĆ

Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Sara Popara, sarapopara@ffsa.unsa.ba

### **Sažetak**

Rad je imao za cilj istražiti ulogu genoma u kreiranju personalizirane prehrane, s naglaskom na interakciju između genetike, prehrane i zdravlja. Analizirani su osnovni pojmovi nutrigenomike i nutrigenetike, biomarkeri prehrane i zdravlja, te dostupne metode analize uključujući OMICS pristup, metabolomiku i nutrigenetsko testiranje. Poseban osvrt je bio na etičkim pitanjima, poput zaštite privatnosti i zloupotrebe genetskih informacija. Rezultati pokazuju da geni značajno utiču na način na koji organizam reaguje na nutrijente, dok istovremeno nutrijenti mogu modulirati ekspresiju gena. Na temelju tih saznanja moguće je razviti prehrambene smjernice prilagođene individualnim potrebama, što predstavlja potencijal za prevenciju hroničnih bolesti i unapređenje zdravlja. Međutim, zaključuje se da je personalizirana prehrana još uvijek u razvoju, da postoje metodološka i etička ograničenja te da je potrebna standardizacija i napredak u tehnologijama kako bi ovaj koncept postao pouzdana i široko primjenjiva praksa.

*Ključne riječi: genom, nutrigenomika, nutrigenetika, personalizirana prehrana*



## The importance of the microbiota for normal vital functions

Tanja VUKMAN\* Davor J.KORČOK

Faculty of Pharmacy Novi Sad

\*Corresponding author: Tanja Vukman, tanja.vukman@ffns.ac.rs

### Abstract

The gut microbiota is a complex community of microorganisms (bacteria, viruses, fungi, archaea, protozoa) that inhabits the digestive tract, especially the large intestine, and plays a key role in maintaining the health of the host. Its colonization begins immediately after birth, whereby the mode of delivery significantly affects the initial composition of the microbiota. During early childhood, the microbiota is formed and stabilized, and by the age of three it resembles that of adults. This community affects digestion, immunity, metabolism and mental health, so it is often referred to as the "forgotten organ". Dysbiosis, i.e. a disturbed balance of the microbiota, is associated with a number of diseases. The preservation of the microbiota through a healthy diet, lifestyle and rational use of medicines is becoming the foundation of modern prevention and personalized medicine.

*Keywords: microbiota, digestive tract, immunity, dysbiosis*

### Introduction

The gut microbiota is the microorganisms that collectively inhabit the ecosystem of the human digestive tract, i.e. it represents a dynamic ecological community of microorganisms that plays a key role in preserving the health of the host.

The microbiota is the community of microorganisms that inhabit the human body – including bacteria, viruses, fungi, archaea and protozoa. These microorganisms live on the skin, mucous membranes, in the respiratory and urogenital tracts, but they are most numerous in the gastrointestinal system, especially in the large intestine. Their role in maintaining health is so significant that the microbiota is often referred to as the "forgotten organ" (Milosavljević, 2017).

Microbiota colonization begins immediately after birth. The method of delivery has a decisive influence – babies born vaginally are inhabited by microorganisms from the mother's digestive tract, while those born by caesarean section receive microorganisms from the skin, which can affect the

later development of the immune system. During early childhood, the microbiota is formed and stabilized, and by the age of three it already resembles the microbiota of an adult (Milosavljević, 2017).

### ***The microbiota as a regulator of vital functions***

The microbiota is involved in a number of vital functions:

#### **1. Digestive function**

- It helps break down complex carbohydrates and fibers that cannot be processed by human enzymes.
- It produces short-chain fatty acids such as butyrate, which nourish colon cells and reduce inflammation.

#### **2. Immune regulation**

- The microbiota stimulates the development and maturation of the immune system.
- It helps to distinguish between pathogenic and non-pathogenic microorganisms, preventing autoimmune reactions.

#### **3. Protection against pathogens**

- A healthy microbiota occupies space and resources, preventing the colonization of harmful microorganisms.
- It produces antimicrobial substances that directly inhibit the growth of pathogens.

#### **4. Metabolic function**

- Participates in the synthesis of vitamins (K, B12, folic acid).
- It regulates the metabolism of cholesterol, glucose and fats.

#### **5. Neurological impact – "gut-brain axis"**

- The microbiota communicates with the central nervous system through nervous, immune, and hormonal pathways.
- An association has been established between dysbiosis (microbiota imbalance) and mood disorders, depression, anxiety and neurodegenerative diseases.

### ***Balance and dysbiosis***

A healthy microbiota is diverse and stable. However, factors such as poor diet, stress, infections, overuse of antibiotics, and exposure to toxins can disrupt this balance, leading to dysbiosis. Dysbiosis is associated with a number of conditions:

- Inflammatory bowel diseases (Crohn's disease, ulcerative colitis)
- Obesity and metabolic syndrome
- Autoimmune diseases (e.g. type 1 diabetes, multiple sclerosis)
- Food allergies and intolerances.

### ***Diet and lifestyle as factors of microbiotic balance***

The composition of the microbiota is mostly influenced by nutrition. A diet rich in fiber, fermented products, and herbal components promotes the growth of beneficial bacteria. On the other hand, diets rich in sugars, saturated fats and industrially processed foods reduce the diversity of the microbiota and promote the development of pathogenic strains (Clemente, Ursell, Parfrey, Knight, 2012) .

Physical activity, quality sleep, stress avoidance, and limited use of antibiotics also contribute to the health of the microbiota.

### ***Therapeutic potential of the microbiota***

Appreciation to the development of metagenomics and microbiological technologies, the microbiota is becoming an increasingly important therapeutic target. Some of the approaches include:

- Probiotics – live microorganisms that have a beneficial effect on the health of the host.
- Prebiotics – substances that feed beneficial bacteria.
- Symbiotics – a combination of probiotics and prebiotics.
- Fecal transplantation – transfer of the microbiota of a healthy donor into the patient's digestive tract, successfully applied in *Clostridium difficile* infections (Sekirov, Russell, Antunes, Finlay 2010).

In the future, the development of personalized therapies based on the individual microbiome is expected, which could revolutionize the treatment of a number of diseases.

### ***Microbiota and mental health***

The connection between the microbiota and the brain, known as the gut-brain axis, is one of the most fascinating aspects of modern biomedicine. This two-way communication involves nerve pathways (e.g., the vagus nerve), immune signals, and hormones. The microbiota affects the production of neurotransmitters such as serotonin, dopamine, and GABA, which directly affect mood, behavior, and cognitive function (MEF Repository Zagreb 2025). Studies have shown that people with depression and anxiety often have a disturbed microbiota – reduced diversity and the presence of pro-inflammatory bacteria. Animal experiments have shown that microbiota transplantation from depressed individuals can cause depressive symptoms in healthy individuals, further confirming this link.

### ***Microbiota in early development***

In the first years of life, the microbiota plays a key role in the development of the immune system, digestive tract, and neurological functions.

Breastfeeding, contact with nature, a varied diet and the avoidance of unnecessary antibiotics contribute to the healthy development of the microbiota (Rios-Covian, Ruas-Madiedo, Margolles 2016).

Children with a disturbed microbiota at an early age have a higher risk of developing allergies, asthma, atopic dermatitis, obesity and autoimmune diseases. That is why more and more attention is given to probiotic supplements in pediatrics, as well as educating parents about the importance of microbiotic balance.

### ***Microbiota and immunotherapy***

In oncology, the microbiota has been shown to be an important factor in the success of immunotherapy. Patients with a diverse microbiota respond better to therapies that include checkpoint inhibitors (checkpoint inhibitors).

Therefore, the use of probiotics and dietary interventions to support immunotherapy is being considered. In the future, microbiome analysis could become a standard part of oncology diagnostics and therapeutic planning (Honda, Littman 2016).

### ***Genetics of the microbiota***

Each person has a unique microbiome – as a genetic imprint. Although there is a common "nucleus" of microorganisms in all people, individual differences are enormous. Genetic factors of the host, as well as epigenetic influences, shape the microbiota profile.

Microbiome sequencing allows for the precise identification of bacterial strains, which opens the door to personalized medicine. Based on the microbiota profile, it is possible to predict the risk of disease, response to therapy, and recommend individualized dietary and probiotic regimens.

### ***Microbiota of the skin, lungs and urogenital tract***

Although most attention is given to the gut microbiota, microorganisms also inhabit other parts of the body:

#### **Skin microbiota**

- Protects against pathogenic microorganisms.
- It is involved in the regulation of pH and the immune response of the skin.
- Skin dysbiosis is associated with acne, eczema, psoriasis and rosacea.

#### **Pulmonary microbiota**

- Although it was long thought that the lungs were sterile, today we know that they have their own microbiota.
- The balance of the microbiota affects the development of asthma, chronic obstructive pulmonary disease and infections.

#### Vaginal microbiota

- It is dominated by *Lactobacillus* species that maintain an acidic environment and protect against infections.
- Dysbiosis can lead to bacterial vaginosis, yeast infections, and an increased risk of sexually transmitted diseases.

#### ***Microbiota and chronic diseases***

Microbiota disorders are associated with a number of chronic conditions:

- Type 2 diabetes: Dysbiosis contributes to insulin resistance and inflammation.
- Cardiovascular disease: Some microbiota metabolites, such as trimethylamine-N-oxide (TMAO), have been linked to atherosclerosis.
- Neurodegenerative diseases: Parkinson's and Alzheimer's disease exhibit specific microbiotic profiles.
- Autoimmune diseases: The microbiota is involved in the regulation of T cells and can influence the development of diseases such as rheumatoid arthritis and lupus.

#### ***Conclusion***

The microbiota is a crucial regulator of health, influencing digestion, immunity, metabolism and mental state. Its balance is necessary for the normal functioning of the body, while dysbiosis can lead to a number of diseases. The preservation of the microbiota through a healthy diet, lifestyle and responsible use of medicines is becoming the foundation of modern prevention and therapy, with great potential in the future of personalized medicine

#### ***References:***

Clemente, J. C., Ursell, L. K., Parfrey, L. W., & Knight, R. (2012). The Impact of the Gut Microbiota on Human Health: An Integrative View. *Cell*, 148(6), 1258–1270

Honda, K., & Littman, D. R. (2016). The microbiota in adaptive immune homeostasis and disease. *Nature*, 535(7610), 75–84.

Milosavljević, T. (2017). The secrets of the gut microbiota. ISBN 978-86-900030-0-06

Repository MEF Zagreb (2025). The role of the microbiota in neurodegenerative diseases.

Rios-Covián, D., Ruas-Madiedo, P., Margolles, A., et al. (2016). Short-chain intestinal fatty acids and their relationship with nutrition and human health. *Frontiers in Microbiology*, 7,185.

Sekirov, I., Russell, S. L., Antunes, LCM, & Finlay, B. B. (2010). The gut microbiota in health and disease. *Physiological Reviews*, 90(3), 859–904.

## **Značaj mikrobiote za normalne životne funkcije**

Tanja VUKMAN\* Davor J. KORČOK

Farmaceutski fakultet Novi Sad

\*Autor za korespondenciju: Tanja Vukman, tanja.vukman@ffns.ac.rs

### **Sažetak**

Crevna mikrobiota predstavlja kompleksnu zajednicu mikroorganizama (bakterije, virusi, gljivice, arhee, protozoe) koja naseljava digestivni trakt, posebno debelo crevo, i ima ključnu ulogu u očuvanju zdravlja domaćina. Njena kolonizacija počinje odmah po rođenju, pri čemu način porođaja značajno utiče na početni sastav mikrobiote. Tokom ranog detinjstva mikrobiota se formira i stabilizuje, a do treće godine podseća na onu kod odraslih. Ova zajednica utiče na varenje, imunitet, metabolizam i mentalno zdravlje, pa se često naziva „zaboravljenim organom“. Disbioza, odnosno narušena ravnoteža mikrobiote, povezuje se s brojnim bolestima. Očuvanje mikrobiote kroz zdravu ishranu, stil života i racionalnu upotrebu lekova postaje temelj savremene preventive i personalizovane medicine.

*Ključne reči: mikrobiota, digestivni trakt, imunitet, disbioza*

## Postbiotics - a new promising approach to improving gut and digestive health

Azra BUZA Ilfa MAVRIĆ Enida MUHOVIĆ Jasmina ĐEĐIBEGOVIĆ

Faculty of Pharmacy, University of Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Azra Buza; azrabuza1@ffsa.unsa.ba

### Abstract

Postbiotics are defined as "preparations of non-living microorganisms and/or their components that provide a health benefit to the host". Postbiotic components include short-chain fatty acids, exopolysaccharides, vitamins, teichoic acids, bacteriocins, enzymes, and peptides in a crude preparation of inactivated cells. Two main mechanisms by which postbiotics could potentiate clinical benefit are modulation of the immune system and strengthening of the intestinal barrier. Postbiotics are safe and stable with a long shelf life that allows for easy storage and transport and can be administered during antibiotic treatment without affecting efficacy, making them an attractive alternative to probiotics. In addition to supplements, there are also postbiotics in food: buttermilk, cottage cheese, foods rich in fiber, oats, flax seeds, garlic, bananas, artichokes, berries, etc. As for the clinical effects of postbiotics, they have been shown to be effective in gastrointestinal disorders, immunity enhancement and allergies, upper respiratory tract infections, stress and neurological conditions, cardiac and vascular disorders, and metabolic syndrome.

*Keywords: postbiotics, digestion, intestinal health, strengthening of intestinal flora*

### Introduction

Postbiotics are a new category of biotics that have the potential to provide health benefits. Unlike probiotics, they do not require living cells to exert health-promoting effects and are therefore not subject to the food safety requirements that apply to living microorganisms. Postbiotics are defined as "a preparation of non-living microorganisms and/or their components that confer a health benefit to the host".

Postbiotic components include short-chain fatty acids, exopolysaccharides, vitamins, teichoic acids, bacteriocins, enzymes and peptides in an unpurified preparation of inactivated cells (Hill, Guarner, Reid et al, 2014).

Postbiotics have the potential to modulate human health. In particular, a number of postbiotics have been shown to improve gut health by strengthening the intestinal barrier, reducing inflammation and promoting antimicrobial activity against enteric pathogens. In addition, research is being conducted on the potential application of postbiotics to other parts of the body, including the skin, vagina and oral cavity.

The objectives of this work are:

- To investigate adequate scientific literature and, based on relevant data, to explain what postbiotics are and what they can be used for.
- To explain the mechanism of action of postbiotics.
- To try to answer the question of whether postbiotics represent a potential new approach for improving digestion and gut health.
- To present the advantages and disadvantages of such an approach

### ***Experimental***

This paper is a review paper on the topic "Postbiotics - a new promising approach to improving gut and digestive health?".

To achieve the stated goals, data from the following sources were used:

- 1) Original articles published in relevant biomedical journals
- 1) Review articles published in relevant biomedical journals
- 3) Medical and chemical databases PubMed, MDPI, Google Scholar

### ***Results and discussion-***

#### ***Postbiotics and their effects on human health***

Postbiotic research to date has mainly focused on the gut, but the potential application of postbiotics has also been explored in other areas of the human body, including the skin, vagina and oral cavity.

#### ***Postbiotics and their effect on human gut health***

In recent years, deteriorating gut health has been linked to a number of chronic diseases. There is evidence to suggest that various postbiotic compounds from a wide range of microbes can positively influence gut health. The production of short-chain fatty acids (SCFA) butyrate, propionate and acetate in the gut microbiome is important for human health. SCFAs are also produced by bacterial fermentation of dietary fiber and cross-feeding in the human colon. SCFAs, among other things, provide protection against intestinal inflammation by activating SCFA-sensitive receptors (Sun, Wu, Liu, Z et al, 2016). A number of studies have shown that butyrate-producing bacteria are depleted in the gut microbiota of patients with inflammatory bowel disease (including Crohn's disease and ulcerative colitis) and colorectal cancer compared to healthy controls. Butyrate-producing bacteria,



such as *Faecalibacterium prausnitzii* and *Butyricicoccus pullicaecorum*, are endogenous to the human gut and are associated with the "healthy" human gut microbiota (Geirnaert, Calatayud, Grootaert et al, 2017).

Propionate is produced by the fermentation of sugars by a specific group of gut bacteria via either the succinate (also called the randomization pathway), propanediol, or acrylate pathways. The succinate pathway is the major pathway for the production of propionate from dietary carbohydrates where hexose and pentose sugars are converted to propionate. Although propionate has been less studied than butyrate, there is evidence that high concentrations of propionate also have anticancer effects, with evidence identifying both butyrate and propionate as the most potent fatty acids that induce differentiation and apoptosis. There is also evidence that propionate lowers lipogenesis and serum cholesterol levels (Bartolomaeus, Balogh, A, Yakoub et al, 2019). Acetate is the most abundant SCFA in the gut reaching three times higher molar ratio than butyrate and propionate. Acetate is produced by fermentation of dietary fiber by intestinal bacteria, including *Ruminococcus spp.*, *Prevotella spp.*, *Bifidobacterium spp.* and *Akkermansia muciniphila*. Research has shown that acetate contributes to human health. For example, acetate has been shown to reduce inflammation and insulin sensitivity and improve glucose tolerance by regulating fasting insulin and glucagon levels. Microbes that produce butyrate and propionate are currently not considered safe for human consumption because they are not included in the QPS (Qualified presumption of safety) list (Mandaliya, Patel, Seshadri, 2020).

#### *Postbiotics to strengthen the function of the intestinal epithelial barrier*

The intestinal barrier is one of the most important barriers between the external environment (including diet, drugs, pathogens and microbiota) and the host. A weakened intestinal barrier favors bacterial translocation and inflammation and is associated with an increased risk of chronic bowel diseases, including Crohn's disease, ulcerative colitis, and irritable bowel syndrome, as well as foodborne infectious diseases, including gastroenteritis caused by pathogens such as *Salmonella typhimurium*. In addition to providing the body with protection against potentially harmful compounds and translocation of pathogens, the intestinal epithelium also acts as a selective barrier to the transport of nutrients.

A study by Zhou et al. showed that *Lactiplantibacillus plantarum* has the property of strengthening the intestinal barrier. Also, it was described that *Streptococcus thermophilus* increased the expression of tight junction proteins (claudin-1, occludin and E-cadherin) and suppressed pro-inflammatory cytokines (interleukin-6 and interferon- $\gamma$ ) (Chen, Zhang, Ren, 2019).

### *Postbiotics to Reduce Inflammation*

Chronic intestinal diseases, such as inflammatory bowel disease and irritable bowel syndrome, are characterized by inflammation and impaired intestinal barrier function and are associated with oxidative stress resulting from excessive production of reactive oxygen species (ROS). Free radicals and other ROS originate from normal essential metabolic processes in the human body or from external sources, such as exposure to X-rays, ozone, cigarette smoking, air pollutants, and industrial chemicals. Due to their highly reactive nature, ROS can modify other oxygen species, DNA, proteins, or lipids, and excessive amounts of ROS can cause genomic instability. Consequently, the continuous excessive production of ROS compromises intestinal function, resulting in nutritional malabsorption, increased intestinal permeability, and impaired intestinal motility, leading to severe tissue injury, resulting in deep ulcers in the ileum, the lower part of the small intestine. Severe tissue damage can trigger a cascade of events that result in the development or progression of several diseases including atherosclerosis, arthritis, diabetes, Alzheimer's disease, neurodegenerative diseases, and cardiovascular disease, as well as inflammatory bowel disease and irritable bowel syndrome (Sharma, Kapila, Kapasiya et al, 2014).

### ***Conclusion***

Overall it can be concluded that postbiotics represent a new potential approach for improving digestion and gut health. In recent years, the deterioration of gut health has been linked to a number of chronic diseases. There is evidence to suggest that various postbiotic compounds from a wide range of microbes can positively influence gut health.

### ***References***

- Bartolomeaus, H.; Balogh, A.; Yakoub, M.; Homann, S.; Markó, L.; Höges, S.; Tsvetkov, D.; Krannich, A.; Wundersitz, S.; Avery, E.G.; et al. (2019). Short-Chain Fatty Acid Propionate Protects From Hypertensive Cardiovascular Damage. *Circulation*, 139, 1407–1421.
- Chen, Y.; Zhang, M.; Ren, F. (2019). A Role of Exopolysaccharide Produced by *Streptococcus thermophilus* in the Intestinal Inflammation and Mucosal Barrier in Caco-2 Monolayer and Dextran Sulphate Sodium-Induced Experimental Murine Colitis. *Molecules*, 24, 513.
- Geirnaert, A.; Calatayud, M.; Grootaert, C.; Laukens, D.; Devriese, S.; Smagghe, G.; de Vos, M.; Boon, N.; de Wiele, T.V. (2017). Butyrate-producing bacteria supplemented in vitro to Crohn's disease patient microbiota increased butyrate production and enhanced intestinal epithelial barrier integrity. *Sci. Rep.*, 7, 11450.

Hill, C., Guarner, F., Reid, G., Gibson, G.R., Merenstein, D.J., Pot, B., Morelli, L., Canani, R.B., Flint, H.J., Salminen, S. et al. (2014), Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nat. Rev. Gastroenterol. Hepatol.*, 11, 506–514.

Mandaliya, D.K.; Patel, S.; Seshadri, S. (2020), The Combinatorial Effect of Acetate and Propionate on High-Fat Diet Induced Diabetic Inflammation or Metaflammation and T Cell Polarization. *Inflammation*, 44, 68–79.

Sharma, R.; Kapila, R.; Kapasiya, M.; Saliganti, V.; Dass, G.; Kapila, S. (2014). Dietary supplementation of milk fermented with probiotic *Lactobacillus fermentum* enhances systemic immune response and antioxidant capacity in aging mice. *Nutr. Res.*, 34, 968–981.

Sun, M.; Wu, W.; Liu, Z.; Cong, Y. (2016). Microbiota metabolite short chain fatty acids, GPCR, and inflammatory bowel diseases. *J. Gastroenterol.*, 52, 1–8.

## **Postbiotici – novi perspektivan pristup unapređenju zdravlja crijeva i probave**

Azra BUZA Ilfa MAVRIĆ Enida MUHOVIĆ Jasmina ĐEĐIBEGOVIĆ

Farmaceutski fakultet, Univerzitet u Sarajevu, Bosna i Hercegovina

\*Autor za korespondenciju: Azra Buza; azrabuza1@ffsa.unsa.ba

### **Sažetak**

Postbiotici se definišu kao „preparati neživih mikroorganizama i/ili njihovih komponenata koje daju zdravstvenu korist domaćinu”. Postbiotičke komponente uključuju kratkolančane masne kiseline, egzopolisaharide, vitamine, teihoične kiseline, bakteriocine, enzime i peptide u nepročišćenom preparatu inaktiviranih ćelija. Dva glavna mehanizma pomoću kojih bi postbiotici mogli potencirati kliničku korist su modulacija imunološkog sistema i jačanje crijevne barijere. Postbiotici su sigurni i stabilni s dugim rokom trajanja koji omogućuje jednostavno skladištenje i transport te se mogu davati tijekom liječenja antibioticima bez utjecaja na učinkovitost, što ih čini privlačnom alternativom probioticima. Osim u suplementima, postbiotike imamo i u hrani: mlaćenica, svježi sir, hrana bogata vlaknima, zob, sjemenke lana, bijeli luk, banana, artičoka bobičasto voće itd. Što se tiče kliničkih efekata postbiotika, pokazalo se da su pokazali djelotvornost kod gastrointestinalnih poremećaja, jačanje imuniteta i kod alergija, kod infekcija gornjih dišnih puteva, kod stresa i neuroloških stanja, kod srčanih i vaskularnih poremećaja, te u metaboličkom sindromu.

*Ključne riječi: postbiotici, probava, zdravlje crijeva, jačanje crijevne flore*

### 3-P-2

#### Scientific Basis of Turmeric Advertising: A Critical Review

Lejla JUSUFBEGOVIĆ\* Lejla PEPIĆ Vildana HODŽIĆ Lamija FAKIĆ Ivor  
OBERAN Jasmina ĐEDIBEGOVIĆ

University of Sarajevo, Faculty of Pharmacy, Sarajevo, Bosna i Hercegovina

\*Corresponding author: Lejla Jusufbegović, lejla.jusufbegovic@ffsa.unsa.ba

#### Abstract

This study aimed to critically evaluate a popular YouTube advertisement titled “10 Turmeric Water Benefits at Night Your Doctor Hasn't Discussed”, focusing on the scientific validity of its health claims. The analysis was conducted in three stages: identification of claims presented in the video, systematic review of relevant scientific literature, and assessment of the claims based on available evidence. Results indicate that the video employs repetitive, AI-like language, lacks credible references, and presents turmeric water as a universal and rapid solution for health improvement. While turmeric exhibits well-documented biological activities, including anti-inflammatory, antimicrobial, and antioxidant effects, many claims in the video are not substantiated by clinical studies, and the quantities of turmeric used in the recipe are insufficient to produce therapeutic effects due to curcumin's low bioavailability. The study highlights the risk of disseminating pseudo-scientific health information through social media and emphasizes the ethical responsibility of healthcare professionals to provide accurate, evidence-based guidance. These findings suggest that stricter regulation of health-related advertising and enhanced consumer education are necessary to prevent misinformation and protect public health.

*Keywords: turmeric, curcumin, pseudo-scientific claims, social media*

#### Introduction

Turmeric (*Curcuma longa* L.) is a tropical plant widely used in culinary and traditional medicine, particularly in India and China. (Thavorn, Wolfe, Faust et al., 2024) Its rhizome contains curcuminoids, with curcumin I (94%) as the main active compound, responsible for its yellow color and attributed therapeutic properties. (Kiamahalleh, Najafpour-Darzi, Rahimnejad et al, 2016; Nelson, Dahlin, Bisson et al, 2017). Despite extensive research, curcumin's clinical efficacy remains limited due to chemical instability, low bioavailability, and frequent false-positive results in laboratory assays. (Boscariol, Paulino, Oliveira et al, 2022). Moreover, quality control of

commercial turmeric products is inconsistent, with some samples showing low curcumin content or toxic contaminants. Popular media often exaggerate turmeric's health benefits, influencing consumer behavior without scientific support. This study critically analyzes claims about turmeric in online media, evaluating their scientific validity, therapeutic potential of curcumin, and safety of commercial products, to provide evidence-based insights. (Youtube, 2024)

### ***Experimental***

In this study, the analysis was based on the YouTube video titled "*10 Turmeric Water Benefits at Night Your Doctor Hasn't Discussed*." The video is structured into several segments with timestamps, each containing different claims regarding the benefits of turmeric water, including historical context, preparation methods, health effects, and frequently asked questions about turmeric and turmeric water consumption. (Youtube, 2024)

The analysis was conducted in three steps:

**Video analysis and claim identification:** The video was carefully reviewed, and all explicit health-related statements were documented.

**Literature search:** Each claim was investigated using scientific databases such as Google Scholar, PubMed, ScienceDirect, and Scopus to identify supporting or contradicting evidence. Standard search methods were applied, and relevant peer-reviewed articles were recorded.

**Evaluation and critical assessment:** Claims were evaluated against scientific evidence, and a guide was developed to identify pseudo-scientific or misleading health claims related to turmeric water.

### ***Results and Discussion***

The analysis of the video "How to Make Turmeric Water" revealed several misleading and scientifically questionable claims, particularly regarding the recipe's efficacy and safety.

**Efficacy and Bioavailability Concerns:** The video's simple recipe for turmeric water ( $\frac{1}{2}$  teaspoon of turmeric powder in one glass of warm water, consumed one hour before sleep) suggests a significant therapeutic benefit. However, a major scientific issue with curcumin, the primary active compound in turmeric, is its low oral bioavailability. Curcumin's absorption after oral intake is relatively small, with bioavailability reported as less than 65% and curcuminoids constituting only 3-6% of the drug. Curcumin is rapidly metabolized and eliminated (75% via stool, the rest via urine) (Heidari et al, 2023) While the recipe correctly suggests adding a pinch of black pepper to "enhance the taste and further improve health," it fails to fully explain the crucial role of piperine (an active component in black

pepper) in overcoming the bioavailability issue. Piperine significantly increases curcumin absorption by up to 2000% by facilitating its passage into the bloodstream and inhibiting its degradation in the liver (Heidari et al, 2023) Nevertheless, combining black pepper powder with turmeric powder in a drink, as suggested in the video, is unlikely to achieve the therapeutic effects observed in clinical trials, which often use specialized, high-bioavailability curcumin supplements combined with piperine or other delivery systems. Furthermore, the therapeutic claims are highly questionable given the low dose and poor absorption. For instance, studies on chronic diseases like rheumatoid arthritis have shown that a **500 mg dose of standardized curcumin** (which resulted in significant improvements comparable to, or even better than, 50 mg diclofenac) is required to achieve a therapeutic effect. (Al-Jenoobi, Al-Thukair, Alam et al, 2015) The video oversimplifies complex biological processes by claiming anti-inflammatory power "in prevention and protection at the cellular level" and that curcumin can "prevent the occurrence of chronic diseases associated with inflammation, including cardiovascular diseases, arthritis and diabetes" (Youtube, 2024), without acknowledging the critical requirement for adequate dose and high bioavailability.

### ***Conclusion***

While turmeric has a long history of medicinal use, particularly in Ayurveda, its recent popularity has been largely driven by social media, where new recipes and claims promising “miraculous” health benefits appear daily. Although turmeric possesses various beneficial biological properties, such as anti-inflammatory, antimicrobial, and antioxidant effects, many therapeutic claims are still based on limited studies and lack robust clinical evidence. This gap between scientific facts and popular claims creates opportunities for misinformation, potentially misleading consumers. Furthermore, most studies focus on turmeric extracts containing curcumin at doses exceeding 1 g per day. Turmeric water made with half a teaspoon of powder, as shown in the advertisement, is unlikely to produce similar effects, particularly given curcumin’s low bioavailability and poor absorption.

***Author contributions:*** Conceptualization L. J. and L. P.; methodology V. H. and I. O.; investigation L. F. and I.O.; writing—original draft preparation, L. J., writing— review and editing, L.P.; visualization, L. F.; supervision, J.Đ. All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding

***Informed Consent Statement:*** “Not applicable”

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

„10 Turmeric Water Benefits at Night Your Doctor Hasn't Discussed“ (2024) – YouTube Video available from: <https://www.youtube.com/watch?v=nCdKMEAMMII>

Al-Jenoobi FI, Al-Thukair AA, Alam MA, Abbas FA, Al-Mohizea AM, Alkharfy KM, AlSuwayeh SA. (2015). Effect of *Curcuma longa* on CYP2D6- and CYP3A4-mediated metabolism of dextromethorphan in human liver microsomes and healthy human subjects. *Eur J Drug Metab Pharmacokinet*, 40, 61-6.

Boscariol, R., Paulino, T. H., Oliveira Jr., J. M., Balcão, V. M., Vila, M. M. D. C. (2022). Characterization of commercially available turmeric for use in pharmaceutical products and food supplements. *Journal of the Brazilian Chemical Society*, 33(12), 1392–1401. <https://doi.org/10.21577/0103-5053.20220073>

Heidari, Hajar et al. (2023). “Curcumin-piperine co-supplementation and human health: A comprehensive review of preclinical and clinical studies.” *Phytotherapy research: PTR* vol. 37,4: 1462-1487. doi:10.1002/ptr.7737

Mohammad Valizadeh Kiamahalleh, Ghasem Najafpour-Darzi, Mostafa Rahimnejad, Ali Akbar Moghadamnia, Meisam Valizadeh Kiamahalleh (2016). High performance curcumin subcritical water extraction from turmeric (*Curcuma longa* L.), *Journal of Chromatography B*, doi.org/10.1016/j.jchromb.2016.04.021.

Nelson, K. M., Dahlin, J. L., Bisson, J., Graham, J., Pauli, G. F., Walters, M. A. (2017). The Essential Medicinal Chemistry of Curcumin. *Journal of Medicinal Chemistry*, 60(5), 1620–1637. doi:10.1021/acs.jmedchem.6b00975  
Thavorn K, Wolfe D, Faust L, et al. A systematic review of the efficacy and safety of turmeric in the treatment of digestive disorders. *Phytother Res*. 2024;38(6):2687-2706. doi:10.1002/ptr.8189

## **Naučna zasnovanost reklame za kurkumu: kritička recenzija**

Lejla JUSUFBEGOVIĆ\* Lejla PEPIĆ Vildana HODŽIĆ Lamija FAKIĆ Ivor  
OBERAN Jasmina ĐEDIBEGOVIĆ

Univerzitet u Sarajevu, Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Lejla Jusufbegović, lejla.jusufbegovic@ffsa.unsa.ba

### **Sažetak**

Cilj ovog istraživanja bio je kritički analizirati popularnu reklamu o vodi s kurkumom prikazanu u YouTube videu "*10 Turmeric Water Benefits at Night Your Doctor Hasn't Discussed*". Analiza je sprovedena u tri koraka: identifikacija tvrdnji u videu, pretraga naučne literature i evaluacija tvrdnji u kontekstu naučnih dokaza. Rezultati pokazuju da video koristi repetitivni i robotski jezik i ne navodi relevantne izvore, dok prikazuje kurkumu kao univerzalno i brzo rješenje za poboljšanje zdravlja. Iako kurkuma ima dokazane biološke osobine poput antiinflamatornog, antimikrobnog i antioksidativnog djelovanja, mnoge tvrdnje u videu nisu potkrijepljene kliničkim studijama, a doze prikazane u receptu ne omogućavaju terapijske efekte zbog niske bioraspoloživosti kurkumina. Analiza ističe problem širenja pseudo-naučnih tvrdnji putem društvenih mreža i naglašava odgovornost zdravstvenih stručnjaka u pružanju tačnih informacija. Potrebna je stroža regulacija i edukacija potrošača kako bi se smanjio rizik od dezinformacija i potencijalne štete po zdravlje.

*Ključne riječi: kurkuma, kurkumin, pseudo-naučne tvrdnje, društvene mreže*



**Consumer awareness of dietary supplements in the Sarajevo Canton**

Lejla PEPIĆ\* Vildana HODŽIĆ Fahrija IMAMOVIĆ Jasmina  
ĐEĐIBEGOVIĆ

University of Sarajevo, Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Lejla Pepić, lejlapepic@ffsa.unsa.ba

**Abstract**

Dietary supplements are products designed to complement the diet with key nutrients (vitamins, minerals, amino acids, herbal products, etc.), but they must not replace a balanced diet. Supplements are used in various contexts - from supporting vegetarian/vegan diets and enhancing athletic performance and recovery, to maintaining health in the elderly population and ensuring adequate nutrients for pregnant women. The primary objective of this paper is to determine the most frequently consumed dietary supplements and the reasons for their use among the adult population in the Sarajevo Canton. The paper is structured into three main sections: a review of the most common and well-known supplements (such as Vitamin D, C, and magnesium), an analysis of less frequently used yet crucial supplements for certain ailments, and the presentation and analysis of the results from a survey conducted among the Sarajevo Canton population. Through this research, we aim to assess the respondents' level of knowledge regarding supplement intake from different sources, address the socio-economic aspect of their selection, and identify the need for further education and promotion of healthy eating habits.

*Keywords: dietary supplements, consumer awareness, diet, nutrition*

**Introduction**

Dietary supplements are non-food products taken to complement the diet and ensure an adequate intake of essential nutrients, such as vitamins, minerals, and amino acids. While they serve as an excellent source of necessary micronutrients for specific groups, including athletes, the elderly, pregnant women, and those following restrictive diets, it is crucial to emphasize that supplements are not intended to replace a balanced and varied diet. The global market for these products is continuously expanding, reflecting a growing consumer interest in proactive health maintenance and performance enhancement. Given this rising prevalence, understanding the local context of their use is vital. This paper aims to shed light on consumer awareness, usage

patterns, and motivations regarding dietary supplements among the adult population in the Sarajevo Canton.

### ***Experimental***

This study employed a mixed-methods approach, combining a review of the scientific literature with primary data collection through a quantitative survey. The literature review utilized established academic databases, including PubMed, WebMD, Google Scholar, and Cochrane, to provide a foundational understanding of dietary supplement use. For the primary research, an online survey was conducted using Google Forms during December 2024. A total of 218 voluntary participants residing in the Sarajevo Canton (KS) completed the questionnaire. This study was conducted anonymously to ensure the protection of participants' personal data. The sample included adults ranging from 18 to over 50 years old, with a majority being female. The survey was designed to gather relevant data on the respondents' dietary habits, the prevalence of different dietary supplements in the adult population's diet, and the key decisive factors influencing the choice and purchase of these products.

### ***Results and Discussion***

Dietary supplements have become a prominent feature in modern health maintenance and self-care practices. Their widespread adoption is driven by consumer desire to address perceived nutritional deficiencies, enhance general well-being, and support the management of various health conditions. In particular, essential micronutrients such as Magnesium, Vitamin C, and Vitamin D are among the most frequently consumed supplements globally, given their critical roles in numerous physiological processes (NIH, 2025)

Magnesium, for instance, is fundamental as a cofactor in over 300 enzymatic systems, regulating muscle and nerve function and contributing to structural bone development (NIH, 2021). Vitamin C, a vital water-soluble antioxidant, is essential for collagen synthesis, immune defense, and iron absorption (Mayo Clinic, 2023; NHS, 2020). Similarly, Vitamin D acts as a steroid hormone, crucial for bone health by regulating calcium and phosphorus homeostasis, and plays a key role in modulating immune and psychological function (NIH, 2021).

Despite the established importance of these nutrients, studies indicate that consumer decisions regarding supplementation are often complex, influenced by a blend of professional advice, personal research, and socio-economic factors. A critical concern remains the source of health information, as non-professional avenues, particularly digital media, can bypass healthcare consultation, potentially leading to inappropriate usage or missed opportunities for personalized advice. (NIH, 2025)

The findings of this survey provide data for healthcare professionals to better understand consumer behavior and guide public health strategies related to appropriate and evidence-based supplementation.

**Demographic and Educational Profile:** The survey included 218 voluntary participants from the Sarajevo Canton (KS), with the majority of respondents falling into the 18-30 age group (55.6%), followed by the 30-50 age group (38%). The smallest portion (6.5%) was over 50. The sample was overwhelmingly female, with 94% identifying as female and 5.5% as male. Regarding education, 74.7% of respondents held a university degree, while 25.3% had a secondary education. A significant portion of the participants (45.6%) reported that their education was closely related to the medical profession, suggesting a high baseline level of health literacy within the sample, even though the majority (54.4%) did not have a direct professional medical background.

**Information Sources and Consultation:** Despite the high educational background, the survey revealed a mixed approach to professional consultation. Nearly half of the respondents (51.6%) stated that they do not consult a healthcare professional before taking supplements, while 48.4% do. The primary source of information regarding supplements was the Internet (57.3%), followed by pharmacists (44.5%) and other healthcare workers/institutions (39.3%). Friends and family were also a notable source (22.7%). This reliance on non-professional sources, particularly the Internet, is a critical finding that warrants discussion regarding potential misinformation risks.

**Purchasing Habits and Selection Factors:** The most significant factor influencing supplement choice was ingredients and dosage (72.4%), followed by manufacturer reputation (34.8%), certification (32.4%), and price (27.1%). Notably, 60.3% of respondents indicated that price *does* influence their purchasing decision. This highlights a socio-economic aspect where consumers prioritize quality and ingredient transparency but remain sensitive to cost. The primary purchase location was pharmacies (72.5%), reinforcing the pharmacist's role as a trusted point of sale, even if not always as an initial consultant. Drogerie markets and similar stores accounted for 19%, while herbal pharmacies made up 5%.

**Supplement Usage and Reasons:** A vast majority of the respondents (88.5%) reported currently using or having used dietary supplements. Self-initiation was the leading reason for starting supplement use (53%), slightly surpassing the recommendation of a healthcare professional (40.6%). The most consumed supplements align with popular micronutrients, with Magnesium (72.6%) being the most prevalent, followed by Vitamin D (66.8%) and Vitamin C (60.1%). B vitamins (30.3%), Iron (26%), and Zinc

(24.5%) were also frequently used. This pattern suggests a focus on supplements perceived to support general health, energy, and immune function. While 51.2% of respondents did not use supplements due to specific health issues, a significant portion (48.8%) did. The most common health problems cited for supplement use were autoimmune and endocrine disorders, including various thyroid diseases (e.g., Hashimoto's), Polycystic Ovary Syndrome (PCOS), anemia, celiac disease, and insulin resistance.

**Correlation with Dietary Intake:** Despite the high usage of supplements, an assessment of food intake frequency suggested potential deficiencies that supplements are addressing. The consumption frequency of foods rich in the most popular supplements (Vitamin D, C, and Magnesium) showed a moderate pattern:

- For **Vitamin D-rich foods**, the most common rating was **"sometimes" (37.3%)**.
- For **Vitamin C-rich foods**, the majority reported **"often" (38.7%)**.
- For **Magnesium-rich foods**, the most frequent rating was **"sometimes" (34.6%)**.

This result indicates that while Vitamin C-rich food intake is relatively high, the moderate intake of foods rich in Vitamin D and Magnesium may correlate with the high prevalence of these specific supplements, suggesting that supplementation is used to bridge perceived or actual dietary gaps.

### ***Conclusion***

This research aimed to understand consumer awareness, usage patterns, and influential factors in the selection of dietary supplements among adults in the Sarajevo Canton (KS). The study confirms that supplements, consumed by 88.5% of respondents, are viewed as important for health maintenance, particularly for addressing specific conditions like thyroid diseases and PCOS. The most popular supplements are Magnesium, Vitamin D, and Vitamin C, often taken to bridge perceived dietary gaps.

Key findings highlighted a high rate of self-initiated consumption and a primary reliance on the Internet for information, despite the majority purchasing from pharmacies. While ingredient quality is the main selection criterion, price significantly influences over 60% of purchases, pointing to important socio-economic considerations. In summary, while there is widespread engagement with supplementation in the Sarajevo Canton, the reliance on informal sources for information necessitates targeted public health education. This education should focus on promoting safe, evidence-based supplement use and reinforcing the foundational importance of a healthy, balanced diet.

**Author contributions:** Conceptualization L.P.; methodology V.H.; investigation F.I.; writing—original draft preparation, L.P., writing—review and editing, V.H.; visualization, F.I.; supervision, J.Đ. All authors have read and agreed to the published version of the proceeding.

**Funding:** This work did not receive funding

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## **References**

Mayo Clinic. “Vitamin C.” Mayo Clinic, (2023), [www.mayoclinic.org/drugs-supplements-vitamin-c/art-20363932](https://www.mayoclinic.org/drugs-supplements-vitamin-c/art-20363932).

National Health Service (NHS). “Vitamin D - Vitamins and Minerals.” NHS, NHS, (2020), [www.nhs.uk/conditions/vitamins-and-minerals/vitamin-d/](https://www.nhs.uk/conditions/vitamins-and-minerals/vitamin-d/).

National institutes of health (NIH), Office of Dietary Supplements (ODS) – (2025). Vitamin D.” [Ods.od.nih.gov, ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/#h36](https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/#h36)

Vitamin C.” National Institutes of Health (NIH), National Institutes of Health, (2021), [ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/](https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/).

## **Informiranost potrošača o dodacima prehrani u Kantonu Sarajevo**

**Lejla PEPIĆ\* Vildana HODŽIĆ Fahrija IMAMOVIĆ Jasmina  
ĐEĐIBEGOVIĆ**

Univerzitet u Sarajevu, Farmaceutski fakultet, Sarajevo, BiH

\*Autor za korespondenciju: Lejla Pepić, lejlapepic@ffsa.unsa.ba

### **Sažetak**

Dodaci prehrani su proizvodi namijenjeni nadopunjavanju ishrane ključnim nutrijentima (vitaminima, mineralima, aminokiselinama, biljnim proizvodima, itd.), ali nikako ne smiju zamijeniti uravnoteženu ishranu. Suplementi se koriste u različitim kontekstima, od podrške vegetarijanskoj/veganskoj ishrani i poboljšanja sportskih performansi i oporavka, do održavanja zdravlja starije populacije i osiguravanja adekvatnih nutrijenata za trudnice.

Osnovni cilj ovog rada jeste utvrditi najčešće korištene dodatke prehrani i razloge za njihovu upotrebu među odraslim stanovništvom u Kantonu Sarajevo. Rad je strukturiran u tri glavne cjeline: pregled najčešćih i najpoznatijih suplemenata (poput vitamina D, C i magnezija), analiza manje zastupljenih, ali ključnih suplemenata za određena oboljenja, te prezentacija i analiza rezultata ankete provedene na stanovništvu Kantona Sarajevo. Kroz ovo istraživanje nastojimo procijeniti razinu znanja ispitanika o unosu suplemenata iz različitih izvora, osvrnuti se na socio-ekonomski aspekt njihovog odabira, te identificirati potrebe za daljnjom edukacijom i promocijom zdravih prehrambenih navika.

*Ključne riječi: dodaci prehrani, informiranost potrošača, ishrana, prehrana*

## The Use of Colostrum in Sports Nutrition and Its Effect on Athletic Performance

Jovana ŠEŠUM

Department of Veterinary Medicine, University of Novi Sad, Faculty of Agriculture

\*Corresponding author: Jovana Šešum, jovanasesum27@gmail.com

### Abstract

The study examines the effects of bovine *colostrum* on athletic performance and recovery. The results indicate that *colostrum* enhances immunity, accelerates regeneration, and increases endurance. Additionally, an anonymous survey was conducted in a local gym in Novi Sad, aiming to assess the level of awareness of the term *colostrum* among recreational athletes, as well as to evaluate their willingness to potentially use *colostrum* as a natural dietary supplement for improving performance and recovery. Based on the survey results, it was concluded that the respondents demonstrated limited knowledge, while the majority expressed a positive attitude toward its potential use.

*Keywords: colostrum, sports nutrition, recovery, immune system, performance*

### Introduction

*Colostrum*, or “first milk,” is secreted within 24 to 72 hours after birth and provides essential immune protection and nutrients to newborns. In human nutrition, bovine *colostrum* is most commonly used because of its composition and safety.

Main components of *colostrum* include:

1. *Immunoglobulins* (IgG, IgA, IgM) – Strengthen immune defense and protect against pathogens.
2. *Lactoferrin* – Possesses antimicrobial and anti-inflammatory properties.
3. Growth Factors (IGF-1, TGF- $\beta$ ) – Stimulate cell regeneration and tissue repair.
4. Vitamins and minerals – High levels of vitamins A, D, E, B2, B12, and minerals such as calcium, magnesium, zinc, and selenium.
5. Essential fatty acids – Omega-3 and omega-6 improve recovery and reduce inflammation.

*Colostrum* supports immune balance, reduces inflammation, and accelerates tissue repair. Intense training often causes immune suppression and micro-

damage to muscles. Studies (Jones et al., 2014) show that athletes who supplemented with 10–20 g of *colostrum* daily for 6–8 weeks reported fewer infections and improved endurance. Furthermore, growth factors in *colostrum* help repair the intestinal lining and improve nutrient absorption, which is crucial for athletes with high caloric needs.

The aim of this research was to evaluate the awareness and perception of bovine *colostrum* as a natural dietary supplement among recreational athletes, and to compare its potential advantages with other commonly used synthetic supplements.

Research by Brinkworth & Buckley (2003) demonstrated that athletes who consumed colostrum showed higher VO<sub>2</sub>max values and longer time to exhaustion compared to those using conventional supplements.

As presented in *Table 1*, colostrum provides unique advantages over common synthetic supplements such as whey protein, creatine, and branched-chain amino acids (BCAA), primarily due to its content of immune and growth factors, which contribute to improved recovery, reduced oxidative stress, and enhanced endurance.

**Table 1.** Comparison of colostrum with other common supplements:

<b>Supplement</b>	<b>Primary Function</b>	<b>Advantage of <i>Colostrum</i></b>
Whey Protein	Muscle building	Contains immune and growth factors
Creatine	Increases strength and power	Supports recovery and immune balance
BCAA	Reduces muscle breakdown	Includes natural growth factors and immunoglobulins

### ***Experimental***

The survey was conducted anonymously among 30 participants (10 women and 20 men) aged 25–35 years in a local gym in Novi Sad. Participation was voluntary, and informed consent was obtained prior to completing the questionnaire.



**Table 2.** The survey results:

Question	Yes	No	Neutral/Unsure
Do you know what <i>colostrum</i> is?	2	28	-
Have you ever consumed <i>colostrum</i> or a product containing it?	1	29	-
Would you consider using <i>colostrum</i> as a supplement?	23	5	2
Do you believe natural supplements are better than synthetic ones?	27	2	1
Do you think <i>colostrum</i> can improve recovery after training?	18	4	8
Would you recommend it to other athletes?	20	3	7

### **Results and Discussion**

The results presented in Table 2 show that only a small number of respondents were familiar with *colostrum* (2 out of 30) or had previously consumed it (1 respondent). However, most participants (77%) stated they would consider using *colostrum* as a supplement, and 90% believed that natural supplements are better than synthetic ones. These findings suggest a generally positive attitude toward natural supplementation despite limited awareness of *colostrum* itself.

### **Conclusion**

*Colostrum* represents a promising natural supplement for athletes, providing immune support, faster muscle recovery, and improved endurance. However, due to limited scientific evidence, high production costs, and the need for standardization, its use should be individualized. Further research and public education could expand its application in sports nutrition.

**Conflict of interest:** The author declares no conflicts of interest.

### **References**

- Antonio, J., Stout, J. R. (2001). Sports Supplements. Lippincott Williams & Wilkins.
- Brinkworth, G. D., Buckley, J. D. (2003). Concentrated bovine *colostrum* protein supplementation reduces the incidence of self-reported symptoms of

upper respiratory tract infection in adult males. *European Journal of Nutrition*, 42(4), 228–232.

Shing, C. M., Peake, J. M., Suzuki, K., Okutsu, M., Pereira, R., Jenkins, D. G. (2007). Effects of bovine *colostrum* supplementation on immune variables in highly trained cyclists. *Journal of Applied Physiology*, 102(3), 1113–1122.

Davison, G. (2011). Bovine *colostrum* and immune function after exercise. *Medicine and Sport Science*, 59, 62–69.

Yalçıntaş, S. (2024). *Colostrum* supplementation and muscle recovery: A systematic review. *Journal of Sports Science and Medicine*.

## **Upotreba kolostruma u prehrani sportista i njegovi efekti na sportske performanse**

Jovana ŠEŠUM

Odsjek Veterinarske medicine, Univerzitet u Novom sadu, Poljoprivredni fakultet

\*Autor za korespondenciju: Jovana Šešum, jovanasesum27@gmail.com

### **Sažetak**

Rad proučava uticaj goveđeg kolostruma na sportske performanse i oporavak sportista. Rezultati istraživanja ukazuju da kolostrum poboljšava imunitet, ubrzava regeneraciju i povećava izdržljivost. Takođe, sporevedena je anonimna anketa u lokalnoj teretani u Novom Sadu, čiji je cilj bio da se proceni stepen poznavanja pojma kolostruma među rekreativnim sportistima, kao i da se ispita njihova spremnost za potencijalnu upotrebu kolostruma kao prirodnog dodatka ishrani u svrhu poboljšanja performansi i oporavka. Na osnovu rezultata ankete, zaključeno je da su ispitanici pokazali slabu informisanost, pri čemu je većina ispitanika pokazala pozitivan stav prema njegovoj potencijalnoj upotrebi

*Ključne riječi: kolostrum, prehrana sportista, oporavak, imuni sistem, performanse*

4. DIJETOTERAPIJA  
DIETOTHERAPY



## The impact of dietary habits on lipid status parameters

<sup>1</sup>Ismihan ALIĆ, <sup>1</sup>Amela IBIŠEVIĆ, <sup>1</sup>Emsel PAPIĆ, <sup>2</sup>Mubera ŠAHINAGIĆ,  
<sup>1</sup>Sabina ŠEGALO

<sup>1</sup>University of Sarajevo – Faculty of Health Studies; Department of Laboratory technologies;  
Bosnia and Herzegovina, 71000 Sarajevo

<sup>2</sup>Primary Health Care Center of Sarajevo Canton “Vogošća”, Department of Medical  
Laboratory Diagnostics

Corresponding author: Ismihan Alić, ismihan.alic@fzs.unsa.ba

### Abstract

Lipids are a major source of energy for metabolic processes, contribute to the construction of cell membranes, and serve as precursors for the synthesis of various hormones, signaling molecules, and steroids. The lipid profile primarily includes total cholesterol, triglycerides, low-density lipoproteins (LDL), and high-density lipoproteins (HDL). The aim of this study is to present the influence of dietary habits on lipid status parameters. Preparation for lipid profile determination includes maintaining a stable body weight for two weeks before blood sampling. The day before sampling, a light, low-fat diet is recommended, avoiding milk and dairy products, fried foods, eggs, fatty meats, white bread, fats, and sweets. In addition, fasting for eight to twelve hours before laboratory analysis of lipid status is advised. However, many studies agree that there are no significant differences in lipid values measured in the fasting and postprandial states. Positive lifestyle habits help maintain lipid parameters within established reference intervals. In conclusion, a balanced diet, regular physical activity, and prevention of risky behaviors help maintain normal lipid status parameters, and proper patient preparation for laboratory tests is crucial for the prevention and monitoring of lipid disorders.

*Keywords: nutrition, lipid status, HDL, LDL*

### Introduction

Lipids, in the form of lipoproteins, play a crucial role in the functioning of the human body. They primarily serve as a source of energy for metabolic processes, contribute to the formation of cell membranes, and act as precursors for the synthesis of various hormones, signaling molecules, and steroids (Chait, Ginsberg, Vaisar et al., 2020). In addition to endogenous synthesis, lipids must also be obtained through food of animal and/or plant origin (Green, Shallal, 2020). In the diagnostic algorithm for suspected

dyslipidemias, the concentrations of total cholesterol, triglycerides, high-density lipoproteins (HDL), and low-density lipoproteins (LDL) are measured. According to the recommendations of the World Health Organization (WHO), lipid status should be monitored once a year, while in individuals whose values fall within the reference range, the monitoring interval can be extended to two years (Who). In addition to general recommendations for patient preparation for laboratory testing, which include several hours of fasting, avoiding certain foods, alcohol, smoking, and intense physical activity, specific requirements for lipid status analysis involve maintaining stable body weight for two weeks prior to blood sampling. On the day before blood collection, a light, low-fat diet is recommended, avoiding milk and dairy products, fried foods, eggs, fatty meats, white bread, fats, and sweets. The last meal should be consumed no later than 7 p.m. (Peran, 2021). This study aims to present the influence of dietary habits on lipid status parameters.

### ***Experimental***

As part of a qualitative, non-experimental study, relevant databases such as Medline (PubMed) and Google Scholar were searched using the keywords: lipid profile, fasting, nutrition, cholesterol, HDL, LDL, and triglycerides. The selected scientific papers were analyzed, critically examined, and tabulated by presenting the basic data of the study, the research objective, the methodology, the main results, and the conclusions drawn. Only scientific papers published within the last 10 years were considered. Based on this information, our own considerations and conclusions regarding the problem posed are presented.

### ***Results and discussion***

Studies show that more than half of patients lack sufficient information about proper preparation for laboratory testing. In the study by Kackov and colleagues (Kackov, Simundic, Gatti-Drnica, 2013), 96% of participants did not change their dietary habits 2–3 days before going to the laboratory for blood analysis. Results from other studies, such as the one conducted by Nordestgaard and colleagues (Nordestgaard, 2017), indicate that in individuals who were not fasting, there was no significant change in HDL-C values, while changes in total cholesterol and LDL-C were minimal (up to 0.2 mmol/L), and triglyceride changes were moderate (up to 0.3 mmol/L). Similar findings were reported by Cartier and colleagues (Cartier, Collins, Lagacé, 2018) as well as Dipankar and colleagues (Dipankar, Pawar, 2019), who concluded that there is no significant difference between total cholesterol, LDL-C, and HDL-C concentrations measured in fasting versus

postprandial states. However, regarding triglycerides, Cartier and colleagues (Cartier et al., 2018), observed that participants with elevated fasting triglyceride levels experienced a more pronounced increase after meals. These data are consistent with EAS and EFLM guidelines, which recommend measuring fasting triglycerides only in individuals with hypertriglyceridemia. Lifestyle habits also significantly influence the lipid profile. Castillo and colleagues (Luna-Castillo, Lopez-Quintero, Carrera-Quintanar, 2023), demonstrated that individuals with lipid values within the reference range more often practice healthy habits—maintaining a balanced diet, moderate alcohol consumption, and regular physical activity. Conversely, increased intake of saturated fatty acids, frequent alcohol consumption, smoking, and lack of physical activity are associated with elevated lipid levels. Thorning and colleagues (Thorning, Raziani, Bendtsen, 2015), reported that a diet high in fatty meat results in 8% higher HDL-C compared to a diet dominated by dairy products or carbohydrates. The importance of lifestyle in regulating lipid concentrations is further supported by the findings of Todorović and colleagues (Todorović, Ćuković, Marković, 2016), who showed that the combination of antihypertensive therapy and dietary measures leads to a significant reduction in total cholesterol and LDL-C levels. Similarly, Fuadah and colleagues (Fuadah, Heravati, 2024), demonstrated a significant positive correlation between fast food consumption and total cholesterol values ( $p < 0.05$ ). These findings highlight the impact of processed foods, along with high sugar and salt content, on the prevalence of dyslipidemia, emphasizing the need for strategies and nutritional interventions.

### ***Conclusion***

Healthy, balanced diet combined with regular physical activity and avoidance of risk factors helps maintain normal cholesterol and triglyceride levels, while unhealthy habits increase the risk of developing dyslipidemia. Lifestyle modification, along with proper patient preparation for laboratory testing, is essential for preventing and effectively monitoring lipid profile disorders.

***Author contribution:*** conceptualization, I.A. and A.I.; methodology, A.I. and S.Š.; investigation, M.Š.; writing—original draft preparation, I.A., and E.P.; writing—review and editing, I.A., A.I. and E.P.; visualization, I.A.; supervision, S.Š. and E.P.; All authors have read and agreed to the published version of the proceeding

***Funding:*** This work did not receive funding.

***Informed consent statement:*** Not applicable.

***Conflict of interest:*** The authors declare no conflict of interest.

## References

- Cartier, L.J., Collins, C., Lagacé, M., Douville, P. (2018). Comparison of fasting and non-fasting lipid profiles in a large cohort of patients presenting at a Community Hospital. *Clinical Biochemistry*, 52, 61–66.
- Chait, A., Ginsberg, H.N., Vaisar, T. (2020). Remnants of the triglyceride-rich lipoproteins, diabetes, and cardiovascular disease. *Diabetes*, 16;69(4):508–16.
- Dipankar, S. and Pawar, S. (2019). Comparison of fasting and non-fasting lipid profile in young healthy adults. *International Journal of Clinical and Experimental Physiology*, 6(1).
- Fuadah, F. and Heravati, L. (2024). Adolescent dietary patterns and their influence on cholesterol: A study on fast food consumption at junior high schools in Bandung, Indonesia. *Clinical Investigation*, 14(10).
- Green, S. and Shallal, K. (2020). Nutrition Essentials. In: Gessinger A, editor. Dietetics and Nutrition. Maricopa Community Colleges.
- Kackov, S., Simundic, A.M., Gatti-Drnic, A. (2013). Are patients well informed about the fasting requirements for laboratory blood testing? *Biochemia Medica*, 23(3):326–31.
- Luna-Castillo, K.P., López-Quintero, A., Carrera-Quintanar, L. (2023). The influence of lifestyle on high-density lipoprotein concentration among Mexican emerging adults. *Nutrients*, 15(21), 4568.
- Nordestgaard, B.G. (2017). A test in context: Lipid profile, fasting versus nonfasting. *Journal of the American College of Cardiology*, 70(13):1637–46.
- Peran, N. (2021). Priručnik za korisnike. Šibenik, Hrvatska: Opća bolnica Šibensko-kninske županije.
- Thorning, T.K., Raziani, F., Bendsen, N.T. (2015). Diets with high-fat cheese, high-fat meat, or carbohydrate on cardiovascular risk markers in overweight postmenopausal women: A randomized crossover trial. *American Journal of Clinical Nutrition*, 102(3), 573–581.
- Todorović, M., Ćuković, M., Marković, V. (2016). Uticaj dijetoterapije na koncentraciju lipida i glukoze u serumu gojaznih bolesnika sa hipertenzijom. *Biomedical Research*, 7(2), 98–103.
- World Health Organization, Global Patient Safety Action Plan 2021-2030 <https://www.who.int/teams/integrated-health-services/patient-safety/policy/global-patient-safety-action-plan> (15/09/2025).



## Utjecaj prehrambenih navika na parametre lipidnog statusa

<sup>1</sup>Ismihan ALIĆ, <sup>1</sup>Amela IBIŠEVIĆ, <sup>1</sup>Emsel PAPIĆ, <sup>2</sup>Mubera ŠAHINAGIĆ,  
<sup>1</sup>Sabina ŠEGALO

<sup>1</sup>Univerzitet u Sarajevu-Fakultet zdravstvenih studija; Studijski program Laboratorijske tehnologije; Bosna i Hercegovina, 71000 Sarajevo

<sup>2</sup>JU Dom zdravlja Kantona Sarajevo "Vogošća", Služba za medicinsko-laboratorijsku dijagnostiku

Autor za korespondenciju: Ismihan Alić, [ismihan.alic@fzs.unsa.ba](mailto:ismihan.alic@fzs.unsa.ba)

### Sažetak

Lipidi predstavljaju značajan izvor energije za metaboličke procese, učestvuju u izgradnji ćelijskih membrana, te predstavljaju prekursore za sintezu različitih hormona, signalnih molekula i steroida. Osnovu lipidnog profila čine ukupni kolesterol, trigliceridi, lipoproteini niske gustoće (engl. *low density lipoproteins*; LDL) i lipoproteini visoke gustoće (engl. *high density lipoproteins*; HDL). Cilj istraživanja je predstaviti utjecaj prehrambenih navika na vrijednosti parametara lipidnog statusa. Priprema za određivanje lipidnog profila uključuje održavanje stabilne tjelesne težine dvije sedmice prije uzimanja uzorka krvi, a dan uoči uzorkovanja krvi preporučuje se lagana, nemasna prehrana, uz izbjegavanje mlijeka i mliječnih proizvoda, pržene hrane, jaja, masnog mesa, bijelog hljeba, masnoća i slatkiša. Uz pridržavanje navedenog, savjetuje se post u trajanju od osam do 12 sati prije laboratorijske analize lipidnog statusa. Međutim, autori brojnih istraživanja saglasni su da nema značajnih promjena u vrijednostima lipida kvantificiranih natašte i postprandijalno. S druge strane, pozitivne životne navike doprinose održavanju lipidnih parametara u okvirima postavljenih referentnih intervala. Zaključujemo da uravnotežena i pravilna prehrana, redovna fizička aktivnost i prevencija rizičnih ponašanja pomažu u održavanju normalnih vrijednosti parametara lipidnog statusa, a pravilna priprema pacijenata za laboratorijske pretrage ključna je za prevenciju i praćenje poremećaja lipidnog statusa.

*Ključne riječi: prehrana, lipidni status, HDL, LDL*

## 4-O-2

### **The role of stable vitamin K intake in the control of INR values in a patient on warfarin therapy: a case study**

Arnela ARNAUTOVIĆ<sup>1, 2\*</sup>

<sup>1</sup> PZU Poliklinika „ADRIA“ Medical Center Tuzla

<sup>2</sup> Faculty of Technology, University of Tuzla

\* Corresponding author: Arnela Arnautović, arnela.arnautovic.aa@gmail.com

#### **Abstract**

Warfarin is a widely used oral anticoagulant whose effectiveness depends on maintaining stable international normalized ratio (INR) values in the target range of 2.0–3.0. Fluctuations of INR are often associated with inconsistent intake of vitamin K. This paper presents the case of an 18-year-old patient with infective endocarditis of the mitral valve who started warfarin therapy after cardiac surgery for valve replacement. In the initial period of monitoring, INR values were unstable, often outside the therapeutic range. After a nutritional intervention, which included education and a personalized diet plan with an even daily intake of vitamin K (90–120 µg/day), INR stabilization was achieved within three weeks. The results coincide with previous research that confirms that a stable and sufficient intake of vitamin K improves the control of anticoagulant therapy and reduces the risk of bleeding and thrombosis. This case highlights the importance of a multidisciplinary approach, including collaboration between physician, nutritionist, and patient, in optimizing warfarin therapy and dietary habits.

*Keywords: warfarin, vitamin K, INR, nutritional intervention, multidisciplinary approach*

#### **Introduction**

Warfarin is an oral coumarin anticoagulant that is the mainstay of treatment and prevention of deep vein thrombosis and pulmonary embolism, and is frequently prescribed for use in patients with permanent atrial fibrillation due to a proven significant reduction in the relative risk of ischemic stroke. It is used as a prophylactic drug after implantation of artificial heart valves and in the prophylactic treatment of transient cerebral ischemia. It is one of the most commonly prescribed drugs on the market, despite the introduction of new anticoagulant agents. (Gojo Tomić, 2012) Warfarin works by inhibiting vitamin-K-epoxide-reductase, thereby reducing the activation of vitamin K-dependent clotting factors. The resulting anticoagulant effect is monitored using the International Normalized Ratio (INR). The goal is to keep the INR

in the target range between 2.0-3.0 to reduce the risk of bleeding and thrombosis. (Leblanc, Presse, Lalonde, et. al. 2014). Previous research indicates that sudden changes in vitamin K consumption can cause INR values to fluctuate. (Holbrook, Pereira, Labiris, et. al. 2025) That is why patients starting warfarin treatment are given educational advice, with a strong emphasis on nutritional information. The generally accepted opinion is that the intake of vitamin K through the diet can neutralize the anticoagulant effect of warfarin. For this reason, for years patients have not been recommended to consume foods rich in vitamin K, such as green leafy vegetables. (Violi, Lip, Pignatelli, et. al. 2016) The aim of this paper is to show the influence of a stable and even daily intake of vitamin K on the control of INR values in a patient on warfarin therapy, through a case study and nutritional intervention.

### ***Experimental***

Patient, 18 years old, hospitalized on June 9, 2025. due to high temperature after an insect bite. Laboratory findings showed extremely elevated parameters of the inflammatory response (leukocytes and CRP) and elevated cardiac necrosis markers cTnI.

Echocardiography revealed vegetations up to 2.4 cm in size on the mitral valve, severe mitral insufficiency, aortic and mild tricuspid regurgitation, and signs of pulmonary hypertension.

The patient was transferred to the Infectious Diseases Clinic due to a diagnosis of mitral valve infective endocarditis with positive blood cultures for methicillin-resistant *Staphylococcus aureus* (MRSA) and *Candida albicans*. During hospitalization, the patient developed neurological symptoms, but a brain CT did not show acute ischemic changes.

The patient was managed multidisciplinarily. He was prescribed quadruple antimicrobial therapy targeted according to the antibiogram, along with glucocorticoids, intravenous immunoglobulin, and supportive therapy.

After the therapeutic intervention, there was clinical improvement, reduction of neurological symptoms, regression of vegetations, and a significant decrease in inflammation parameters. Nevertheless, the severe mitral insufficiency persisted, which is why the patient, hemodynamically stable, normotensive, and cardiac compensated, was transferred to the Clinic for Cardiac Surgery for cardiac surgery - mitral valve replacement.

After the procedure, the patient was recommended a hygienic diet and warfarin therapy with regular INR controls with target values of 2.0-3.0.

The nutritional intervention included an analysis of eating habits and a conversation with the patient. The previous recommendations that the patient received included the restriction of foods rich in vitamin K, such as green

leafy vegetables, peas, kiwi, avocado... The patient's eating habits were assessed retrospectively using the recall method (24-hour recall), taking into account the patient's subjective feeling about usual food intake, meal structure, and eating patterns.

The assessment of vitamin K intake was conducted using the Food Frequency Questionnaire (FFQ). The participant reported the types and amounts of foods consumed during the previous seven days, and the data on vitamin K content were analyzed using the EFSA Food Composition Database. (EFSA, 2024) The total intake was calculated by summing the vitamin K content of all reported foods. The results were then compared to the recommended daily intake (RDI) established by the National Institutes of Health (NIH). (NIH, 2023)

When planning menus and recommendations, the target daily intake of vitamin K is 90-120 µg/day, evenly distributed across multiple smaller meals with an emphasis on continuous and equal intake of foods containing vitamin K. For this reason, vitamin K supplementation was not included, as the goal was to achieve stable and gradual intake through food.

Supplementation could lead to sudden fluctuations in vitamin K levels and potentially interfere with anticoagulant therapy and INR stability. The patient is recommended to keep a detailed food diary to approximately monitor and control vitamin K intake, which allows for more adequate adjustment and control of anticoagulant therapy.

### ***Results and Discussion***

The surgical procedure was performed on July 3, 2025, and the patient was discharged from the clinic on July 11, 2025. In the clinical setting and after discharge from the clinic, the INR was unstable, variable, and outside the recommended range of 2.0-3.0. After the nutritional intervention, the patient followed a personalized plan and instructions with the aim of achieving a stable daily intake of vitamin K.

An improvement in INR values was noted immediately in the first week, while after 4 weeks, the INR values were completely stable and within the therapeutic range of 2.0-3.0. The average INR value 4 weeks before the collaboration was 1.5, while the average INR value 4 weeks after the collaboration was 2.7 (Table 1.).

**Table 1.** Measured INR values

Date	INR
03.07.2025	1,3
04.07.2025	2,1
05.07.2025	3,4
07.07.2025	1,2
08.07.2025	1,3
09.07.2025	1,4
11.07.2025 (discharged from clinic)	2,6
14.07.2025	3,8
21.07.2025	3,1
01.08.2025	1,9
15.08.2025	1,3
22.08.2025 (beginning of collaboration)	1,4
29.08.2025	3,0
05.09.2025	2,9
19.09.2025	2,4

The results of this case study confirm that a stable daily intake of vitamin K can significantly contribute to achieving and maintaining INR values within the therapeutic range in a patient on warfarin therapy.

Similar results were shown in a study from 2010 involving 66 subjects who were on long-term warfarin therapy, and it was proven that the long-term effect of warfarin is more stable in patients who take more than a certain dose of vitamin K through diet. (Kim, Choi, Lee, et.al. 2010)

Another study from 2005 shows that improper vitamin K intake is associated with an unstable anticoagulation response to warfarin, with patients with unstable INR having significantly lower average daily vitamin K intake compared to stable patients. (Scone, Khan, Mason, et.al. 2005)

It has also been proven that vitamin K supplementation of 100 µg improves the stability of anticoagulant therapy, and that such improvement probably reduces the number of bleeding and thrombotic events. (Rombouts, Rosendaal, Van Der Meer, 2007)

### **Conclusion**

The case report of an 18-year-old patient emphasizes the importance of a stable intake of vitamin K in the diet during warfarin therapy. It was clearly observed in the patient that variations in the daily intake of vitamin K can

lead to oscillations in the INR value, which can result in thrombosis or bleeding. After individual nutritional counseling and the introduction of consistent eating habits, better control of INR was achieved. This case report highlights the importance of a multidisciplinary approach in which the nutritionist, physician, and patient work together to optimize therapy.

**Informed Consent Statement:** Informed consent was obtained from the patient included in this study. The data used in this work are completely anonymous, and the patient's identity is protected in accordance with ethical guidelines and valid data protection laws.

**Acknowledgments:** The author would like to thank Polyclinic ADRIA for their support during data collection and realization of this work.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

European Food Safety Authority (EFSA). Food Composition Database. Parma, Italy: EFSA; 2024. <https://www.efsa.europa.eu/en/data-report/food-composition-data>

Gojo Tomić, N. (2012). *Utjecaj interakcija lijekova na međunarodni normalizirani omjer (INR) u hospitaliziranih pacijenata na terapiji varfarinom*. Doktorska disertacija, Sveučilište u Zagrebu, Farmaceutsko-biokemijski fakultet. <https://repozitorij.pharma.unizg.hr/islandora/object/pharma%3A394/datastream/PDF/view>

Holbrook A.M., Pereira J.A., Labiris R., et. al. (2025). Systematic Overview of Warfarin and Its Drug and Food Interactions. *Arch Intern Med*. 2005;165(10):1095–1106. doi:10.1001/archinte.165.10.1095

Kim, K. H., Choi, W. S., Lee, J. H., Lee, H., Yang, D. H., & Chae, S. C. (2010). Relationship between dietary vitamin K intake and the stability of anticoagulation effect in patients taking long-term warfarin. *Thrombosis and haemostasis*, 104(4), 755–759. <https://doi.org/10.1160/TH10-04-0257>

Leblanc C., Presse N., Lalonde G., Dumas S., Ferland G. (2014). Higher vitamin K intake is associated with better INR control and a decreased need for INR tests in long-term warfarin therapy. *Thrombosis Research: Volume 134, Issue 1, p210-212* July 2014 .

National Institutes of Health (NIH). Vitamin K — Fact Sheet for Health Professionals. Office of Dietary Supplements, 2023. <https://ods.od.nih.gov/factsheets/VitaminK-HealthProfessional/>

Rombouts, E. K., Rosendaal, F. R., & Van Der Meer, F. J. (2007). Daily vitamin K supplementation improves anticoagulant stability. *Journal of thrombosis and haemostasis : JTH*, 5(10), 2043–2048.

Sconce, E., Khan, T., Mason, J., Noble, F., Wynne, H., & Kamali, F. (2005). Patients with unstable control have a poorer dietary intake of vitamin K compared to patients with stable control of anticoagulation. *Thrombosis and haemostasis*, 93(5), 872–875. <https://doi.org/10.1160/TH04-12-0773>

Violi, F., Lip, G. Y., Pignatelli, P., & Pastori, D. (2016). Interaction Between Dietary Vitamin K Intake and Anticoagulation by Vitamin K Antagonists: Is It Really True?: A Systematic Review. *Medicine*, 95(10), e2895.

### **Uloga stabilnog unosa vitamina K u kontroli INR vrijednosti kod pacijenta na terapiji varfarinom: studija slučaja**

Arneta ARNAUTOVIĆ<sup>1, 2\*</sup>

<sup>1</sup> PZU Poliklinika „ADRIA“ Medical Center Tuzla

<sup>2</sup> Tehnološki fakultet Univerziteta u Tuzli

#### **Sažetak**

Varfarin je široko korišten oralni antikoagulans čija učinkovitost zavisi od održavanja stabilnih vrijednosti međunarodnog normaliziranog omjera (INR) u ciljnom rasponu 2,0–3,0. Oscilacije INR-a često su povezane s neujednačenim unosom vitamina K. Ovaj rad prikazuje slučaj 18-godišnjeg pacijenta s infektivnim endokarditisom mitralne valvule koji je nakon kardiohirurškog zahvata zamjene zaliska započeo terapiju varfarinom. U početnom periodu praćenja INR vrijednosti su bile nestabilne, često izvan terapijskog raspona. Nakon nutricionističke intervencije, koja je uključivala edukaciju i personalizirani plan ishrane s ravnomjernim dnevnim unosom vitamina K (90–120 µg/dan), postignuta je stabilizacija INR-a unutar tri sedmice. Rezultati se podudaraju s prethodnim istraživanjima koja potvrđuju da stabilan i dovoljan unos vitamina K poboljšava kontrolu antikoagulantne terapije te smanjuje rizik od krvarenja i tromboze. Ovaj slučaj naglašava važnost multidisciplinarnog pristupa, uključujući saradnju ljekara, nutricionista i pacijenta, u optimizaciji terapije varfarinom i prehrambenih navika.

*Ključne riječi: varfarin, vitamin K, INR, nutricionistička intervencija, multidisciplinarni pristup*

#### 4-O-3

### **The role of probiotics, prebiotics and synbiotics in optimizing the gut microbiota in women with polycystic ovary syndrome**

Merisa BAJROVIĆ\* Nusejba ŠLJIVO Lamija KULOVIĆ Sabina ŠEČIĆ-SELIMOVIĆ

University of Sarajevo, Faculty of Health Studies, Department of Health Nutrition and Dietetics, Bosnia and Herzegovina

\*Corresponding author: Merisa Bajrović; e-mail: [merisa.bajrovic@fzs.unsa.ba](mailto:merisa.bajrovic@fzs.unsa.ba)

#### **Abstract**

Polycystic ovary syndrome (PCOS) is a complex endocrine disorder that affects a significant number of women of reproductive age worldwide, with a prevalence ranging from 2.2% to 26%, depending on the diagnostic criteria used. It is characterized by a variety of clinical manifestations, including menstrual irregularities, hyperandrogenism, and metabolic disorders such as insulin resistance and obesity. Recent research highlights the role of the intestinal microbiota in the etiopathogenesis of PCOS, as dysbiosis is associated with deterioration of hormonal and metabolic parameters, as well as psychological changes in the gut-brain axis, which can manifest as anxiety. The aim of this paper is to analyze and systematize findings on the role of probiotics, prebiotics, and synbiotics in optimizing the intestinal microbiota in women with PCOS. For this research, relevant scientific literature was reviewed using the keywords “probiotics,” “prebiotics,” „synbiotics“, “PCOS,” and “gut.” Studies suggest that supplementation with these strains can improve insulin sensitivity, lower HOMA-IR, reduce free androgens, and increase sex hormone-binding globulin. Positive effects on inflammatory markers, body mass index, and mental health have also been identified. Microbiotic supplements, especially synbiotics, are increasingly recognized as a therapeutic approach in the treatment of PCOS. Their ability to target gut microbiota imbalances, inflammatory processes, and insulin resistance offers new opportunities for improving the health and daily quality of life of women with polycystic ovary syndrome.

*Keywords: probiotics, prebiotics, synbiotics, PCOS, gut*

#### **Introduction**

Polycystic ovary syndrome (PCOS) is a multifactorial disorder characterized by a combination of clinical features (anovulation and hyperandrogenism),



biochemical markers (excessive androgen and luteinizing hormone), and morphological ovarian features (polycystic ovaries). PCOS is often associated with obesity and leads to impaired reproductive health (Calcaterra, Verduci, Cena, et al., 2021). Diagnosis is usually based on the Rotterdam criteria, which require at least two of the following: oligo- or anovulation, clinical and/or biochemical signs of hyperandrogenism, and polycystic ovarian morphology demonstrated by ultrasound. PCOS phenotypes differ in metabolic profiles and risks (Giampaolino, Foreste, Di Filippo, et al., 2021). Although the main cause of PCOS is unknown, various genetic and environmental factors are believed to contribute to its development. Infertility with anovulation has been reported in almost 90% of women with PCOS. PCOS is also associated with an increased risk of diabetes and obesity due to its interaction with insulin resistance. In addition, this population has a higher prevalence of mental health disorders, such as hypersomnia and depression, as well as breast and endometrial cancer (Arab, Hossein-Boroujerdi, Moini, et al., 2022). Currently, infertility affects 10–15% of women worldwide and is considered one of the most serious social and health challenges (Ramzan, Bukhari, Bibi, et al., 2025).

Recently, prebiotics, probiotics, and synbiotics have attracted significant attention in the therapeutic approach to PCOS. Probiotics are live microorganisms that, when consumed in appropriate amounts, provide health benefits. Prebiotics are non-digestible substances that stimulate the growth of beneficial microbes. Synbiotics are a combination of probiotics and prebiotics. Main task of synbiotics is for the prebiotic to provide a favorable environment and nutrients needed by the probiotic, thereby enhancing their positive effects on the gut microbiota and overall health (Arab, et al., 2022).

Early diagnosis and treatment of PCOS are key to restoring ovulation (Calcaterra, et al., 2021). The use of synbiotics helps restore the gut microbiota, positively affects the immune system by reducing inflammatory processes, and regulates the hypothalamic-pituitary-adrenal (HPA) axis, leading to decreased cortisol. Probiotic treatment improves insulin and leptin signaling pathways in the hypothalamus, thus controlling insulin resistance. Short-chain fatty acids, especially butyrate, stimulate the production of glucagon-like peptide-1 (GLP-1) and reduce the number of adipocytes, while increasing insulin sensitivity and secretion (Martinez Guevara, Vidal Cañas, Palacios, et al., 2024).

The goal of this paper is to analyze and systematize the results on the role of probiotics, prebiotics and synbiotics in the optimization of intestinal microbiota in women with PCOS.

## ***Experimental***

This review was conducted by collecting data from available scientific and professional literature published in relevant databases such as Google Scholar, PubMed, ScienceDirect, and NCBI, using keywords including “Polycystic ovary syndrome (PCOS),” “probiotics,” “prebiotics,” “synbiotics,” “gut”. This paper analyzed randomized controlled trials, narrative reviews, systematic reviews, and meta-analyses. All papers were published between 2021 and 2025. The most widely used literature directly examined the impact of probiotics, prebiotics, and synbiotics on women's reproductive health. Therefore, their effects on hormones, clinical signs, and daily life were monitored.

## ***Results and Discussion***

Prebiotic and probiotic supplementation has shown significant benefits in improving the health of women with PCOS. Studies have demonstrated that probiotic consumption balances gut pH and microbial flora, improves nutrient absorption and digestion, and inhibits the production of inflammatory cytokines. It also enhances the digestion of lipids and starches (Shamasbi, Ghanbari-Homayi, M. Mirghafourvand, 2020). Prebiotic and probiotic consumption reduces blood glucose levels, thereby regulating insulin resistance, and also decreases the production of androgens, including sex hormone-binding globulin and testosterone (Hadi, E. Ghaedi, S. Khalesi, M., et al., 2020). Probiotics lower cholesterol, increase ghrelin and leptin, and lead to reductions in male sex hormones, body weight, and fat. In this way, they can positively affect clinical symptoms of PCOS, such as hirsutism and acne (Shamasbi, et al., 2020).

Statistical analyses conducted on 52 participants showed that supplementation with synbiotics has a positive effect on the quality of life of women with PCOS. Positive changes were observed in body weight, emotional status, and infertility (Hariri, Yari, Hoseini, Abhari, et al., 2021). Martinez Guevara et al. (2024) conducted a systematic study and found that probiotics and synbiotics can improve insulin resistance and hormonal imbalance by regulating the intestinal microbiota. Despite these promising results, they noted limitations such as small sample sizes, homogeneous populations, and short intervention durations, making generalization impossible (Martinez Guevara, et al., 2024).

Pharmacological treatment in adolescents has not yet been approved, but there are different options, which are divided into basic and additional treatments for PCOS. The first line of basic interventions includes lifestyle changes, such as modifications in eating habits, increased physical activity, and weight loss. These interventions have been proven to alter the course of

the disease in overweight and obese girls, reducing menstrual irregularities and androgen levels, and positively affecting cardiometabolic health (Calcaterra, et al., 2021).

A six-month randomized, placebo-controlled trial of synbiotic supplementation in women with polycystic ovary syndrome (PCOS) undergoing lifestyle changes was conducted. During the trial, all participants made lifestyle changes, including dietary modifications and increased physical activity. Participants were randomly assigned (1:1) to receive either synbiotic supplementation (Synbiotic group) or placebo (Placebo group). Both groups experienced significant reductions in body weight and body fat percentage. This trial demonstrated that synbiotic supplementation led to significant improvements in several key clinical and laboratory aspects of PCOS, including hyperandrogenism, lipid profile, and markers of endotoxemia (Chudzicka-Strugała I, Kubiak A, Banaszewska B, et al., 2025). Notably, synbiotics consistently showed the greatest positive impact compared to prebiotics and probiotics administered separately. The synergy between both components improves intestinal microbiota, as well as metabolic and hormonal functions. The most commonly used probiotic strains included *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus rhamnosus*, *Bifidobacterium longum*, *Streptococcus thermophilus*, and *Bacillus coagulans*. Capsules and pharmaceutical juices are the most common forms and are typically used for 8 to 12 weeks (Martinez Guevara et al., 2024). The best-known prebiotics are fructooligosaccharides (FOS), inulin, galactooligosaccharides (GOS), and lactulose. These positively affect host health by altering the composition of the intestinal microbiota. Prebiotics promote the growth of *Bifidobacterium* and *Lactobacillus*, leading to significant decreases in fasting plasma glucose, serum triglycerides, total cholesterol, and LDL cholesterol, and a significant increase in HDL cholesterol levels (Giampaolino et al., 2021). The available literature emphasizes the importance of specific strains, dosage, and duration of therapy. McFarland et al. (2018) emphasized that different strains within the same group may have different health impacts and highlighted the need for specific clinical guidelines (Martinez Guevara et al., 2024).

Many studies with high adherence rates reported that side effects were insignificant or absent. The combined use of probiotics and prebiotics can be effectively integrated into current treatment modalities and represents a viable alternative to conventional pharmacological therapies, with only minor differences. However, additional research is needed to clarify and compare the effects of different probiotic strains and doses, determine the appropriate duration of therapy, and further elucidate the health benefits of prebiotics,

probiotics, and synbiotics on the clinical symptoms of women diagnosed with PCOS.

### **Conclusion**

Based on the available literature, the use of prebiotics, probiotics, and synbiotics in women diagnosed with PCOS improves biochemical findings. Many studies have shown that combining probiotics and prebiotics can improve the hormonal profile, reduce insulin resistance and androgen levels, and thus enhance the daily life of women with this diagnosis. Nutritional therapy can play a preventive and therapeutic role and is especially important in the early stages of the disease. It is important to note that the underlying mechanism is still not sufficiently clear, and new prospective randomized clinical studies are needed to explain the mechanisms of connection and the causes of intestinal microbiota dysbiosis in PCOS. Women diagnosed with PCOS need a holistic approach to treatment, which includes changes in dietary habits, physical activity, regular sleep, rest, and stress reduction.

**Author's contribution:** conceptualization, S.Š.S. ; methodology, S.Š.S., research: M.B., N.Š.; preparation of the original draft, M.B., N.Š.; revision and editing: L.K.; visualization by L.K.; supervision, S.Š.S.; all authors agreed with the final version of the paper and contributed to its quality and accuracy.

**Funding:** This work was not funded.

**Informed consent statement:** Not applicable.

**Conflicts of interest:** The authors declare no conflicts of interest.

### **References**

- Arab, A., Hossein-Boroujerdi M., Moini, A., Sepidarkish, M., Shirzad, N., Karimi, E. (2022). Effects of probiotic supplementation on hormonal and clinical outcomes of women diagnosed with polycystic ovary syndrome: A double-blind, randomized, placebocontrolled clinical trial. *J Funct Foods*, 96.
- Calcaterra, V., Verduci, E., Cena, H., Magenes, V. C., Todisco, C. F., Tenuta, E., Gregorio, C., De Giuseppe, R., Bosetti, A., Di Profio, E., & Zuccotti, G. (2021). Polycystic Ovary Syndrome in Insulin-Resistant Adolescents with Obesity: The Role of Nutrition Therapy and Food Supplements as a Strategy to Protect Fertility. *Nutrients*, 13(6), 1848.
- Chudzińska-Strugała, I., Kubiak, A., Banaszewska, B., Wysocka, E., Zwozdziak, B., Siakowska, M., Pawelczyk, L., Duleba, A. J. (2025). Six-month randomized, placebo controlled trial of synbiotic supplementation in

women with polycystic ovary syndrome undergoing lifestyle modifications. *Arch Gynecol Obstet.* (2), 499-506.

Giampaolino, P., Foreste, V., Di Filippo, C., Gallo, A., Mercurio, A., Serafino, P., Improda, F.P., Verrazzo, P., Zara, G., Buonfantino, C., Borgo, M., Riemma, G., Angelis, C., Zizolfi, B., Bifulco, G., Della Corte, L. (2021). Microbiome and PCOS: State-of-Art and Future Aspects. 19;22(4), 2048.

Hadi, A. E., Ghaedi, K. S., Pourmasoumi, M., Arab, A. (2020). Effects of synbiotic consumption on lipid profile: A systematic review and meta-analysis of randomized controlled clinical trials. *European Journal of Nutrition*, 59 (7), 2857-2874.

Hariri, Z., Yari Z., Hoseini, S., Abhari, K., Sohrab G. (2024). Synbiotic as an ameliorating factor in the health-related quality of life in women with polycystic ovary syndrome. A randomized, triple-blind, placebo-controlled trial. *BMC Womens Health*, 24(1),19.

Martinez, G. D., Vidal, C. S., Palacios, I., Gómez, A., Estrada, M., Gallego, J., Liscano, Y. (2024). Effectiveness of Probiotics, Prebiotics, and Synbiotics in Managing Insulin Resistance and Hormonal Imbalance in Women with Polycystic Ovary Syndrome (PCOS): A Systematic Review of Randomized Clinical Trials. *Nutrients*. 16;16(22):3916

Ramzan, H., Bukhari, D. A., Bibi, Z., Arifullah, Isha, Nawaz, A., Rehman, A. (2025). Probiotic supplement for the treatment of polycystic ovarian syndrome. *Pharmacol Ther.* 266:108785.

Shamasbi, S. G., Ghanbari-Homayi, S., Mirghafourvand, M. (2020). The effect of probiotics, prebiotics, and synbiotics on hormonal and inflammatory indices in women with polycystic ovary syndrome: A systematic review and meta-analysis. *European Journal of Nutrition*, 59 (2), 433-450. <https://link.springer.com/article/10.1007/s00394-019-02033-1>

## **Uloga probiotika, prebiotika i sinbiotika u optimizaciji crijevne mikrobiote kod žena sa sindromom policističnih jajnika**

Merisa BAJROVIĆ\* Nusejba ŠLJIVO Lamija KULOVIĆ Sabina ŠEČIĆ-SELIMOVIĆ

Univerzitet u Sarajevu, Fakultet zdravstvenih studija, studijski program Zdravstveni nutricionizam i dijetetika, Bosna i Hercegovina

\*Autor za korespondenciju: Merisa Bajrović; e-mail: merisa.bajrovic@fzs.unsa.ba

### **Sažetak**

Sindrom policističnih jajnika (*engl. Polycystic ovary syndrome, PCOS*) predstavlja kompleksan endokrinološki poremećaj koji zahvata značajan broj žena reproduktivne dobi širom svijeta, s prevalencom koja se kreće između 2,2% i 26%, u zavisnosti od primijenjenih dijagnostičkih kriterija. Karakteriziran je nizom kliničkih manifestacija različite kompleksnosti, od menstrualnih nepravilnosti i hiperandrogenizma do metaboličkih poremećaja poput inzulinske rezistencije i gojaznosti. Prema posljednjih istraživanjima, naglašava se uloga crijevne mikrobiote u etiopatogenezi PCOS-a, budući da se disbioza povezuje s pogoršanjem hormonskih, metaboličkih parametara, ali i psiholoških promjena u osovini crijeva-mozak što se manifestira anksioznim stanjima. Cilj ovog rada je analizirati i sistematizirati rezultate o ulozi probiotika, prebiotika i sinbiotika u optimizaciji crijevne mikrobiote kod žena s PCOS-om. Za potrebe istraživanja korištena je relevantna naučna literatura upotrebom ključnih riječi „probiotici“, „prebiotici“, „sinbiotici“, „PCOS“, „crijevna mikrobiota“. Istraživanja ukazuju da suplementacija navedenim sojevima može poboljšati inzulinsku osjetljivost, sniziti HOMA-IR indeks, smanjiti nivo slobodnih androgena i povećati globulin koji veže spolne hormone, a identifikovani su i pozitivni efekti na inflamatorne markere, indeks tjelesne mase i mentalno zdravlje. Mikrobiotski dodaci, naročito sinbiotici, sve više se prepoznaju kao terapijski pristup u liječenju PCOS-a. Njihova sposobnost da ciljano djeluju na neravnotežu crijevne mikrobiote, inflamatorne procese i inzulinsku rezistenciju pruža nove mogućnosti za poboljšanje zdravlja i svakodnevnog kvaliteta života žena sa sindromom policističnih jajnika.

*Ključne riječi: probiotici, prebiotici, sinbiotici, PCOS, crijevna mikrobiota*

## **Application of immunomodulatory enteral formulas in optimizing immune function and nutritional status of patients**

Nadina Džafić\* Sara Grčić Alma Arnautović Sabina Šečić-Selimović Lamija Kulović

University of Sarajevo, Faculty of Health Studies, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Nadina Džafić, e-mail: nadina.dzafic@fzs.unsa.ba

### **Abstract**

Proper nutrition and adequate nutritional status are key aspects of modern treatment. Currently, malnutrition affects up to 55% of hospitalized patients. Clinical nutrition includes various interventions for treating malnutrition, such as oral, enteral, and parenteral nutrition. Enteral nutrition is defined as a method that allows the intake of nutritionally and pharmacologically defined enteral preparations, either orally or via a device (tube) into the stomach or small intestine. Indications for enteral nutrition are broad, ranging from malnutrition to any condition where individuals are at risk of deteriorating nutritional status due to underlying disease or planned diagnostic and therapeutic procedures, as well as for faster recovery. Enteral formulations have evolved over the past 50 years, from simple mixtures of hospital food thin enough to pass through a feeding tube, to the development of commercial standard formulas, followed by specialized formulas with immune modulators and disease-specific properties, and more recently to food-based enteral formulas or blended enteral preparations composed of natural, whole foods with perceived health benefits. Additionally, modern technological advances have significantly improved enteral feeding tubes and pumps, increasing the precision, safety, and ease of nutrient administration. The aim of this paper is to analyze and systematize the results of using immunomodulatory enteral formulas to optimize patients' immune function and nutritional status. For this research, relevant scientific literature was reviewed using the keywords “enteral nutrition” and “immunomodulatory preparations.” The studies cited in this paper include clinical research and meta-analyses that confirm the usefulness of these preparations, which have been shown to shorten intensive care unit stays, reduce the duration of mechanical ventilation, decrease the frequency of postoperative complications, and improve patients' nutritional and immunological status.

*Keywords: enteral nutrition, immunomodulatory preparations, clinical nutrition*

## ***Introduction***

Clinical nutrition includes oral nutrition and the supplementation of natural nutrition with foods for special medical purposes, such as enteral and parenteral nutrition. Implementing a regimen appropriate to the patient's clinical condition and needs improves not only anthropometric but also laboratory parameters (Raczyńska, Leszczyńska, Skotnicki et al, 2025). Enteral nutrition, or tube feeding, is used in various pathological situations when oral nutrition is not possible or is insufficient to achieve adequate nutrient intake to maintain the patient's normal nutritional status (Pavić, Tomek-Roksandić, Bender, 2018). A wide range of commercially available enteral formulas exists for different indications, making knowledge of their composition and the substrates used in their preparation essential for recommending optimal nutritional therapy. Enteral formulas are intended for administration orally or via a nasogastric or nasojejun tube, in the form of powders or ready-to-use solutions. All enteral formulas comply with European Commission regulations and are governed by Regulation EU 609/2013, which refers to food for special groups and includes the category "food for special medical needs," encompassing specially processed or formulated food intended for the nutritional therapy of patients (Church, Zoeller, 2023).

## ***Experimental***

In preparing this article, electronic medical literature databases were thoroughly searched using keywords such as "enteral formula," "parenteral formula," and "immunomodulatory preparations." The aim of this paper is to demonstrate the benefits of immunomodulatory enteral formulas in optimizing the immune function and nutritional status of patients.

## ***Results and discussion***

Maltodextrin is a basic carbohydrate ingredient derived from the hydrolysis of corn starch to lower osmolality. Enteral preparations intended for diabetics contain fructose and modified maltodextrin, which is digested more slowly in the intestine and thus enables a more stable postprandial blood glucose concentration.

Proteins in enteral formulas come from both animal and plant sources. The most commonly used are casein and whey proteins from cow's milk, which contain all essential amino acids in a highly digestible form. Enteral preparations also include vegetable proteins, primarily from soy and peas. In enteral formulas, fats are mostly present as long-chain and medium-chain fatty acids bound to molecules such as triglycerides and phospholipids. The



fat sources in enteral supplements are typically a mixture of oils rich in  $\omega$ -6 fatty acids, although sources of  $\omega$ -3 fatty acids have been increasingly added. To comply with EU regulations, all complete enteral formulas providing 1500 kcal must also contain vitamins, minerals, and trace elements that cover 100% of daily requirements. For standard enteral formulas, this is usually achieved in 1000 ml of the preparation.

An important advantage of enteral preparations is that they do not contain substances that can cause intolerance in certain individuals (such as lactose and gluten) or have harmful effects at higher concentrations (such as purines and cholesterol).

Enteral preparations are used to combat malnutrition in patients, especially when adequate nutrition is crucial for treatment outcomes. Malnutrition is a clinical condition that leads to adverse health changes. It affects 35–55% of hospitalized patients, and in cancer patients, this prevalence increases to 40–90%. Nutritional status screening is essential for preventing malnutrition, which is as important as its treatment. Malnutrition in patients after severe trauma significantly increases catabolic changes. Cytokines and hormones such as adrenaline, glucagon, and cortisol are released, which can increase energy expenditure by 50%.

Patients with gastrointestinal cancer undergoing surgical treatment were randomly assigned to two groups: one receiving standard enteral nutrition and the other receiving immunomodulatory enteral nutrition. Patients receiving immunomodulatory enteral preparations had a lower incidence of diarrhea and postoperative complications such as fistula and sepsis, lower gastric residuals, better nutritional status parameters for iron and vitamin B12, a better immunological profile with higher lymphocyte counts and fewer leukocytes, lower levels of acute phase inflammatory proteins, and a significantly higher albumin/globulin ratio. A study observing 30 patients in the study group and 35 in the control group with gastric cancer showed that three days after gastrectomy, levels of diamine oxidase, D-lactic acid, and endotoxin were significantly lower in the study group. Perioperative enteral immunonutrition improves postoperative immune and intestinal mucosal barrier functions in patients undergoing radical gastrectomy, leading to reduced inflammatory responses, a lower rate of postoperative complications, and faster recovery.

Another study investigated the effect of immunomodulatory enteral preparations on 57 patients with severe neurological diseases. The patients were divided into two groups: one received a standard diet, while the other received immunomodulatory enteral preparations. The results showed better diet tolerability in the immunologically supported group compared to the

standard diet, improved immune parameters, and a decrease in inflammatory cytokine markers.

A meta-analysis investigated the effect of enteral immunomodulatory nutritional formulas on mortality and intensive care parameters in critically ill patients, including 10 studies with a total of 1,166 patients. The results indicate a shorter stay in intensive care units, reduced use of mechanical ventilation, lower scores on organ failure scales, a reduced risk of mortality in the first eight days of treatment, and a higher number of days spent outside the intensive care unit.

### ***Conclusion***

The use of enteral and parenteral nutrition is a key component of clinical nutritional therapy, especially when these methods are the only options for the patient. In this paper, we emphasize the importance of immunomodulatory enteral preparations that, in addition to providing basic nutritional support, also help improve immunological parameters and reduce inflammatory markers. The text presents results from clinical studies and meta-analyses confirming that these preparations can shorten intensive care unit stays, reduce the duration of mechanical ventilation and the incidence of postoperative complications, and improve the nutritional and immunological status of patients. This type of nutritional support has proven effective in patients with severe neurological diseases, gastrointestinal cancers, and critical conditions such as acute lung injury.

***Author contributions:*** conceptualization, S.Š.S.; methodology, S.G.; research, S.Š.S., N.DŽ.; original draft preparation, S.G., N.DŽ., A.A.; revision and editing, S.Š.S.; visualization, S.G., A.A.; supervision, S.Š.S. All authors agreed to the final version of the paper and contributed to its quality and accuracy.

***Funding:*** This work was not funded.

***Informed consent:*** Not applicable.

***Conflict of interest:*** The authors declare no conflict of interest.

### ***References***

Raczyńska, A., Leszczyńska, T., Skotnicki, P., Koronowicz, A. (2025). The impact of immunomodulatory components used in clinical nutrition—a narrative review. *Nutrients*, 17(5), 752.

Pavić, T., Tomek-Roksandić, S., Bender, D. V., Krznarić, Ž. (2018). Enteralna prehrana—gdje smo danas u farmakonutriciji?. *Liječnički vjesnik*, 140(1-2), 50-56.

Church A, Zoeller S. (2023). Enteral nutrition product formulations: A review of available products and indications for use. *Nutr Clin Pract*. 2023;38(2):277-300. doi:10.1002/ncp.10960

Raczyńska, A., Leszczyńska, T., Skotnicki, P., & Koronowicz, A. (2025). The Impact of Immunomodulatory Components Used in Clinical Nutrition-A Narrative Review. *Nutrients*, 17(5), 752.

Li, K., Xu, Y., Hu, Y., Liu, Y., Chen, X., & Zhou, Y. (2020). Effect of enteral immunonutrition on immune, inflammatory markers and nutritional status in gastric cancer patients undergoing gastrectomy: a randomized double-blinded controlled trial. *Journal of Investigative Surgery*, 33(10), 950-959.

Raczyńska, A., Leszczyńska, T., Skotnicki, P., & Koronowicz, A. (2025). The Impact of Immunomodulatory Components Used in Clinical Nutrition-A Narrative Review. *Nutrients*, 17(5), 752.

Santos, S. S., Costa, L. A. T. J. D., Araripe, T. S. O., Reges, B. D. L. O., Ximenes, H. M. A., & Moreira, A. C. O. M. (2025). Immunomodulatory enteral nutrition in post-surgical gastrointestinal cancer: Clinical, biochemical and nutritional impacts. *Clinical nutrition ESPEN*, 68, 254–262.

Ma, M., Zheng, Z., Zeng, Z., Li, J., Ye, X., & Kang, W. (2023). Perioperative Enteral Immunonutrition Support for the Immune Function and Intestinal Mucosal Barrier in Gastric Cancer Patients Undergoing Gastrectomy: A Prospective Randomized Controlled Study. *Nutrients*, 15(21), 4566.

Chao, K., Wang, D., Yang, H., Ma, N., Liu, Q., Sun, X., & Sun, R. (2021). Beneficial Effect of Immune-Enhanced Enteral Nutrition on Immune Function in Patients With Severe Neurological Diseases: A Single-Center Randomized Controlled Trial. *Frontiers in nutrition*, 8, 685422.

Malekahmadi, M., Pahlavani, N., Firouzi, S., Clayton, Z. S., Islam, S. M. S., Rezaei Zonooz, S., Moradi Moghaddam, O., & Soltani, S. (2022). Effect of enteral immunomodulatory nutrition formula on mortality and critical care parameters in critically ill patients: A systematic review with meta-analysis. *Nursing in critical care*, 27(6), 838–848. <https://doi.org/10.1111/nicc.12687>

## **Primjena imunomodulatornih enteralnih formula u optimizaciji imunološke funkcije i nutritivnog statusa pacijenata**

Nadina DŽAFIĆ\* Sara GRČIĆ Alma ARNAUTOVIĆ Sabina ŠEČIĆ-SELIMOVIC Lamija KULOVIC

<sup>1</sup> Univerzitet u Sarajevu, Fakultet zdravstvenih studija, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Nadina Džafić, e-mail: nadina.dzafic@fzs.unsa.ba

### **Sažetak**

Pravilna ishrana i adekvatan nutritivni status su dva ključna područja današnjeg liječenja. Danas pothranjenost pogađa čak oko 55% hospitaliziranih pacijenata. Klinička prehrana obuhvata različite nutritivne intervencije radi liječenja malnutricije uključujući oralnu, enteralnu i parenteralnu prehranu. Enteralna prehrana definira se kao metoda koja omogućuje unos nutritivno i farmakološki definiranih enteralnih pripravaka peroralnim putem ili preko pomagala (sonde) u želudac ili tanko crijevo. Indikacije za primjenu enteralne prehrane su široke, od pothranjenosti do svih stanja kada osobama prijeti pogoršanje nutritivnog statusa zbog osnovne bolesti ili planiranih dijagnostičkih i terapijskih postupaka te radi bržeg oporavka. Enteralne formulacije su se progresivno razvijale tokom posljednjih 50 godina, od jednostavnog miješanja bolničke hrane dovoljno rijetke da prolazi kroz sondu za hranjenje, do razvoja komercijalnih standardnih formula nakon čega su uslijedile specijalizirane formule s imunološkim modulatorima i specifičnim svojstvima vezanih za bolest, potom do najnovijeg prelaska na enteralne formule na bazi hrane ili blendane enteralne pripreme sastavljene od prirodnih, cjelovitih namirnica sa uočenim zdravstvenim prednostima. Pored toga moderna tehnološka dostignuća su značajno poboljšala sonde i pumpe za enteralnu ishranu povećavajući preciznost, sigurnost i jednostavnost primjene hranjivih tvari. Cilj ovog rada je analizirati i sistematizirati rezultate o primjeni imunomodulatornih enteralnih formula u optimizaciji imunološke funkcije i nutritivnog statusa pacijenta. Za potrebe istraživanja korištena je relevantna naučna literatura upotrebom ključnih riječi “enteralna prehrana”, “imunomodulatorni pripravci”. Navedena istraživanja u radu kao rezultat prikazuju klinička istraživanja i meta analize koji nam potvrđuju korisnost primjene ispitanih pripravaka koji dokazano skraćuju boravak pacijenata u jedinicama intenzivne njege, smanjuju trajanje mehaničke ventilacije ali i učestalost postoperativnih komplikacija kao i poboljšanje nutritivnog i imunološkog statusa pacijenta.

*Ključne riječi: enteralna prehrana, imunomodulatorni pripravci, klinička prehrana*

## The role of polyphenols in preserving women's reproductive health

Nur-Esma GAZDIĆ\*<sup>1</sup> Amina MRKONJIĆ<sup>1</sup> Aida OMERAGIĆ<sup>2</sup> Sabina  
ŠEČIĆ-SELIMOVIC<sup>1</sup> Lamija KULOVIĆ<sup>1</sup>

<sup>1</sup>University of Sarajevo, Faculty of Health Studies, Department of Health Nutrition and Dietetics, Bosnia and Herzegovina

<sup>2</sup>University of Sarajevo, Faculty of Health Studies, Department of Midwifery, Bosnia and Herzegovina

\*Corresponding author: Nur-Esma Gazdić, e-mail: nuresma.gazdic@fzs.unsa.ba

### Abstract

Polyphenols are bioactive compounds with antioxidant, anti-inflammatory, and hormone-modulating properties that are important for preserving women's reproductive health. Polyphenolic compounds help regulate hormonal balance, modulate oxidative stress, and reduce inflammatory processes in the body. The aim of this paper is to define the role of polyphenols in preserving reproductive health, with an emphasis on mechanisms of action and potential clinical applications. This paper was conducted by reviewing relevant scientific literature using the keywords: "*polyphenols*", "*women's reproductive health*," and "*fertility*." According to the results, increased polyphenol intake significantly reduces the risk of gestational diabetes by 22% (OR = 0.78; 95% CI: 0.69–0.89). Although polyphenols did not show a significant association with reduced risk of preeclampsia, in women with polycystic ovary syndrome, polyphenol use resulted in an average decrease in insulin levels by 2.49  $\mu$ IU/mL ( $p < 0.01$ ), as well as reductions in luteinizing hormone and body mass index. The authors also note that polyphenols help alleviate inflammatory markers in endometriosis. However, excessive polyphenol intake may affect the mother's adaptation mechanisms during pregnancy, which requires further research. It is especially important to assess their role in pregnancies in older women, as well as their impact on the long-term health of both mother and child. Polyphenols are an important factor in preventing reproductive disorders, but future clinical research is necessary to confirm the safety and effectiveness of their use.

*Keywords:* "*polyphenols*", "*womens's reproductive health*", "*fertility*"

## *Introduction*

Dietary polyphenols, also known as phenols, are a large and diverse group of bioactive plant-derived compounds with numerous beneficial biological properties. These secondary metabolites occur in more than 8,000 different forms and are most commonly consumed through the daily diet, primarily from fruits, tea, coffee, wine, cocoa, and various types of vegetables, legumes, and cereals (Abbas, Saeed, Anjum, 2017; Zhou, Feng, Liao, 2024). As the most abundant non-nutrient antioxidants in the diet, polyphenols are classified based on the number of phenolic rings and their structural connectivity. The most important groups include flavonoids, phenolic acids, stilbenes, and lignans. Flavonoids, which account for the largest portion of total intake, can be further divided into several subgroups with specific mechanisms of action (Phenol-Explorer Database on Polyphenol Content in Foods, 2022).

Recently, there has been growing interest in investigating the role of these compounds in female reproductive health, given their ability to influence hormonal balance, oxidative stress, and immune responses. Although the beneficial effects of polyphenols are well documented in various chronic diseases, data on their impact during pregnancy remain fragmented and often contradictory. Studies show that increased polyphenol intake can occur during pregnancy—up to 2 g per day—which may have significant physiological implications, since their metabolites, although in limited quantities, can be absorbed and reach the placenta, potentially affecting fetal development. The placenta acts as a partial barrier but also as a target structure, as certain compounds can cross the placental barrier and exert biological effects at the molecular level (Probst, Guan, Kent, 2018).

In addition to their direct effects on gestational processes, a growing body of research is examining the role of polyphenols in conditions such as polycystic ovary syndrome (PCOS), endometriosis, and hormone-dependent tumors, where their anti-inflammatory and metabolic regulatory effects have been recognized. Dietary polyphenols have also shown significant prebiotic effects, promoting the growth and activity of beneficial bacteria such as *Lactobacillus* and *Bifidobacterium*, which helps maintain the balance of the intestinal microbiota and supports intestinal mucosal health by inhibiting pathogenic microorganisms. This modulation of the microbiota may have far-reaching implications in the prevention and treatment of reproductive disorders, including PCOS, through the regulation of inflammatory processes and metabolic pathways. However, despite promising results from *in vitro* and *in vivo* studies, additional clinical trials are needed to ensure safety, define recommended doses of polyphenols during sensitive phases such as

pregnancy, and understand long-term effects on maternal and fetal health (Wang et al., 2022; Xia et al., 2022; Li et al., 2023).

### ***Experimental***

The available literature for this non-experimental qualitative research was electronically reviewed across a wide range of relevant databases, including Google Scholar, PubMed, MDPI, Wiley Online Library, and Bentham Open, within the time frame from 2021 to 2025. The search was conducted using keywords related to the topic and aims of this thesis in English: "polyphenols", "women's reproductive health", and "fertility".

The aim of this paper is to define the role of polyphenols in preserving reproductive health, with emphasis on mechanisms of action and potential clinical applications. Inclusion criteria encompassed scientific articles published in the aforementioned period in Bosnian, Croatian, Serbian, or English, focusing on the topic "The role of polyphenols in preserving women's reproductive health". Exclusion criteria referred to non-peer-reviewed papers, conference abstracts, duplicates, and articles lacking relevant data for the analyzed topic.

### ***Results and discussion***

A growing body of research is focused on investigating bioactive plant compounds, particularly polyphenols, for their potential in preventing and treating various chronic non-communicable diseases, including cardiovascular disorders, malignant diseases, and conditions associated with hormonal imbalance. Studies have shown that regular consumption of a diet rich in polyphenols, especially flavonoids and phytoestrogens, can reduce the risk of developing breast and ovarian cancer and have a beneficial effect on disease outcomes. This protective role of polyphenols is attributed to their antioxidant, anti-inflammatory, antiproliferative, and immunomodulatory properties, making them relevant not only for prevention but also as supportive therapy for hormone-dependent diseases.

Recent research has paid particular attention to the association of polyphenols with endometriosis, including their effects on cell proliferation, invasion, angiogenesis, and immune response regulation. Since endometriosis often involves chronic inflammation, oxidative stress, and lipid imbalance, it is understandable that a diet rich in antioxidants is recognized as a potential adjuvant in its treatment. In addition to their direct impact on cellular and molecular processes, polyphenols have also shown a positive effect on the balance of the intestinal microbiota. They are recognized as compounds that act as prebiotics, stimulating the growth of beneficial bacterial strains such as lactobacilli and bifidobacteria, while inhibiting the development of

pathogenic microorganisms. This aspect is particularly important given that changes in the composition of the intestinal microbiota are increasingly associated with various systemic diseases, including polycystic ovary syndrome (PCOS), where polyphenols are thought to have a regulatory effect on metabolic and inflammatory processes (Gołębek, Kowalska, Olejnik, 2021). Grape polyphenols, including grape seed extract, resveratrol, and proanthocyanidin B2, have demonstrated the ability to influence female reproductive processes by modulating hormonal balance, steroidogenesis, cell proliferation, apoptosis, and oxidative stress. Their structural similarity to estrogens allows them to act on estrogen receptors, which may lead to hormone-mediated effects in ovarian cells. These compounds have been shown to affect estradiol and progesterone secretion, reduce oxidative stress, inhibit ovarian and cervical cancer cell proliferation, and promote cell apoptosis through various intracellular pathways (Kohut, Baldovska, Mihal, 2024). Ceballos et al. analyzed the effect of resveratrol on various laboratory and hormonal parameters in female patients. The results showed that total testosterone levels were significantly lower in women receiving resveratrol compared to placebo (SMD = -0.49; 95% CI, -0.91 to -0.08;  $p = 0.02$ ). For follicle-stimulating hormone (FSH), there was no significant difference in the primary analysis (SMD = -0.46; 95% CI, -0.94 to 0.01;  $p = 0.06$ ). Other hormones, including prolactin and thyroid-stimulating hormone, did not show significant changes, nor did insulin and SHBG. Lipid profiles were also not significantly affected by resveratrol use. When pregnancy rates were observed, no significant difference was found between the resveratrol-treated and control groups (Caballos-Sánchez et al., 2025; Carroll et al., 2018; Xiong et al., 2021; Young et al., 2017). Research shows that resveratrol has multiple beneficial effects on PCOS. It reduces the number of sinus follicles, increases the number of secondary follicles, and decreases granulosa cell apoptosis and oxidative stress levels. Resveratrol also helps lower androgen levels and improves insulin sensitivity. In experimental models, resveratrol has been observed to increase the expression and deacetylation of SIRT1 in granulosa cells, which may help improve ovarian luteal function. Its actions include activation of SIRT1 and inhibition of inflammatory pathways, particularly through TNF- $\alpha$ -mediated NF- $\kappa$ B signaling. Resveratrol also protects ovarian follicles from atresia by regulating the SIRT1-FoxO1/P53 pathway, and its therapeutic role may be related to modulation of the gut microbiota. After transplantation of microbiota from donors who consumed resveratrol, significant changes in the composition of the bacterial community were observed, including increased diversity and a higher abundance of beneficial bacterial genera such as *Lactobacillus*.



Although polyphenols have been shown to act as prebiotics and help alleviate PCOS symptoms, including insulin resistance and hormonal imbalances, their impact on the gut microbiota in the context of PCOS and the interdependence of polyphenol and microbiota metabolism have not yet been sufficiently investigated. Isoflavones, present in soy products, have anti-inflammatory and antioxidant properties. One of the most important isoflavones, daidzein, is partially metabolized to equol by the gut microbiota. This relationship suggests an important role for the microbiota in the metabolism and effects of isoflavones. Studies have shown that isoflavones have therapeutic potential in PCOS, and intervention with isoflavones increases the alpha diversity of the gut microbiota and can restore the balance of bacteria associated with equol production, which is reduced in PCOS patients. For this reason, isoflavones represent a promising prebiotic for improving PCOS symptoms through microbiota modulation (Zhou et al., 2024). Haudam et al. examined the effect of isoflavones on the gut microbiota and equol production in women with PCOS. After three days of isoflavone supplementation, patients showed an increase in the alpha diversity of the microbiota to levels similar to healthy women. Equol-producing bacteria were present in 42% of control women, while their prevalence in women with PCOS was significantly lower at 21%. This is consistent with the reduced serum equol levels in PCOS patients and suggests that isoflavones may help restore the balance of the gut microbiota, demonstrating their potential as prebiotics in the treatment of PCOS (Liyanage GSG et al., 2021). Quercetin shows significant protective effects by reducing the incidence of preterm birth by 63.5% and improving the survival rate of newborns to 83.76%. In a large Iranian study of 480 patients, combination therapy including quercetin significantly reduced the rate of early miscarriage compared to other treatments. However, some doses of quercetin may have adverse effects: a dose of 50  $\mu$ M reduced morula and blastocyst formation by 20–30%, while prenatal exposure to 302 mg/kg of food caused a 40% increase in iron storage in the liver of subjects, which may have long-term genetic consequences (Khamineh, Ghiasvand, Panahi-Alanagh, 2025).

### ***Conclusion***

Natural compounds such as resveratrol, isoflavones, and quercetin show significant potential in treating and supporting female reproductive disorders, including PCOS and pregnancy complications. Resveratrol improves ovarian function and reduces oxidative stress, while isoflavones act as prebiotics that modulate gut microbiota and hormonal balance. Quercetin reduces inflammation and oxidative stress in the placenta, contributing to the prevention of spontaneous abortion and premature birth. However, because

of possible side effects at high doses, further clinical studies are needed to ensure the safety and efficacy of these compounds in clinical use.

**Author's contribution:** conceptualization, L.K.; methodology, S.Š.S., research: N.E.G., A.M.; preparation of the original draft, N.E.G., A.M; revision and editing: A.O.; visualization by S.Š.S.; supervision, L.K.; all authors agreed with the final version of the paper and contributed to its quality and accuracy.

**Funding:** This work was not funded.

**Informed consent statement:** Not applicable.

**Conflicts of interest:** The authors declare no conflicts of interest.

## References

Abbas M, Saeed F, Anjum F.M, Afzaal M, Tufail T, Bashir M.S, Ishtiaq A, Hussain S, Suleria H.A.R. Natural Polyphenols: An Overview. *Int. J. Food Prop.* 2017;20:1689–1699. doi: 10.1080/10942912.2016.1220393.

Carroll, R.G et al. An unexpected link between fatty acid synthase and cholesterol synthesis in proinflammatory macrophage activation. *J. Biol. Chem.* 2018, 293, 5509–5521.

Ceballos-Sánchez D, Sáez-Fuertes L, Casanova-Crespo S, Rodríguez-Lagunas MJ, Castell M, Pérez-Cano FJ, Massot-Cladera M. Influence of Dietary Fiber and Polyphenols During Pre-Gestation, Gestation, or Lactation on Intestinal Gene Expression. *Nutrients.* 2025; 17(2):341.

Gołębek A, Kowalska K, Olejnik A. Polyphenols as a Diet Therapy Concept for Endometriosis—Current Opinion and Future Perspectives. *Nutrients.* 2021; 13(4):1347. <https://doi.org/10.3390/nu13041347>

Khamineh Y, Ghiasvand M, Panahi-Alanagh S, Rastegarmand P, Zolghadri S, Stanek A. A Narrative Review of Quercetin's Role as a Bioactive Compound in Female Reproductive Disorders. *Nutrients.* 2025; 17(7):1118.

Kohut L, Baldovska S, Mihal M, Lubomir Belej, Sirotkin AV, Shubhadeep Roychoudhury, et al. The multiple actions of grape and its polyphenols on female reproductive processes with an emphasis on cell signalling. *Frontiers in Endocrinology.* 2024 Jan 4;14.

Li Z, et al. Unique roles in health promotion of dietary flavonoids through gut microbiota regulation: current understanding and future perspectives. *Food Chem.* 2023;399:133959.

Liyanage GSG et al. Effects of soy isoflavones, resistant starch and antibiotics on polycystic ovary syndrome (PCOS)-like features in letrozole-treated rats. *Nutrients*. 2021;13(11).

Phenol-Explorer Database on Polyphenol Content in Foods [(accessed on 20 October 2022)]. Available online: [Http://Phenol-Explorer.Eu/](http://Phenol-Explorer.Eu/)

Probst Y, Guan V, Kent K. A Systematic Review of Food Composition Tools Used for Determining Dietary Polyphenol Intake in Estimated Intake Studies. *Food Chem*. 2018;238:146–152. doi: 10.1016/j.foodchem.2016.11.010.

Wang Y, et al. Anti-fatigue activity of parsley (*Petroselinum crispum*) flavonoids via regulation of oxidative stress and gut microbiota in mice. *J Funct Foods*. 2022;89:104963.

Xia T, et al. The anti-diabetic activity of polyphenols-rich vinegar extract in mice via regulating gut microbiota and liver inflammation. *Food Chem*. 2022;393:133443.

Xiong W, Sun, K.Y, Zhu, Y et al. Metformin alleviates inflammation through suppressing FASN-dependent palmitoylation of Akt. *Cell Death Dis*. 2021, 12, 934.

Young K.E, Flaherty S Woodman K.M et al. Fatty acid synthase regulates the pathogenicity of Th17 cells. *J. Leukoc. Biol*. 2017, 102, 1229–1235.

Zhou P, Feng P, Liao B, Fu L, Shan H, Cao C, et al. Role of polyphenols in remodeling the host gut microbiota in polycystic ovary syndrome. *Journal of ovarian research*. 2024 Mar 27;17(1).

## Uloga polifenola u očuvanju reproduktivnog zdravlja žena

Nur-Esma GAZDIĆ<sup>1\*</sup> Amina MRKONJIĆ<sup>1</sup> Aida OMERAGIĆ<sup>2</sup> Sabina

ŠEČIĆ-SELIMOVIĆ<sup>1</sup> Lamija KULOVIĆ<sup>1</sup>

<sup>1</sup>Univerzitet u Sarajevu, Fakultet zdravstvenih studija, studijski program Zdravstveni nutricionizam i dijetetika, Bosna i Hercegovina

<sup>2</sup>Univerzitet u Sarajevu, Fakultet zdravstvenih studija, studijski program Babičarstvo/Primaljstvo, Bosna i Hercegovina

\*Autor za korespondenciju: Nur-Esma Gazdić; e-mail: nuresma.gazdic@fzs.unsa.ba

### Sažetak

Polifenoli su bioaktivni spojevi s antioksidativnim, antiinflamatornim i hormonski modulirajućim svojstvima, značajni za očuvanje reproduktivnog zdravlja žene. Polifenolna jedinjenja doprinose regulaciji hormonske ravnoteže, modulaciji oksidativnog stresa i reduciranju inflamatornih procesa u organizmu. Cilj ovog rada jeste definisati ulogu polifenola u očuvanju reproduktivnog zdravlja sa naglaskom na mehanizme djelovanja i potencijalnu kliničku primjenu. Rad je urađen pregledom relevantne naučne literature, korištenjem ključnih riječi: „*polifenoli*“, „*reproduktivno zdravlje žene*“, „*fertilitet*“. Prema rezultatima, utvrđeno je da povećan unos polifenola značajno smanjuje rizik od gestacijskog dijabetesa za 22 % (OR = 0,78; 95 % CI: 0,69–0,89). Iako polifenoli nisu pokazali značajnu povezanost sa smanjenjem rizika od preeklampsije, kod žena sa sindromom policističnih jajnika primjena polifenola rezultirala je prosječnim smanjenjem nivoa inzulina za 2,49  $\mu$ IU/mL ( $p < 0,01$ ), te reduciranjem luteinizirajućeg hormona i indeksa tjelesne mase. Također, autori ističu da polifenoli utiču na ublažavanje inflamatornih markera kod endometrioze. Ipak, pretjeran unos polifenola može uticati na mehanizme adaptacije majčinog organizma tokom trudnoće, što zahtijeva dodatna istraživanja. Posebno je važna procjena njihove uloge u trudnoćama kod žena starije životne dobi, kao i uticaj na dugoročno zdravlje majke i djeteta. Polifenoli predstavljaju važan faktor u prevenciji reproduktivnih poremećaja, ali su neophodna buduća klinička istraživanja za potvrdu sigurnosti i efikasnosti njihove primjene.

*Ključne riječi:* „*polifenoli*“, „*reproduktivno zdravlje žene*“, „*fertilitet*“

## **The research on edible vaccines: Current status and future perspectives**

Belma DURAK Nejla HEĆO Tamara GOLOVIĆ Almedina HALILOVIĆ  
Selma HEBIBOVIĆ Jasmina ĐEDIBEGOVIĆ

Faculty of pharmacy, University of Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Almedina Halilović, almedinahalilovic@ffsa.unsa.ba

### **Abstract**

This paper reviews edible vaccines as an innovative immunization strategy based on genetically modified plants capable of producing antigens that elicit immune responses when consumed. Compared to conventional vaccines, they offer several advantages, including needle-free administration, reduced production and distribution costs, simplified storage at room temperature, and improved accessibility in resource-limited settings. The literature review focused on production methods, mechanisms of action, efficacy, and safety aspects, as well as current limitations such as low immunogenicity, oral tolerance, and the absence of clear regulatory frameworks. Despite these challenges, recent progress, including successful clinical trials and the approval of plant-derived vaccines, demonstrates the potential of this technology to complement or even replace traditional approaches. Edible vaccines could play a crucial role in addressing global health challenges by enabling affordable, safe, and widely accessible immunization. With continued research and optimization, they may become a sustainable and effective tool for preventing infectious diseases and improving public health worldwide.

*Keywords: edible vaccines, global health, immunization*

### **Introduction**

Vaccines are biological preparations that stimulate the immune system to recognize and respond to certain pathogens, which provides protection from infections and diseases. The main principal of the vaccine is to activate the immune memory, enabling a faster and more efficient response of the organism to future encounters with the causative agent of the disease. Traditionally, vaccines are applied through injections, while some forms, such as oral vaccines, use an alternative path for easier administration. Edible vaccines represent an innovative concept in immunization development, where genetically modified plants or edible organisms are used as vectors for antigen delivery instead of traditional injections. The idea of this approach is

development of vaccines that people consummate through food, which eliminates the problems with needles, transport and storage. This technology promises that such edible preparations will reduce the cost of manufacturing, enable easier distribution, especially in underdeveloped areas and increase acceptance of immunization in different populations. (Srividhya Venkataraman et al., 2021) First ideas about edible vaccines date back to 1990s, when the progress in genetic engineering enabled the insertion of pathogen genes into the plant genome. One of the first experiments involved research on using potatoes and bananas to manufacture vaccines against diarrhea caused by *Escherichia coli* bacteria. Soon after that, the scientists started experimenting with other cultures such as tomatoes, rice, corn and salad. Each of these plants were chosen because of their wide availability and the possibility of consummation in their raw form, which reduces the cost as well as possible impact of processing on its effectiveness. The production of edible vaccines is based on the genetic modification of plants so that they can produce proteins and other molecules capable of triggering an immune response in humans. The process involves several key stages, including plant selection, genetic modification, production, optimization and then the testing of their efficacy and safety. The mechanism of action of edible vaccines relies on the activity of digestive and bacterial enzymes. (Jyoti Saxena, et al. 2022)

### ***Experimental***

This study was conducted as a bibliographic review, aiming to gather, analyze, and synthesize existing scientific literature on edible vaccines. The main focus was on finding out about the methods of production of edible vaccines, their efficacy, advantages, as well as their mechanism of action. The research was carried out by systematically searching for peer-reviewed articles, books, and relevant scientific reports published in reputable journals. Databases such as PubMed, ScienceDirect, and Google Scholar were used to retrieve studies that covered production, applications, advantages and safety of edible vaccines. The keywords used for the search included “edible vaccines”, “transgenic plant”, “immunization”, “infectious diseases”. The findings from the literature review were used to draw conclusions about the future perspectives of edible vaccines.

### ***Results and discussion***

Advantages of using edible vaccines:

- Ease of application – This refers to the simplicity of use. Edible vaccines enable mass vaccination without the need for medical professionals, potentially increasing vaccination rates in rural and hard-to-reach areas.

- Storage on room temperature
- Lower production costs
- Decreased risk of contamination
- Increased availability and accessibility (Vrinda M Kurup, et al., 2019)

Antigen proteins were successfully produced in many plants (tobacco, potato, tomato, cherry tomatillo, banana, lettuce, spinach, rice, carrot, corn, quinoa, papaya, peanut, and some algae) to target various infectious agents and diseases: measles, HPV, SARS-CoV-2, bursitis, rabies, and rinderpest viruses, Norwalk virus, *Helicobacter pylori*, bluetongue disease, hepatitis B, diabetes, cysticercosis, swine fever disease, cholera, Diphtheria, Pertussis and Tetanus (DPT), and avian flue.

According to Stander et al. (2022), there are certain limitations associated with using plant-based platforms for vaccine production. In some cases, vaccine yields may be too low to produce an adequate number of doses. Additional challenges include the absence of well-established regulatory standards and a global shortage of companies with the capacity to manufacture pharmaceuticals using plant-based systems. Furthermore, for use in humans edible vaccines must be developed in palatable edible plant, while in animals the plant must be part of a regular animal's diet (Podhuvai et al., 2025). Nevertheless, despite these current limitations, the recent success of human clinical trials and the approval by the Canadian government of Medicargo Inc.'s plant derived VLP vaccine against SARS-CoV-2 highlight the flexibility and potential of plant-based platforms to perform on par with conventional vaccine production methods. FDA also approved the benthi (*Nicotiana benthamiana*) derived ebola vaccine, and Health Canada approved tobacco derived H5N1 “avian” influenza vaccine. In addition to these, there are dozens of preclinical and clinical (phase 1-3) trials ongoing (Podhuvai et al., 2025, Munshi et al., 2018). Furthermore, the growing focus on mRNA vaccines has opened new opportunities for the development of plant made vaccines. (Stander J, et al., 2022) As per Sahoo et al., the major limitation of an edible vaccine is oral tolerance and the fact that it is difficult to monitor the immune complexity. Another major factor is low immunogenicity of these forms. (Sahoo et al., 2020). Another main issue is the regulation of genetically modified plants as well as their acceptability by people. Lastly, it is essential to avoid any negative impact on biodiversity by these plants (Munshi et al., 2018). Within this research, different local forums have been searched and no evidence or record has been found that edible vaccines have been used in Bosnia and Herzegovina, nor the neighboring countries.

## ***Conclusion***

Edible vaccines represent a significant advance in the field of vaccination, offering the potential for an effective, safe, and inexpensive alternative to traditional methods. Advances in biotechnology, as well as the growing need for alternative methods of vaccination, make edible vaccines a promising option for global public health. Although the commercialization of these vaccines is still in its early stages, significant research is already demonstrating their potential in preventing diseases such as hepatitis, cholera, influenza, and many other infectious diseases. Further developments in this area could enable the mass production of affordable edible vaccines, and their simple administration could reduce the logistical challenges associated with traditional vaccines. In the future, edible vaccines have the potential to become a key tool in the fight against global health threats, reducing the cost of vaccination, eliminating the need for complex infrastructure systems, and expanding vaccine availability worldwide. With continued research and optimization, edible vaccines could significantly advance global disease prevention, making them not only effective, but also a sustainable solution for improving public health.

***Author contributions:*** Conceptualization, B.D., T.G., N.H. and S.H...; methodology, B.D. and A.H; investigation, S.H., N.H. and T.G..; writing—original draft preparation, B.D. and A.H.; writing—review and editing, B.D. and A.H.; visualization, A.H.; supervision, J.D.; All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding.

***Informed Consent Statement:*** Informed consent was obtained from all subjects involved in the study.

***Conflicts of Interest:*** The authors declare no conflicts of interest.

## ***References***

Sahoo A, Mandal AK, Dwivedi K, Kumar V. A cross talk between the immunization and edible vaccine: Current challenges and future prospects. *Life Sci.* 2020 Nov 15;261:118343. doi: 10.1016/j.lfs.2020.118343.

Keerthana, N. A., Basalingappa, K. M., Gopenath, T. S., Parthiban, R., Rajashekara, P. S., Ashok, G., Karthikeyan, M., Mehenderkar, R., Bakthavatchalam, P., Rajasurian, D., Ashok, I., Stephenie, S., & Devi, S. (2022). Edible vaccines: A novel approach to oral immunization and their application in clinical trails. *International Journal of Health Sciences*, 6(S3), 9402–9421.



Munshi A, Sharma V. Omics and Edible Vaccines. Omics Technologies and Bio-Engineering, 2018,129–41. doi: 10.1016/B978-0-12-815870-8.00008-5.

Pudhuvai, B., Koul, B., Mishra, A.K. Insights into the world of edible vaccines: From lab to reality. Research in Biotechnology, <https://doi.org/10.1016/j.crbiot.2025.100290>. Volume 9, 2025, 100290,.

Venkataraman S, Hefferon K, Makhzoum A, Abouhaidar M. Combating Human Viral Diseases: Will Plant-Based Vaccines Be the Answer? Vaccines (Basel). 2021 Jul 8;9(7):761. doi: 10.3390/vaccines9070761

Stander J, Mbewana S, Meyers AE. Plant Derived Human Vaccines: Recent Developments. BioDrugs. 2022 Sep;36(5):573-589. doi: 10.1007/s40259-022-00544-8. Kurup VM, Thomas J. Edible Vaccines: Promises and Challenges. Mol Biotechnol. 2020 Feb;62(2):79-90. doi: 10.1007/s12033-019-00222 1.

### **Jestive vakcine: Aktuelni status i buduće perspektive**

Belma DURAK Nejla HEĆO Tamara GOLOVIĆ Almedina HALILOVIĆ  
Selma HEBIBOVIĆ Jasmina ĐEĐIBEGOVIĆ

Faculty of pharmacy, University of Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Almedina Halilović, [almedinahalilovic@ffsa.unsa.ba](mailto:almedinahalilovic@ffsa.unsa.ba)

### **Sažetak**

Ovaj rad daje pregled jestivih vakcina kao inovativne strategije imunizacije zasnovane na genetski modificiranim biljkama koje proizvode antigene sposobne da izazovu imunološki odgovor nakon konzumacije. U poređenju s konvencionalnim vakcinama, nude brojne prednosti, uključujući primjenu bez igle, smanjene troškove proizvodnje i distribucije, jednostavnije skladištenje na sobnoj temperaturi te bolju dostupnost u područjima s ograničenim resursima. Pregled literature fokusirao se na metode proizvodnje, mehanizme djelovanja, efikasnost i sigurnosne aspekte, ali i na postojeća ograničenja poput niske imunogenosti, oralne tolerancije i nedostatka jasnih regulatornih okvira. Uprkos tim izazovima, nedavni napredak, uključujući uspješne kliničke studije i odobrenje biljnih vakcina, pokazuje potencijal ove tehnologije da dopuni ili čak zamijeni tradicionalne pristupe. Jestive vakcine mogle bi igrati ključnu ulogu u rješavanju globalnih zdravstvenih izazova omogućavanjem pristupačne, sigurne i široko dostupne imunizacije. Uz dalja istraživanja i optimizaciju, mogu postati održivo i efikasno sredstvo za prevenciju zaraznih bolesti i unapređenje javnog zdravlja širom svijeta.

*Ključne riječi: jestive vakcine, globalno zdravlje, imunizacija*

#### 4-P-1

### **Support for body weight management in Sarajevo Canton: patients' perspective**

Berina MEKIĆ\* Ajla MALKOČ Mahira JAPIĆ Amina TURKOVIĆ  
Amra MAKAN Jasmina ĐEDIĆ

Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Berina Mekić, [berinamekic@ffsa.unsa.ba](mailto:berinamekic@ffsa.unsa.ba)

#### **Abstract**

Obesity is a very significant public health problem and its rapid increase has been recorded, both in adults and in the child population. The aim of this research work was to collect data on body weight control in the Sarajevo Canton, examine the availability and quality of health services, and analyze the influence of socioeconomic and psychological factors. The research involved 30 respondents, 25 of whom were adults and 5 children. The results show that the majority of respondents used public health services, but were not completely satisfied with them. A smaller number of respondents used private services, of which a higher percentage were female. Private services were assessed as more efficient, but less financially accessible. Of great importance in obesity is the influence of psychological factors such as stress and emotional overeating. What we can conclude is that continuous support in the community and improvement of health services are needed, focusing on vulnerable groups of people, and the role of pharmacists.

*Keywords: obesity, Sarajevo Canton, health services, socioeconomic factors, psychological factors*

#### **Introduction**

Obesity represents one of the biggest public health problems today, and its continuous increase poses very serious public health challenges globally. Obesity is associated with many chronic diseases, such as diabetes, hypertension, cardiovascular diseases and many others. The aim of this research work was to collect data on body weight control in Sarajevo Canton with an emphasis on obesity, lifestyle, use of health services and the influence of socio-economic factors. The research included determining the prevalence of obesity in Sarajevo Canton based on weight, height and body mass index, an overview of the use of various health services related to body weight control, including services in the public and private sectors, and social and psychological factors that affect body weight. According to data from the World Health Organization (World Health Organization. Obesity and

overweight, 2021), there is an increasing increase in people with excessive body mass, while local data show a large increase in obesity in the children's population as well as in adults (Institute for Public Health of Sarajevo Canton, 2019-2023).

### ***Experimental***

This research is a descriptive study that included a quantitative and qualitative approach. The quantitative part was based on collecting data on the height, weight and body mass index of the respondents, and the qualitative part related to interviews about the respondents' experiences with using services in both the public and private sectors. The research included 30 respondents (25 adults and 5 children) whose body mass index was higher than 25 or who previously had a problem with excess body weight. The respondents were of different ages, genders and socioeconomic status. The data were collected in three phases. The respondents completed surveys that included only basic information, after which the BMI was calculated for each respondent, and interviews were conducted to obtain more detailed information about personal challenges and access to health services. The quantitative data were analyzed using descriptive statistical methods, while the qualitative data were analyzed using thematic analysis, through categorization of responses. All respondents provided informed consent prior to participating in the research, and the surveys were anonymous.

### ***Results and Discussion***

According to the data obtained within this research, out of 25 adults, 18 had excessive body weight (60% of respondents). In the child population, 3 out of 5 children were obese (60%). These data coincide with the data of the Institute for Public Health of the Sarajevo Canton, according to which 38% of adults and 22% of children fall into the category of obese people. According to the Institute, every third child has an eating disorder, but the situation is better in secondary schools than in primary schools (Institute for Public Health of Sarajevo Canton, 2019-2023). Regarding health services, 16 respondents used public sector services for weight control, while 7 respondents used private sector services. The respondents assessed public services as useful, but the disadvantages were delayed appointments and insufficient dedication to the person as an individual. Most of them used services such as free advice on healthy eating, advice on physical activity and monitoring of body weight. Some of the respondents mentioned that the people responsible for advice in health centers gave them only basic advice on nutrition, without mentioning the importance of physical activity and without psychological support. Private services were considered much more

effective, however, their disadvantage was the high price, as well as the lack of support after the program ended. Private services included personalized weight loss programs with dietary advice, different types of training with experts and personal consultations in private clinics. The interview data show that there is a significant difference in the search for help between men and women. Women used private services and advice to a greater extent than men. Psychological factors represented the greatest challenge for the respondents. One of the biggest causes of obesity was emotional overeating. People who go through some stressful situations often resort to poor nutrition or overeating because it is one of the ways to relieve stress. According to the respondents, psychological support was key to long-term change in their way of thinking and behavior towards food and health.

### ***Conclusion***

The research conducted as a students' curricular task provided insight into the current situation regarding support for weight control in the Sarajevo Canton. What we learned from this research is that a high percentage of respondents stated that they were not satisfied with the quality of public health services, which leads us to the conclusion that it is necessary to improve access to and the efficiency of obesity prevention and treatment programs. Private health services have proven to be much more efficient, but financially inaccessible for the majority of the population. The female population has resorted to using these private sector services more. What is important to emphasize is that we, as future pharmacists, have a very important role in shaping strategies for the prevention and control of obesity. Although conducted in a small sample, the research results indicate the need for better development of public and private health services, greater psychological support, but also greater accessibility of health services to vulnerable groups of people, such as children, the elderly and people of lower social status, and education of the population about the importance of healthy nutrition and physical activity. In conclusion, continuous support in the community is needed in order to adequately respond to the challenges of weight control.

***Author contributions:*** Conceptualization, B.M. and A.M.; methodology, A.M.; investigation, M.J.; writing—original draft preparation, A.T., B.M. and A.M. ; writing—review and editing, A.M. and M.J.; visualization, A.T.; supervision, J.Đ.; All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Conflicts of Interest:** The authors declare no conflicts of interest.

### **References:**

Institute for Public Health of Sarajevo Canton. Youth Strategy of Sarajevo Canton for the Period 2019–2023. Available on: [chromeextension://efaidnbmninnibpcapjpcglclefindmkaj/https://mon.ks.gov.ba/sites/mon.ks.gov.ba/files/202204/Strategija\\_prema\\_mladima\\_kantona\\_sarajevo\\_za\\_period\\_2019.2023.\\_godina\\_0.pdf](chromeextension://efaidnbmninnibpcapjpcglclefindmkaj/https://mon.ks.gov.ba/sites/mon.ks.gov.ba/files/202204/Strategija_prema_mladima_kantona_sarajevo_za_period_2019.2023._godina_0.pdf), (20/07/2025).

World Health Organization. Obesity and overweight. Geneva: World Health Organization; 2021. Available on: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight> (20/07/2025).

## **Podrška kontroli tjelesne mase u Kantonu Sarajevo: perspektiva pacijenata**

Berina MEKIĆ\* Ajla MALKOČ Mahira JAPIĆ Amina TURKOVIĆ

Amra MAKAN Jasmina ĐEDIĆBEGOVIĆ

Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Berina Mekić, [berinamekic@ffsa.unsa.ba](mailto:berinamekic@ffsa.unsa.ba)

### **Sažetak**

Pretilost je veoma značajan javnozdravstveni problem te je zabilježen njen rapidan porast, kako u odrasloj dobi, tako i u dječijoj populaciji. Cilj ovog istraživačkog rada bio je prikupiti podatke o kontroli tjelesne mase u Kantonu Sarajevo, ispitati dostupnost te kvalitet zdravstvenih usluga, analizirati uticaj socioekonomskih i psiholoških faktora. U istraživanju je učestvovalo 30 ispitanika, od kojih je bilo 25 odraslih i 5 djece. Rezultati pokazuju da je većina ispitanika koristila javne zdravstvene usluge, ali nisu bili u potpunosti zadovoljni sa njima. Manji broj ispitanika koristio je privatne usluge, od kojih je veći procenat ženske populacije. Privatne usluge ocijenjene su kao efikasnije, ali finansijski manje dostupne. Od velike važnosti kod pretilosti jeste i uticaj psiholoških faktora kao što su stres te emocionalno prejedanje. Ono što možemo zaključiti jeste da je potrebna je kontinuirana podrška u zajednici te poboljšanje zdravstvenih usluga, stavljajući u fokus ranjive skupine ljudi, te ulogu farmaceuta.

*Ključne riječi:* pretilost, Kanton Sarajevo, zdravstvene usluge, socioekonomski faktori, psihološki faktori



5. SAVREMENA DIJAGNOSTIKA I ANALITIKA HRANE  
MODERN FOOD DIAGNOSTICS AND ANALYSIS





## Determination of Polyphenolic Compounds in Selected *Cucurbita pepo* L. Varieties

Ajša ZUKIĆ Dženeta FAZLIĆ\* Ćerima ZAHIROVIĆ-SINANNOVIĆ Lutvija KARIĆ

University of Sarajevo, Faculty of Agriculture and Food Science, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Dženeta Fazlić, dzeneta.fazlic@ppf.unsa.ba

### Abstract

The present study provides a comprehensive phytochemical evaluation of five *Cucurbita pepo* L. varieties cultivated under controlled greenhouse conditions, focusing on their phenolic and flavonoid composition. Phenolic and flavonoid contents were quantified spectrophotometrically using the Folin–Ciocalteu and  $\text{AlCl}_3$  colorimetric methods. Significant variation was observed among the analyzed cultivars – Tiana, Hokkaido, Mareva, Duga bijela, and Sunburst. Tiana exhibited the highest total phenolic content (96.36 mg GAE / 100 g FW) and total flavonoid concentration (10.30 mg QE / 100 g FW), followed by Hokkaido (55.79 and 5.04 mg / 100 g FW, respectively). Mareva, Duga bijela, and Sunburst contained notably lower amounts of these compounds. The results highlight a strong correlation between phenolic and flavonoid accumulation, emphasizing the role of these bioactive molecules in determining the nutritional and functional quality of zucchini fruits. Cultivars with elevated phenolic and flavonoid content, particularly Tiana and Hokkaido, represent promising candidates for the development of nutritionally enhanced vegetable products and functional foods. This study underscores the importance of detailed phytochemical profiling in evaluating and selecting *Cucurbita pepo* varieties with superior bioactive compound composition, contributing to a better understanding of varietal differentiation in their nutritional and functional traits.

**Keywords:** *Cucurbita pepo* L., phenolic compounds, flavonoids, antioxidant capacity, phytochemical composition

### Introduction

The genus *Cucurbita* (family *Cucurbitaceae*) comprises a diverse group of economically and nutritionally important vegetable crops, including *C. pepo*, *C. maxima*, and *C. moschata*. Originating from Central and South America, these species have been cultivated for centuries and today represent a

significant component of global horticulture and human nutrition (Kulczyński *et al.*, 2020). Among them, zucchini (*Cucurbita pepo* L.) is one of the most widely cultivated and consumed species worldwide, appreciated for its productivity, culinary versatility, and balanced nutritional composition.

*C. pepo* fruits are characterized by high water content (up to 95%), low caloric value, and a favorable ratio of carbohydrates, proteins, and dietary fiber. They are rich in essential micronutrients such as potassium, magnesium, calcium, phosphorus, and iron, and contain vitamins C, E, and provitamin A ( $\beta$ -carotene). Pumpkin and zucchini seeds are also considered highly nutritious, containing up to 40% oil rich in unsaturated fatty acids, tocopherols, sterols, and easily digestible proteins (Hussain *et al.*, 2023).

Beyond their basic nutritional profile, *Cucurbita* species are notable for their abundance of secondary metabolites, including phenolic compounds, flavonoids, carotenoids, saponins, and cucurbitacins, which have demonstrated antioxidant, anti-inflammatory, antimicrobial, and anticancer properties (Peng *et al.*, 2021). These bioactive compounds play a central role in mitigating oxidative stress, a process closely linked to chronic diseases such as cardiovascular disorders, diabetes, and cancer (Hussain *et al.*, 2023; Kulczyński *et al.*, 2020). In plants, phenolic and flavonoid compounds function as natural defense agents against biotic and abiotic stressors, acting as radical scavengers and stabilizers of cell membranes.

The concentration and composition of these metabolites in *C. pepo* depend on genetic background, environmental conditions, and cultivation practices. Genotypic variation strongly influences phenolic and flavonoid biosynthesis, while environmental factors such as light intensity, temperature, and water availability further modulate their accumulation (Karić *et al.*, 2018; Thennakoon *et al.*, 2020). For instance, moderate water stress can enhance phenolic accumulation through the activation of phenylalanine ammonia-lyase (PAL), the key enzyme in the phenylpropanoid pathway (Hussain *et al.*, 2023).

Phenolic acids such as gallic, caffeic, ferulic, and p-coumaric acids, and flavonoids including quercetin, kaempferol, rutin, and isorhamnetin derivatives, are the most abundant bioactive compounds in *C. pepo*, particularly concentrated in the fruit peel (Peng *et al.*, 2021). Their synergistic interaction enhances antioxidant capacity and contributes to the fruit's flavor, color, and postharvest stability. Numerous studies have confirmed a positive correlation between total phenolic content and antioxidant activity, underscoring their importance as key determinants of nutritional and functional value.

Considering the significant biochemical variability among *C. pepo* cultivars, understanding genotype-dependent differences in phenolic and flavonoid

content is essential for identifying varieties with superior nutritional and functional properties. Therefore, this study aims to evaluate the total phenolic and flavonoid contents, of five *C. pepo* L. varieties grown under controlled greenhouse conditions, providing a scientific basis for the selection and utilization of nutritionally enhanced genotypes in the development of functional foods.

### ***Experimental***

The study was conducted under controlled greenhouse conditions at the Experimental Station of the Faculty of Agriculture and Food Sciences, University of Sarajevo (Butmir, Bosnia and Herzegovina). Five varieties of *Cucurbita pepo* L. (Tiana, Hokkaido, Mareva, Duga bijela, and Sunburst) were selected for analysis based on their morphological diversity and local availability. All varieties were cultivated under identical agronomic conditions to minimize environmental variability and ensure that observed biochemical differences were primarily genotype-dependent.

Standard horticultural practices were applied, including soil preparation, fertilization, irrigation, and pest management. The experimental layout followed a randomized block design with three replicates per cultivar. Each replicate consisted of ten plants. Fruits were harvested at full physiological maturity, manually cleaned, and immediately transported to the laboratory for further analysis. Samples were dried at room temperature to constant weight immediately after harvesting. Then, 1 g of dry matter from each variant was weighed for determining phenol and flavonoid content.

Freshly harvested fruits were washed, peeled, and separated into pulp and peel. Phenolic compounds were extracted using a 30% aqueous ethanol solution. Samples of plant material (1 g dry weight) were extracted under reflux in a water bath at 60 °C for 60 minutes. After filtration, the extracts were adjusted to a final volume of 50 ml with 30% ethanol and stored at 4 °C until further analysis. These extracts were then used to determine total phenols and flavonoids

The total phenolic content was determined using the Folin–Ciocalteu colorimetric method described by Ough and Amerine (1988) with slight modifications. Briefly, 0.5 mL of methanolic extract was mixed with 2.5 mL of 10% Folin–Ciocalteu reagent and 2.0 mL of 7.5% sodium carbonate solution. The mixture was incubated in the dark at room temperature for 30 min, and absorbance was measured at 765 nm using a UV–Vis spectrophotometer (Shimadzu, Japan). The total phenolic content was calculated from a calibration curve constructed with gallic acid and expressed as milligrams of gallic acid equivalents (mg GAE / 100 g fresh weight, FW). All measurements were performed in triplicate.

The total flavonoid content was quantified following the aluminum chloride colorimetric method of Zhishen *et al.* (1999). A 1.0 mL aliquot of the extract was mixed with 4.0 mL of distilled water and 0.3 mL of 5% NaNO<sub>2</sub> solution. After 5 min, 0.3 mL of 10% AlCl<sub>3</sub> was added. Following 6 min of incubation, 2 mL of 1 M NaOH and 2.4 mL of distilled water were added to reach a final volume of 10 mL. The mixture was gently vortexed, and absorbance was read at 510 nm. Quercetin was used as the reference standard, and the results were expressed as milligrams of quercetin equivalents (mg QE / 100 g FW).

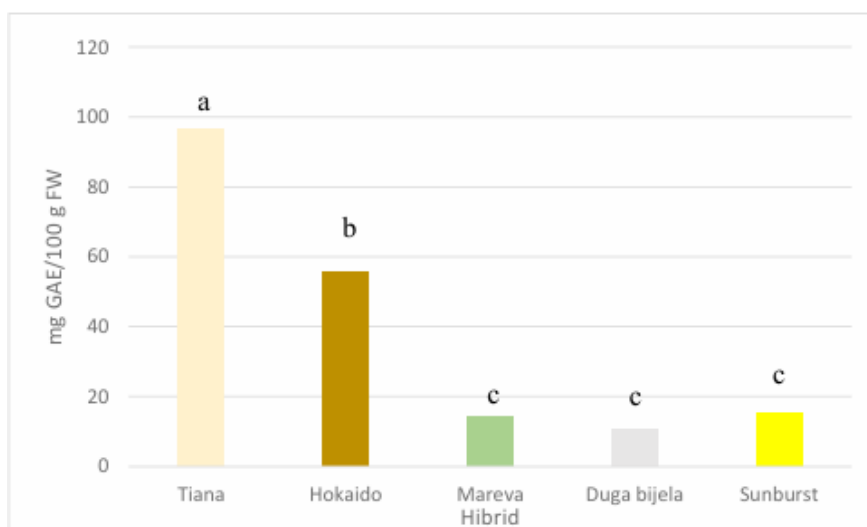
All measurements were conducted in triplicate, and results were expressed as mean  $\pm$  standard deviation (SD). Statistical analyses were performed using SPSS v.25. One-way analysis of variance (ANOVA) was applied to determine significant differences among varieties, and mean comparisons were carried out using Tukey's HSD test at a confidence level of  $p < 0.05$ . Pearson correlation analysis was used to examine the relationships between total phenolic content, flavonoid concentration, and antioxidant activity parameters (DPPH and FRAP).

### **Results and discussion**

The following section presents a detailed analysis of the biochemical composition and antioxidant potential of the five investigated *Cucurbita pepo* L. varieties. The results are structured according to the major groups of bioactive compounds, phenolics and flavonoids, and their associated antioxidant activity. Emphasis is placed on inter-variety differences and their possible physiological and biochemical implications, providing insights into the functional value of each cultivar.

#### **Total Phenolic Content (TFC)**

Significant differences in total phenolic content were observed among the five analyzed *Cucurbita pepo* L. varieties ( $p < 0.05$ ). The variation in total phenolic content among the analyzed *Cucurbita pepo* L. varieties is shown in **Figure 1**. The Tiana variety exhibited the highest phenolic concentration, reaching **96.36 mg GAE / 100 g FW**, followed by Hokkaido (**55.79 mg GAE / 100 g FW**). Mareva, Duga bijela, and Sunburst contained substantially lower amounts, ranging from **10.42 to 15.42 mg GAE / 100 g FW**.



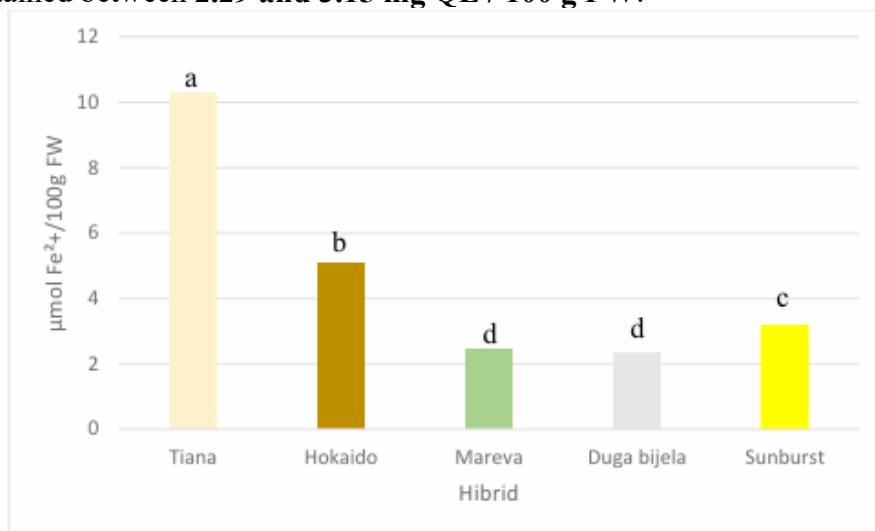
**Figure 1.** Total phenolic content (mg GAE / 100 g FW) in five *Cucurbita pepo* L. varieties. Results are expressed as mean  $\pm$  SD (n = 3). Different letters above bars indicate significant differences between means at  $p < 0.05$  Authors' own results (2025).

These findings clearly indicate that the accumulation of phenolic compounds in zucchini fruits is **genotype-dependent**, which aligns with previous research demonstrating substantial biochemical variation within *Cucurbita* species (Kulczyński *et al.*, 2020; Peng *et al.*, 2021). Phenolic content in plants is influenced by the activity of key enzymes in the phenylpropanoid pathway, particularly phenylalanine ammonia-lyase (PAL), whose expression varies among genotypes (Hussain *et al.*, 2023).

The remarkably high phenolic content in Tiana suggests a more efficient phenylpropanoid metabolism, possibly linked to enhanced stress-response pathways and metabolic allocation toward phenolic biosynthesis. Hokkaido, though somewhat lower, maintained a considerable phenolic profile, indicative of its capacity to synthesize hydroxycinnamic derivatives such as ferulic and caffeic acid, known contributors to antioxidant activity. When compared with literature data, the values obtained in this study fall within the upper range reported for *C. pepo* fruits. Kulczyński *et al.* (2020) reported phenolic concentrations between 20 and 95 mg GAE / 100 g FW in different *C. pepo* and *C. moschata* cultivars, emphasizing that both genetic and environmental factors contribute to this variability. The superiority of Tiana thus confirms its biochemical potential as a functional genotype, suitable for nutritional enhancement and possible industrial utilization in natural antioxidant formulations.

### Total Flavonoid Content (TFC)

Patterns observed in flavonoid content closely mirrored those found in total phenolics. Tiana recorded the highest concentration of total flavonoids, reaching **10.30 mg QE / 100 g FW**, followed by Hokkaido (**5.04 mg QE / 100 g FW**). The remaining cultivars, Mareva, Duga bijela, and Sunburst, contained between **2.29 and 3.15 mg QE / 100 g FW**.



**Figure 2.** Total flavonoid content (mg QE / 100 g FW) in five *Cucurbita pepo* L. varieties. Results are expressed as mean  $\pm$  SD ( $n = 3$ ). Different letters above bars indicate significant differences between means at  $p < 0.05$ . Authors' own results (2025).

The distribution of flavonoid content among the examined varieties is illustrated in Figure 2. As shown, the pattern closely mirrors that observed for total phenolic content (Figure 1), suggesting a strong positive correlation between these groups of compounds, as commonly reported in the literature (Hussain *et al.*, 2023). This correlation likely reflects their shared biosynthetic origin within the phenylpropanoid pathway and co-regulation by common enzymatic systems. Flavonoids such as quercetin, kaempferol, and rutin derivatives are known for their potent antioxidant activity, metal chelation, and ability to modulate cellular oxidative balance. The higher levels of flavonoids observed in Tiana and Hokkaido likely contribute to their enhanced antioxidant capacity, confirming their superior nutraceutical potential. Earlier studies by Peng *et al.* (2021) and Kulczyński *et al.* (2020) also reported that cultivars with darker green or orange peels, such as Hokkaido, tend to accumulate higher levels of flavonoids due to increased exposure to ultraviolet light and associated activation of secondary metabolism. These results corroborate the idea that pigment intensity in

*Cucurbita pepo* fruits may serve as a visual indicator of bioactive compound abundance.

### **Antioxidant Capacity**

Although antioxidant capacity was **not directly measured** in this study, the results on phenolic and flavonoid composition indicate a clear **potential for strong antioxidative performance** in *Cucurbita pepo* L. varieties. Previous studies have consistently shown a close relationship between phenolic concentration and antioxidant activity in pumpkins and zucchinis, where genotypes with higher phenolic content generally exhibit greater radical-scavenging potential (Kulczyński *et al.*, 2020; Hussain *et al.*, 2023; Peng *et al.*, 2021). This correlation reflects the structural characteristics of phenolic compounds, particularly the number and position of hydroxyl groups capable of donating hydrogen atoms or electrons to neutralize reactive oxygen species. Such mechanisms underline the biological importance of phenolics and flavonoids in protecting plant tissues from oxidative damage.

Moreover, earlier research has demonstrated that specific phenolic acids (e.g., ferulic and caffeic acid) and flavonoids such as rutin and quercetin are key contributors to the antioxidant potential of *Cucurbita pepo* extracts (Zhishen *et al.*, 1999; Kreft *et al.*, 2022). These findings suggest that the high phenolic and flavonoid concentrations observed in Tiana and Hokkaido may confer superior antioxidative capacity, consistent with literature reports. Overall, the antioxidant potential of *Cucurbita pepo* is a multifactorial trait influenced by both the **quantity and composition** of bioactive compounds, as well as their interactions with other antioxidants such as carotenoids and vitamin C (Kulczyński *et al.*, 2020).

### **Conclusion**

The present study provided an evaluation of the phytochemical composition of five *Cucurbita pepo* L. varieties cultivated under controlled greenhouse conditions, with particular focus on the accumulation of phenolic and flavonoid compounds. The results revealed notable variability among the analyzed cultivars, reflecting significant differences in their phytochemical profiles. Among the investigated varieties, Tiana exhibited the highest total phenolic (96.36 mg GAE / 100 g FW) and flavonoid content (10.30 mg QE / 100 g FW), followed by Hokkaido, whereas Mareva, Duga bijela, and Sunburst contained substantially lower levels. The observed correlation between phenolic and flavonoid concentrations underscores the central role of these bioactive compounds in defining the nutritional and functional quality of zucchini fruits. Such compounds contribute not only to the overall phytochemical richness but also to the potential health-promoting properties associated with the consumption of these vegetables.

The findings highlight the importance of selecting cultivars with elevated phenolic and flavonoid content for the development of nutritionally enhanced vegetable products and functional foods. Varieties like Tiana and Hokkaido, with particularly high levels of these compounds, demonstrate considerable potential for application in food systems that aim to maximize intake of beneficial bioactive molecules. Additionally, the study reinforces the value of systematic phytochemical profiling as a tool for guiding cultivar selection, breeding programs, and horticultural practices focused on enhancing the functional quality of crops. From a broader perspective, these results emphasize the substantial contribution of phenolic and flavonoid compounds to the overall quality of *Cucurbita pepo* L. fruits. Beyond their direct nutritional value, these compounds play a key role in shaping the biochemical profile of the fruit, potentially influencing flavor, color, and other organoleptic properties that are important for consumer acceptance. Recognizing and utilizing the natural variability in phytochemical content among cultivars can inform targeted cultivation strategies aimed at producing zucchini that are not only rich in nutrients but also offer added functional benefits. In conclusion, the pronounced phenolic and flavonoid content observed in certain *Cucurbita pepo* L. varieties represents a valuable natural resource with significant implications for both nutrition and functional food development. By combining high agronomic performance with elevated phytochemical traits, future cultivation strategies can optimize the production of zucchini with superior nutritional quality, enhanced functional properties, and increased value for both consumers and the food industry. These findings provide a solid foundation for further research on the utilization of *Cucurbita pepo* L. as a source of health-promoting bioactive compounds and support the ongoing efforts to integrate phytochemical considerations into modern horticultural and food production systems.

## References

- Hussain, A., Kausar, T., Sehar, S., Sarwar, A., & Quddoos, M. Y. (2023). Biochemical constituents of pumpkin and their role as pharma foods: A key strategy to improve health in the post-COVID-19 period. *Food Production, Processing and Nutrition*, 5(1), 22.
- Karić, L., Zahirović, Ć., Žnidarič, D., Jurković, J., Muminović, Š., & Hadžiasimbeg, A. (2018). Influence of selected lettuce varieties on yield and nitrate concentrations. *Agrosym 2018 Proceedings*, 65–68.
- Kreft, S., Knapp, M., & Kreft, I. (2022). Zucchini (*Cucurbita pepo* L.) as a source of health-promoting compounds: A review. *Antioxidants*, 11(6), 1150.



Kulczyński, B., Sidor, A., & Gramza-Michałowska, A. (2020). Antioxidant potential of phytochemicals in pumpkin varieties belonging to *Cucurbita moschata* and *Cucurbita pepo*. *CyTA – Journal of Food*, 18(1), 472–484.

Peng, M., Lu, D., Liu, J., Jiang, B., & Chen, J. (2021). Effect of roasting on antioxidant activity, phenolic composition, and nutritional quality of pumpkin (*Cucurbita pepo* L.) seeds. *Frontiers in Nutrition*, 8, 647354.

Thennakoon, T. M. I., Fonseka, H. D., Ranaweera, G. K. M. M. K., Silva, A. M., & Kumara, U. M. A. (2020). Evaluation of pumpkin (*Cucurbita spp.*) accessions for morphological and yield characteristics and resistance to viral diseases. *Tropical Agricultural Research*, 31(4), 23–34.

### **Određivanje sadržaja polifenolnih spojeva u odabranim sortama *Cucurbita pepo* L.**

Ajša ZUKIĆ Dženeta FAZLIĆ\* Ćerima ZAHIROVIĆ-SINANović Lutvija KARIĆ

Univerzitet u Sarajevu, Poljoprivredno-prehrambeni fakultet, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Dženeta Fazlić, dzeneta.fazlic@ppf.unsa.ba

### **Sažetak**

Studija pruža fitohemijsku procjenu pet sorti *Cucurbita pepo* L. uzgajanih u kontrolisanim stakleničkim uslovima, sa posebnim naglaskom na njihov sadržaj fenolnih i flavonoidnih jedinjenja. Koncentracija fenola i flavonoida kvantifikovana je spektrofotometrijskim metodama Folin–Ciocalteu i AlCl<sub>3</sub>. Značajne razlike u sadržaju ovih spojeva uočene su među analiziranim sortama – Tiana, Hokkaido, Mareva, Duga bijela i Sunburst. Sorta Tiana pokazala je najviši ukupni sadržaj fenola (96,36 mg GAE / 100 g SV) i flavonoida (10,30 mg QE / 100 g SV), slijedi Hokkaido (55,79 i 5,04 mg / 100 g SV, redom). Mareva, Duga bijela i Sunburst sadržale su znatno niže količine ovih jedinjenja. Rezultati ukazuju na snažnu povezanost između akumulacije fenola i flavonoida, ističući ulogu ovih bioaktivnih molekula u određivanju nutritivne i funkcionalne vrijednosti tikvica. Sorte s višim sadržajem fenolnih i flavonoidnih jedinjenja, posebno Tiana i Hokkaido, predstavljaju perspektivne kandidate za razvoj nutritivno unaprijeđenih povrtnica i funkcionalnih namirnica. Ova studija naglašava važnost detaljnog fitohemijskog profiliranja pri ocjeni i selekciji sorti *Cucurbita pepo*, doprinoseći boljem razumijevanju varietalne diferencijacije u njihovim nutritivnim i funkcionalnim osobinama.

**Ključne riječi:** *Cucurbita pepo* L., fenolna jedinjenja, flavonoidi, antioksidativni kapacitet, fitohemijski sastav

## AI in food quality control

Nađa LIGATA Mirza HUSAGIĆ Jasmina ĐEĐIBEGOVIĆ

Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

\*Corresponding author: Nađa Ligata, nadjaligata@gmail.com

### Abstract

AI technologies are increasingly present in most fields and industries, food quality control included. The growing need for efficacy, precision, and speed makes space for AI to assist standard methods. Some of these technologies, covered here, are computer vision, which allows surface contamination and spoilage to be detected. Combination of AI models with traditional methods, like ELISA, is also mentioned, in context of mycotoxin detection. E-nose systems, mimicking human olfactory system can also be used to classify products, for example, coffee beans, based on origin. Advantages and disadvantages of AI implementation were also discussed, with focus on benefits like reduced labor and human error, but also the downsides, including the effect on environment, loss of jobs that doesn't provide additional value, and the weaknesses of AI solutions.

*Keywords: AI, food, quality control, artificial intelligence*

### Introduction

The term artificial intelligence covers a wide range of modern technologies that imitate human capabilities, like learning, concluding, and planning. Application of such systems is even wider, present in most of fields and industries, as well as everyday life. With the goal of achieving high levels of efficacy, precision, and speed, AI is being integrated in food quality control and inspection. Regulations regarding food are strict, and AI could help businesses meet the required standard. It is also important, today more than ever, to take care of the brand reputation, and companies do that by providing safe and high quality food. Our goal was to research which specific methods are being used, but also to investigate the need for them in food quality control, and finally to find the advantages and the disadvantages of their integration in standard procedure.

### Experimental

As this was not an experimental work, the research was done by searching terms like AI and food quality control on the online available archives and

journals, including PubMed, Wiley Online Library, Science Direct, and Research Gate.

## ***Results and Discussion***

### ***Technologies***

Computer vision is one of the AI technologies, used to recognize damage in food products. First, the image is obtained using a camera, thermal imaging, or other tools. Then image data is analyzed with the help of the pretrained models. If the model was properly trained, and on quality data, computer vision can detect surface contamination in the form of mold, as well as color changes which can indicate spoilage. Studies have applied this technology to sort fruit (mango and apples) into categories based on whether it is fresh or rotten, based on visual features (Hemamalini, Rajarajeswari, Nachiyappan, et al., 2022).

AI systems can also assist traditional chemical and physical analyses, and help in screening samples especially for tests which are time-consuming or require extensive sample preparation. One study (Sadimantara, Argo, Sucipto, et al., 2024) investigated use of a combination of fluorescence imaging and a deep learning model to classify levels of aflatoxin contamination in cocoa beans based on spectral data.

AI has also been investigated as a tool in expiration date estimation. In one study (Muniandy, Benyathiar, Ozdali, et al., 2024) it was used in combination with ultra-accelerated shelf-life test, and produced results close to those of standard methods. Predictive capabilities are also of interest in machine maintenance, as they could help save production costs by anticipating equipment failure (Yadav, Kaushik, Yadav, 2024).

Organoleptic analysis is one of the earliest methods in quality control, and technologies like e-nose imitate it. These technologies use sensors that detect volatile compounds, which human brain perceives as a smell. One study used this approach to classify coffee based on origin of the beans (Lee, Chen, Yang, et al., 2022). Other studies have investigated the application of these methods on meat, oil, and dairy samples (Anwar, Anwar, Murtaza, 2023).

### ***Advantages and disadvantages of AI in food quality control***

Advantages attributed to AI use include decreased need for human labor, reduced human error, and waste reduction, among others. However, the disadvantages are often neglected. One of them is the effect on environment. While AI can be used to reduce waste, the infrastructure that supports it – data centers and hardware – produce waste, including e-waste. Improperly handled e-waste increases levels of lead, barium, cadmium, chromium, and arsenic in the environment. High levels of these contaminants, which end up

in environment through many different sources, are associated with higher incidence of miscarriages, abnormal development, mutations, abnormal function of organs, and other health issues (Wang, Zhang, Masanet, 2024). Of course, it must be highlighted that AI is neither the only, nor the biggest source of e-waste, that the possible effects are usually indirect consequences, and that different technologies related to AI behave differently, and their effect on environment varies. Due to the use of clean water by cooling systems of data centers, and contribution to the polluted water, several issues need to be taken into account and investigated when talking about AI: disruption of local ecosystems, effect on biodiversity, and influence on drinking and agriculture water availability, however, there aren't many studies focusing on this issue.

It is important for AI implementation to be carefully evaluated on a case by case basis, and only resorted to when benefits are very clear, significant, and good for the most people. For example, in case of detecting mycotoxins, which are a serious problem if found in food, and samples need special preparation for the standard tests, there is a very clear benefit. However, automating the tasks, solely for the sake of reducing the number of jobs cannot be considered a clear benefit to society. AI is also considered a tool which reduces human error, but its implementation needs to be well planned and careful, in order to retain skilled human experts who would be able to recognize when AI makes the mistake, correct it, and operate independent of the tool.

It must also be remembered that, just because it is possible to monitor a parameter constantly and process that data constantly, doesn't mean that there is practical value in doing so. In some cases, it might simply not bring any significant improvement. Because as it is, we have a relatively safe food in most parts of the world, and there are many efficient methods for detection and quantification of nutrients, additives, and contaminants. When the food in developed world fails to meet safety and quality standard and requirements, or it causes a health issue, it is often due to contamination and spoilage, that happens after the product has reached the market, or even the consumer, due to inadequate storage, or preparation. No AI system can predict if the consumer will decide not to follow the storage instruction on the label, or if they won't cook their food for long enough. Another case in which AI might be ineffective, is when manufacturers or sellers add ingredients that they shouldn't, on purpose, in order to improve sensory experience for the customer, increase profit, or prolong the expiration date. AI can also have weaknesses related to the data and methods used for training the models, and decreased performance when encountering new and unexpected patterns.

## ***Conclusion***

Different applications of AI use in food quality control were mentioned, as well as advantages and disadvantages. While we did point out the usually overlooked issues, and consequences which widespread and uncritical use of AI can result in, we do not believe that this technology should be abandoned. However, we believe that the priority must be the development of AI systems that generate less waste, support recycling, rely on renewable energy sources, and mitigate other harmful environmental effects.

Based on the information found, we are of the opinion that even after these environmental concerns are addressed, AI should only be implemented when it leads to significant improvements or enables tasks that humans were previously unable to perform. It is important to remember that AI can also be a source of error, and that an AI model can't bear responsibility for its decisions. We conclude that AI may be most appropriate for use in research and development, where findings are subject to validation. Considering the benefits, limitations, and investments that AI requires, in some cases, it may be more fruitful to invest in human intelligence and in the improvement of production processes themselves, in order to reduce contamination risks.

Ultimately, this promising field still requires further investigation, supported by thorough and unbiased assessments of its advantages and drawbacks, with the goal of developing sustainable technologies that will not themselves become a source of contamination.

***Author contributions:*** Conceptualization, N.L., M.H.; methodology, N.L., M.H.; investigation, N.L., M.H.; writing—original draft preparation, N.L., M.H.; writing—review and editing, N.L., M.H.; visualization, N.L., M.H.; All authors have read and agreed to the published version of the proceeding.

***Funding:*** This work did not receive funding.

***Informed Consent Statement:*** Not applicable

***Conflicts of Interest:*** The authors declare no conflicts of interest.

## ***References***

Anwar H, Anwar T, Murtaza S. Review on food quality assessment using machine learning and electronic nose system. *Biosensors and Bioelectronics*: X. 2023 Sep;14:100365.

Hemamalini V, Rajarajeswari S, Nachiyappan S, Sambath M, Devi T, Singh BK, et al. Food Quality Inspection and Grading Using Efficient Image Segmentation and Machine Learning- Based System. Khan R, editor. *Journal of Food Quality*. 2022 Feb 11;2022:1–6

Lee CH, Chen IT, Yang HC, Chen YJ. An AI-powered Electronic Nose System with Fingerprint Extraction for Aroma Recognition of Coffee Beans. *Micromachines* (Basel). 2022 Aug 13;13(8):1313.

Muniandy A, Benyathiar P, Ozadali F, Mishra DK. Development of predictive model for the novel ultra-accelerated shelf-life test (UASLT) for shelf-life of packaged beverage. *LWT*. 2024 Oct;210:116686

Sadimantara MS, Argo BD, Sucipto S, Al Riza DF, Hendrawan Y. The Classification of Aflatoxin Contamination Level in Cocoa Beans using Fluorescence Imaging and Deep learning. *Journal of Robotics and Control*. 2024 Jan 10;5(1):82–91.

Wang P, Zhang LY, Tzachor A, Masanet E, Chen WQ. E-waste Challenges of Generative Artificial Intelligence. 2024. Available from: <https://www.researchsquare.com/article/rs-3978528/v1>

Yadav DK, Kaushik A, Yadav N. Predicting machine failures using machine learning and deep learning algorithms. *Sustainable Manufacturing and Service Economics*. 2024;3:100029.

### **AI u kontroli kvaliteta hrane**

Nada LIGATA\* Mirza HUSAGIĆ Jasmina ĐEDIBEGOVIĆ

Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

\*Autor za korespondenciju: Nada Ligata, [nadjaligata@gmail.com](mailto:nadjaligata@gmail.com)

### **Sažetak**

AI tehnologije su sve prisutnije u većini oblasti i industrija, uključujući i kontrolu kvaliteta hrane. Rastuća potreba za efikasnošću, preciznošću i brzinom otvara prostor da vještačka inteligencija podrži standardne metode. Neke od tehnologija, koje su ovdje obrađene, uključuju računarski vid, koji omogućava detekciju kontaminacije i kvarenja na površini. Takođe je pomenuta kombinacija AI modela sa tradicionalnim metodama, poput ELISA testa, u kontekstu detekcije mikotoksina. E-nos sistemi, koji imitiraju ljudski olfaktorni sistem, mogu se koristiti za klasifikaciju proizvoda, na primer, zrna kafe prema porijeklu. Diskutovane i prednosti i mane primjene AI, sa fokusom na koristi kao što su smanjenje potrebe za radnom snagom i smanjenje ljudske greške, ali i na nedostatke, uključujući uticaj na životnu sredinu, gubitak poslova koji ne nudi druge benefite, i slabosti AI sistema.

*Ključne riječi: AI, umjetna inteligencija, hrana, kontrola kvaliteta*

## Extraction and characterization of phenolic compounds from the plant *Achillea millefolium*

Dženita ALIBEGIĆ\* Esmera KAJTAZ Belma ALIHODŽIĆ- DILBEROVIĆ  
Almaida ALAGIĆ Haris NIKŠIĆ

Faculty of Pharmacy, University of Sarajevo, Zmaja od Bosne 8, 71000 Sarajevo, Bosnia  
and Herzegovina

\*Corresponding author: MA Dženita Alibegić, dzenita.alibegic@ffsa.unsa.ba

### Abstract

**Yarrow**, scientifically known as *Achillea millefolium*, is a perennial plant from the Asteraceae family. It is renowned for its anti-inflammatory, antimicrobial, astringent, and analgesic properties. The aim of this research was to prepare extracts from the yarrow herb and compare their efficiency in extracting phenolic compounds using maceration over 24 and 72 hours. The study also aimed to compare different combinations of extraction solvents to determine the most effective method for obtaining extracts with high phenol content from *Achillea millefolium*. The research analyzed the influence of different solvents on the extraction of phenolic compounds from yarrow herb collected in the Podveležje-Mostar area in August 2023. The plant material was air-dried and then ground. The homogenized sample was then subjected to maceration extraction at room temperature using distilled water and aqueous solutions of ethanol, acetone, and methanol at different concentrations (30%, 50%). The total phenol content ranged from 211.23 to 311.14 mg GAE/g (Gallic Acid Equivalent) depending on the different extraction solvents used during the maceration process. The use of a 50% aqueous methanol solution achieved the highest extraction capacity for total phenols, while the capacity was lowest when water was used as the solvent. The results of this research show that variations in the amount of total phenols significantly depend on the type of solvent used.

*Key words:* *Achillea millefolium*, extraction, maceration, phenolic compounds

### Introduction

Yarrow (*Achillea millefolium*) is one of the most widespread and commonly used medicinal plants in the world. This species belongs to the genus *Achillea*, the family Asteraceae, the order Asterales, the class Magnoliopsida, the division Magnoliophyta, and the kingdom Plantae. The

Asteraceae family includes about 115 other plant species (Mabberley, 1997), but the greatest pharmacological significance among them is held precisely by *Achillea millefolium* (Nemeth, 2005; Si et al., 2006). Yarrow is a perennial herbaceous plant with a characteristic aromatic scent and a creeping rhizome. The stem of this plant grows to a height of 20 to 80 cm and usually branches only in the upper part. The color of the stem can vary from light green to reddish-brown. The leaves are triply pinnately divided into a large number of small, linear lobes, which is why the plant is called "milfoil" (*millefolium* - thousand leaves). At the top of the stem are flower heads, arranged in a shield-like shape (corymb), which consist of two types of flowers: ray florets located along the edge, which are white to pink in color, and tubular disc florets in the center, which are yellow. In young plants, the stem and leaves are usually covered with hairs, but most of these hairs fall off as the plant ages (Mišan et al., 2013). Yarrow is typically collected during the summer months, from June to August, when it is exposed to the strongest sunlight, as during this period the plant contains the highest concentration of essential oil. Harvesting involves cutting the tops of the plants, which can be 20-25 cm long, or just the flower heads about 2 cm long. After the cut plant parts are collected, they are usually tied into bundles and dried in places with good air circulation or in dryers at a temperature of 35-50 °C. More than 120 chemical compounds have been identified in yarrow (Chandler et al., 1982). The main active components of this plant can be classified into several categories, including essential oil, monoterpenes and sesquiterpenes, phenolic compounds, triterpenes and sterols, alkaloids, minerals and vitamins, and other compounds. The pharmacological effects of yarrow are mainly a consequence of the presence of essential oils, proazulenes and other sesquiterpene lactones, and phenolic compounds such as dicaffeoylquinic acids and flavonoids (EMA/HMCP/290309/2009). There are variations in the amount of these components that can be found in different parts of the plant, as documented in research by other authors (Blumenthal et al., 2000; Benedek and Kopp, 2007). Yarrow is classified as a bitter agent due to its high content of bitter substances and essential oil. Thanks to these properties, it is used in the therapy of various gastrointestinal disorders. The key parts of yarrow from a medical perspective are its flower tops, which contain essential oil known for its anti-inflammatory and disinfectant properties. It is often applied as a hemostatic agent, for relieving cold symptoms, and for reducing elevated body temperature (Baser et al., 2002; Benedek et al., 2008; Smelcerovic et al., 2010). In general, yarrow, its extracts, and main compounds exhibit the following effects: anti-inflammatory action (Benedek et al., 2008; Chandler, 1982; Evans, 2002; Newall, 1996), antioxidant action (Candan et al., 2003; Agar et al., 2015), antimicrobial action (Candan et al.,



2003; Stojanović et al., 2005), choleric and spasmolytic action (Benedek et al., 2008), hepatoprotective and antispasmodic action (Yaesh et al., 2006), vasoprotective action (Dall'Acqua et al., 2011), antispermatic action (Montanari et al., 1998; Innocenti et al., 2007), antitumor action (Agar et al., 2015), antimalarial action (Lehane and Saliba, 2008). The phytochemical composition of *Achillea millefolium* shows the presence of organic acids, among which oxalic, quinic, and citric acids are the most prevalent, fatty acids like linolenic and palmitic acid, and tocopherols, particularly  $\gamma$ -tocopherol (Gharibi et al., 2013; Dias et al., 2013; Benedek et al., 2007). Qualitative and quantitative research on bioactive constituents from plant materials greatly depends on the selection of an appropriate extraction method and its adequate application (Azmir et al., 2013). Solvent extraction methods are based on mixing samples with a suitable solvent or subjecting samples to a two-phase system composed of two or more solvents that are poorly miscible with each other (Dai and Mumper, 2010). A review of the literature has established the significant influence of acetone, methanol, and ethanol (in different ratios of the organic solvent phase) on the extraction of phenolic compounds. Therefore, the aim of this work was to prepare extracts of *Achillea millefolium* herb and to determine the optimal solvent combination and maceration duration (24 and 72 hours) for the maximum isolation of phenolic compounds.

## **Experimental**

### **Reagents and Equipment:**

**Reagents:** Folin-Ciocalteu reagent – Semikem (BiH), Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) – Centrophem (Serbia), Gallic acid ( $\text{C}_7\text{H}_6\text{O}_5 \cdot \text{H}_2\text{O}$ ) – Semikem (BiH), distilled water.

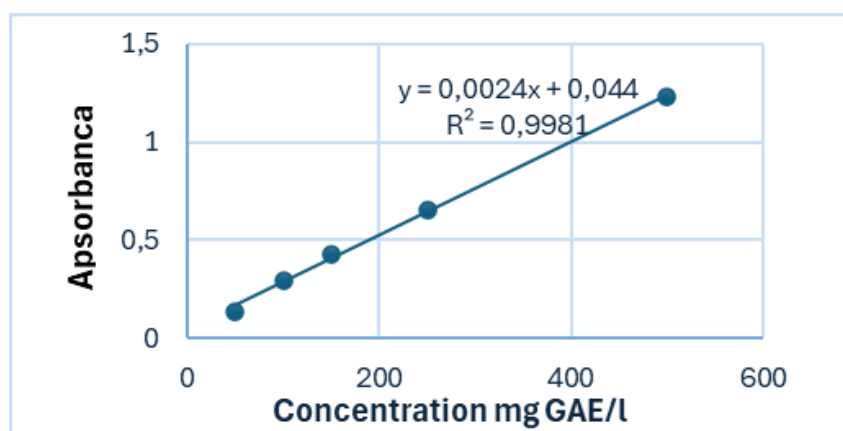
**Equipment:** UV-1800 Shimadzu spectrophotometer, MEMMERT water bath, IKA Lab Dancer Vortex, KERN ABJ-NM analytical balance.

**Plant Material:** For the research, the aerial part of the wild species *Achillea millefolium* was used, collected from the area of Podveležje – Mostar (43.287911, 17.957652) during August 2023.

**Extraction Procedure:** After air-drying and grinding, the plant material was subjected to extraction techniques using the maceration method at room temperature. This procedure was carried out using distilled water and aqueous solutions of ethanol (30%, 50%), acetone (30%, 50%), and methanol (30%, 50%) over periods of 24 and 72 hours. A 2 g sample of the ground plant leaves was transferred into a 100 mL Erlenmeyer flask. Then, 25 mL of the extraction solvent was added, in which the sample was soaked for 24 and 72 hours. After the maceration process was completed, the contents of the flask were filtered through a funnel and filter paper into a 25 mL volumetric

flask. After filtration, the solution was made up to the mark with the solvent used.

**Identification of Total Phenols:** The Folin-Ciocalteu method (Singleton and Rossi, 1965) was used to determine the total phenol content. This method is based on the spectrophotometric measurement of the total phenol content in a reaction mixture containing the test extract, distilled water, Folin-Ciocalteu reagent (a mixture of phosphomolybdic and phosphotungstic acid), and a 20% sodium carbonate solution. During this process, a complex polymeric ion is formed with phosphomolybdic acid ( $\text{H}_3\text{PMo}_{12}\text{O}_{40}$ ) and phosphotungstic acid ( $\text{H}_3\text{PW}_{12}\text{O}_{40}$ ). This reagent oxidizes polyphenolic compounds while being itself reduced to a mixture of tungstates ( $\text{W}_8\text{O}_{23}$ ) and molybdates ( $\text{Mo}_8\text{O}_{23}$ ). The reaction solution develops an intense blue color, and the color intensity is proportional to the concentration of phenolic compounds. The concentration of total phenols was calculated using the slope equation obtained in Excel, with the gallic acid concentration (mg/L) plotted on the abscissa and the absorbance values measured on a UV-1800 Shimadzu spectrophotometer at 765 nm (Graph 1).



**Graph 1.** Standard Curve for the Determination of Total Phenols

**Procedure for Determining Total Phenols:** An aliquot of 125  $\mu\text{L}$  of the yarrow extract (previously diluted) is pipetted into a glass test tube, followed by the addition of 625  $\mu\text{L}$  of Folin-Ciocalteu reagent and 10 ml of distilled water. After 3 minutes, 1.9 ml of a saturated sodium carbonate solution is added. The mixture is vortexed and then the samples are incubated for 25 minutes at  $T=50^\circ\text{C}$  in a water bath. After this, the absorbance is measured at a wavelength of 765 nm. The mass fractions of total phenols are expressed as gallic acid equivalents in mg GAE per gram of dry matter (mg GAE/g dry matter).

## Results and discussion

The research analyzed the influence of different solvents on the extraction of phenolic compounds from *Milefolii herba*. The mean values of total phenols depending on the applied solvent and the maceration extraction time at room temperature are shown in Table 1.

**Table 1.** Total phenol content in aqueous extracts and aqueous extracts of ethanol, acetone, and methanol (*Achillea millefolium*) expressed in mg of gallic acid per gram of dry matter (mg GAE/g dry matter).

Solvent	24-hour maceration (mg GAE/g $\pm$ SD)	72-hour maceration (mg GAE/g $\pm$ SD)
Water	211,23 $\pm$ 5,60	222,94 $\pm$ 3.07
Ethanol 30%	226,45 $\pm$ 6,25	291,77 $\pm$ 10,15
Ethanol 50%	226,90 $\pm$ 1,27	293,05 $\pm$ 3,36
Acetone 30 %	213,66 $\pm$ 0,24	273,00 $\pm$ 2,91
Acetone 50%	279,26 $\pm$ 2,05	301,91 $\pm$ 4,58
Methanol 30%	256,17 $\pm$ 3,87	259,46 $\pm$ 4,21
Methanol 50%	296,40 $\pm$ 5,68	311,14 $\pm$ 7,71

From Table 1, we can observe that the share of total phenols ranges from 211.23 to 311.14 mg GAE/g, depending on the different extraction solvents used during the maceration process. Using a 50% aqueous methanol solution achieves the highest extraction capacity for total phenols, while the capacity is lowest when water is used as the solvent. In the 24-hour room temperature maceration process, the mass fractions of total phenols varied between 211.23 and 296.40 mg GAE/g depending on the extraction solvent. Using 50% methanol, a higher mass fraction of total phenols was extracted compared to water. In the 72-hour room temperature maceration process, the mass fractions of total phenols varied between 222.94 and 311.14 mg GAE/g depending on the extraction solvent. Using 50% methanol, a higher mass fraction of total phenols was extracted compared to water.

The obtained extracts are a rich source of phenolic compounds, but their concentration varies significantly depending on the extraction conditions, solvent polarity, and extraction time and temperature. Besides the choice of extraction solvent having an influence, the chemical composition of the sample also plays a role in the extraction capacity. Furthermore, the presence and proportion of water in the organic solvent phase play an important role because water promotes the diffusion process and facilitates the extraction of phenolic compounds from the plant material. If we compare the results of the mass fractions of total phenols obtained from both extraction procedures, we

see that over the total period of 72 hours, higher mass fractions of total phenols were extracted from *Achillea millefolium* compared to the extraction carried out over 24 hours. From the obtained results, we can conclude that aqueous extracts of ethanol, acetone, and methanol at higher concentrations contribute to a greater extraction capacity for the isolation of total phenols from *Achillea millefolium* in both examined procedures. If we consider the duration of maceration extraction, the advantage lies with the extraction that lasted 72 hours due to a significantly higher yield of total phenols. Many studies show the influence of different solvents on the extraction of phenolic compounds. The most commonly used solvents for extracting polyphenolic compounds are water, ethanol (96%), methanol, and acetone (Robards and Antolovich, 1997), as well as ethyl acetate, diethyl ether, methanol, or aqueous methanol solution, which are suitable for extracting phenolic acids. The most commonly used solvent for phenol extraction is aqueous methanol solution, with a methanol content of 50 to 80%, due to its high extraction capacity. Research conducted by Areias et al. (2000) analyzed the influence of aqueous ethanol solution with different percentages of the organic phase in the solvent (30-80%) on the extraction of phenolic compounds. The conclusion of the research suggests that the proportion of water in the solvent has a greater influence on the amount of extracted phenolic compounds than the choice of the solvent itself. Research by other authors, such as Naczki and Shahidi (2006), also confirms the influence of solvent polarity on the extraction of phenolic compounds. Their results show that increasing the ethanol content from 30% to 50% increases the extraction capacity. These results correspond with the results of this study, which suggest that better extraction capacity is achieved using solvents with a higher proportion of ethanol. In previous research (Benedec et al., 2015), total phenols in a 70% ethanolic extract of *Achillea millefolium* flowers were analyzed, and the obtained results showed values of 38.12 mg GAE/g, which is significantly lower compared to the results of our research. In research conducted by a group of authors led by Vitalini (2011), a significantly higher content of total phenols of 281.7 mg/g was observed in a methanolic extract of *Achillea millefolium*. These results are relatively similar to the results of this study. Eghdami and his colleagues (2010) concluded in their research that the phenol content in the methanolic extract was  $123.9 \pm 2.6$  mg GAE/g. Conversely, the total phenol content was even lower in the aqueous extract, only  $48.4 \pm 2.7$  mg GAE/g, which are significantly lower values compared to the results of our research. Dias et al. (2013) recorded a higher content of total phenolic compounds in the methanolic extract of *Achillea millefolium* L., which was about  $128.36 \pm 0.0$  mg GAE/g. Georgieva et al. (2015) researched that the total phenol content in the aqueous extract

of *Achillea millefolium* L. varied in the range from  $2.77 \pm 0.03$  mg GAE/g to  $7.92 \pm 0.09$  mg GAE/g. It was also noted in our research that the lowest amount of phenolic compounds was recorded in the aqueous extract.

The results obtained in this research show that the amount of total phenols varies significantly depending on the concentration of ethanol, acetone, and methanol in the extraction solvent, which is consistent with research by other authors according to which the extraction capacity of phenolic compounds in various plant species depends on the type of solvent (Akowuah et al., 2005; Turkmen, Sari, and Velioglu, 2006).

### **Conclusion**

Based on the results obtained in the conducted research, we can conclude that the extracts of the plant *Achillea millefolium* are a rich source of phenolic compounds, which is confirmed by the high mass fractions of total phenols determined by spectrophotometric methods. The results obtained in this research show that the amount of total phenols ranges from 211.23 to 311.14 mg GAE/g, depending on the different extraction solvents used during the maceration process. Using a 50% aqueous methanol solution achieves the highest extraction capacity for total phenols, while the capacity is lowest when water is used as the solvent. The highest extraction capacity for the isolation of total phenols, if we compare the results of mass fractions obtained from both extraction procedures, we see that over the total period of 72 hours, higher mass fractions of total phenols were extracted from *Achillea millefolium* compared to the extraction carried out over 24 hours. From the obtained results, we can conclude that aqueous extracts of ethanol, acetone, and methanol at higher concentrations contribute to a greater extraction capacity for the isolation of total phenols from *Achillea millefolium* in both examined procedures. If we consider the duration of maceration extraction, the advantage lies with the extraction that lasted 72 hours due to a significantly higher yield of total phenols.

**Author contributions:** Conceptualization, Dž.A. and E.K.; methodology, E.K.; investigation, Dž.A.; writing—Dž.A. and E.K., writing— review and editing, B.A.D. and A.A.; visualization, Dž.A.; supervision H.N. All authors have read and agreed to the published version of the proceeding

### **References**

Agar, O.T., Dikmen, M., Ozturk, N., Yilmaz, M.A., Temel, H. i Turkmenoglu, F.P. (2015) Comparative studies on phenolic composition, antioxidant, wound healing and cytotoxic activities of selected *Achillea* L. species growing in Turkey, *Molecules*, 20: 17976-18000, 2015

Akowuah, G.; Ismail, Z.Nrhayati, ISdikun, A. (2005) Food chemistry 93(2): 311-317.

Areias F.M., Valentão P., Andrade P.B., Ferreres F., Seabra R.M. (2000) Flavonoids and phenolic acids of sage: influence of some agricultural factors. Journal of Agricultural and Food Chemistry 48: 6081-6084.

Azmir, J., Zaidul, I.S.M., Rahman, M.M., Sharif, K.M., Mohamed, A., Sahena, F., Jahurul, M.H.A., Ghafoor, K., Norulaini, N.A.N., Omar, A.K.M. (2013) Techniques for extraction of bioactive compounds from plant materials: A review. J. Food Eng., 117, 426-436.

Baser, K.H.C., Demirci, B., Demirci, F., Kocak, S., Akinci, C., Malyer, H. i Guleryuz, G. (2002) Composition and antimicrobial activity of the essential oil of *Achillea multifida*. Planta Medica, 68: 941-943.

Benedec, D., Popica, I.-E., Oniga, I., Hanganu, D., Duma, M., Silaghi-Dumitrescu, R., Bischin, C., Vlase, L. (2015): Comparative HPLC-MS analysis of phenolics from *achillea distans* and *achillea millefolium* and their bioactivity. Stud. Univ. Babes-Bolyai Chem., 60, 257–266.

Benedek, B., Kopp, B. (2007) *Achillea millefolium* L.s.l. revisited: Recent findings confirm the traditional use, Wiener Medizinische Wochenschrift, 157: 312-314.

Benedek, B., Rothwangl-Wiltschnigg, K., Rozema, E., Gjoncaj, N., Reznicek, G., Jurenitsch, J., Kopp, B. i Glasl, S. (2008) Yarrow (*Achillea millefolium* L.s.I.): pharmaceutical quality of commercial samples. Pharmazie, 63: 23-26.

Blumenthal, M., Goldberg, A., Brinckmann, J.(2000) Herbal Medicine.: Expanded Commission E Monographs, Austin, Texas: American Botanical Council.

Candan, F., Unlu, M., Tepe, B., Daferera, D. Polissiou, M., Sokmen, A., Akpulat, H.A. (2003) Antioxidant and antimicrobial activity of the essential oil and methanol extracts of *A.millefolium*, J Ethnopharmacol, 87: 215-220.

Chandler, R., Hooper, S., Harvey, M. (1982) Ethnobotany and phytochemistry of yarrow, *Achillea millefoium*, Compositae, Economic Botany, 36: 203-223.

Dai J., Mumper R.J. (2010): Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. Molecules 2010; 15(10):7313–52.

Dall' Acqua, S., Bolego, C., Cignarella, A., Gaion, R.M., Innocenti, G. (2011) Vasoprotective activity of standardized *A. millefolium* extract, Phytomedicine.

Dias, M.I., Barros, L., Duenas, M., Pereira, E., Carvalho, A.M., Alves, R.C., Oliveira, M.B.P.P., Santos-Buelga, C., Ferreira, I.C.F.R. (2013): Chemical composition of wild and commercial *Achillea millefolium* L. and bioactivity of the methanolic extract, infusion and decoction. Food Chem., 141(4), 4152–4160.

Dias, M.I., Barros, L., Duenas, M., Pereira, E., Carvalho, A.M., Alves, R.C., Oliveira, M.B.P.P., Santos-Buelga, C., Ferreira, I.C.F.R. (2013) Chemical composition of wild and commercial *Achillea millefolium* L. and bioactivity of the methanolic extract, infusion and decoction. Food Chem., 141(4), 4152–4160.

Eghdami, A., Sadeghi, F. (2010): Determination of total phenolic and flavonoids contents in methanolic and aqueous extract of *Achillea millefolium*. Org. Chem. J., 2, 81–84.

EMA/HMPC/290309/2009, EMA (2011) European Medicines Agency, Science Medicines Health, Committee on Herbal Medicinal Products (HMPC), London.

Evans W.C., (2002) Trease and Evans Pharmacognosy, W. B. Saunders, edonburg, London, New York, Philadelphia. St Luis, Sydney, Toronto.

Georgieva, L., Gadjalova, A., Mihaylova, D., Pavlov, A. (2015): *Achillea millefolium* L. – phytochemical profile and in vitro antioxidant activity. International Food Research Journal., 22(4), 1347-1352.

Gharibi, S., Tabatabaei, B.E.S., Saeidi, G., Golic, S.A.H., Talebi, M. (2013): Total phenolic content and antioxidant activity of three Iranian endemic *Achillea* species. Ind. Crop. Prod., 50, 154–158.

Innocenti, M., Niccoli, L., Vasacci, L., Vincieri, F.F., Mulinacci, N. (2004) Componenti bioattivi nei falsi frutti di cultivars selezionate di *Rosa canina*, V Congresso Nazionale di Chimica degli Alimenti, Morgan, Milan, 20-25.

Lehane, A.M., Saliba, K.J. (2008) Common dietary flavonoids inhibit the growth of the intraerythrocytic malaria parasite, BMC Res Notes, 1: 26-30.

Mabberley, DJ (1997) The Plant-Book. 2. izdanje, Cambridge University Press, Cambridge, 680.

- Mišan, A., Arsić, I., Đorđević, S., Tadić, V., Psodorov Đ. (2013) Funkcionalna hrana i lekovito bilje, monografija, Naučni institut za prehrambene tehnologije, Novi Sad.
- Montanari, T., Carvalho, J.E., Dolder, H. (1998) Antispermatic effect of *A. millefolium* L. in mice, *Contraception*, 58: 309-313.
- Naczek, M. and Shahidi, F. (2006) Phenolics in cereals, fruits and vegetables: occurrence, extraction and analysis. *Journal of Pharmaceutical and Biomedical Analysis*, 41, 1523-1542.
- Nemeth, E. (2005) Essential oil composition of species in the genus *Achillea*, *Journal of Essential Oil Res.*, 17: 501-512.
- Robards K., Antolovich M. (1997) Analytical chemistry of fruit bioflavonoids-a review. *Analyst* 122: 11R-34R.
- Si, X.T., Zhang, M.L., Shi, Q.W., Kiyota, H. (2006) Chemical constituents of the plants in the genus *Achillea*, *Chemistry and Biodiversity*, 3: 1163-1180.
- Singleton, V.L. i Rossi, J.A. (1965) Kolorimetrija ukupnih fenola s reagensima fosfomolibdinske-fosfotungstične kiseline. *American Journal of Enology and Viticulture*, 16, 144-158.
- Smelcerovic, A., Lamshoeft, M., Radulovic, N., Ilic, D. i Palic, R. (2010) LC/MS analysis of the essential oils of *Achillea millefolium* and *Achillea crithmifolia*. *Chromatographia*, 71: 113-116.
- Stojanović, G., Radulović, N., Hashimoto, T., Palić, R. (2005) In vitro antimicrobial activity of extracts of four species: the composition of *A. millefolium* L. (Asteraceae) extract, *J Ethnopharmacol*, 101: 185-190.
- Turkmen, N., Sari, F. and Velioglu, S. (2006) Effect of extraction solvent on the concentration and antioxidant activity of black and black mate polyphenols determined by the ferric tartrate and Folin-Ciocalteu methods. *Food Chemistry*, 99, 838-841.
- Vitalini, S., Beretta, G., Iriti, M., Orsenigo, S., Basilico, N., Dall'Acqua, S., Iorizzi, M., Fico, G. (2011) Phenolic compounds from *Achillea millefolium* L. And their bioactivity. *Acta Biochim. Pol.*, 58, 203-212.
- Yaeesh, S., Jamal, Q., Khan, A.U. i Gilani, A.H. (2006) Studies on hepatoprotective, antispasmodic and calcium antagonist activities of the aqueous-methanol extract of *A. millefolium*, *Phytother Res*, 20: 546-551.



## **Ekstrakcija i karakterizacija fenolnih spojeva iz biljke *Achillea millefolium***

Dženita ALIBEGIĆ\* Esmera KAJTAZ Belma ALIHODŽIĆ- DILBEROVIĆ  
Almaida ALAGIĆ Haris NIKŠIĆ

Farmaceutski fakultet, Univerzitet u Sarajevu, Zmaja od Bosne 8, 71000 Sarajevo, BiH

\*Autor za korespondenciju: MA Dženita Alibegić, dzenita.alibegic@ffsa.unsa.ba

### **Sažetak**

Hajdučka trava, poznata i pod naučnim nazivom *Achillea millefolium*, je višegodišnja biljka iz porodice glavočika (Asteraceae). Hajdučka trava je poznata po svojim antiupalnim, antimikrobnim, adstrigentnim i analgetičkim svojstvima. Cilj istraživanja bio je pripremiti ekstrakte herbe vrste *Achillea millefolium* te usporediti njihovu sposobnost ekstrakcije fenolnih spojeva primjenom maceracije tokom 24 i 72 sata. Također, istraživanje je imalo za svrhu usporediti različite kombinacije ekstrakcijskih otapala kako bi se odredila najučinkovitija metoda za dobivanje ekstrakata s visokim sadržajem fenola iz *Achillea millefolium*. U istraživanju je analiziran utjecaj različitih otapala na ekstrakciju fenolnih spojeva iz herbe hajdučke trave koja je prikupljena na području Podveležja-Mostar u augustu 2023 godine. Biljni materijal je sušen na zraku a potom usitnjen. Homogenizirani uzorak zatim je podvrgnut ekstrakciji maceracije na sobnoj temperaturi koristeći destiliranu vodu i vodene otopine etanola, acetona i metanola različitih koncentracija (30%, 50%). Udio ukupnih fenola kreće u rasponu od 211,23 do 311,14 mg GAE/g, s obzirom na različita ekstrakcijska otapala koja se koriste tokom procesa maceracije. Upotrebom vodene otopine metanola koncentracije 50% postiže se najveći kapacitet ekstrakcije ukupnih fenola, dok je kapacitet najniži kada se koristi voda kao otapalo. Rezultati ovog istraživanja pokazuju da varijacije u količini ukupnih fenola značajno zavise o vrsti korištenog otapala.

*Ključne riječi: Achillea millefolium, ekstrakcija, maceracija, fenolni spojevi*

## 5-P-2

### **Analysis of polyphenol and anthocyanin content in commercially available fruit and herbal teas**

Jasmina BEGOVIĆ<sup>1\*</sup> Arna KLJUČO<sup>1</sup> Nejira IDRIZOVIĆ<sup>1</sup> Sajra  
HAJDAROVIĆ<sup>1</sup> Anisa GOSTO<sup>1</sup> Haris NIKŠIĆ<sup>2</sup>

<sup>1</sup>Department of Pharmacy, “Džemal Bijedić” University of Mostar, Sjeverni logor b.b.,  
88104 Mostar, Bosnia and Herzegovina

<sup>2</sup> Faculty of Pharmacy, University of Sarajevo, Zmaja od Bosne 8, 71000 Sarajevo, Bosnia  
and Herzegovina

\*Corresponding author: Jasmina Begović, [begovicj6@gmail.com](mailto:begovicj6@gmail.com)

### **Abstract**

Tea, second in global consumption after water, plays an important role in dietary habits and cultures worldwide. Its popularity stems not only from its appealing aroma and taste but also from its recognized health benefits. This study aimed to quantitatively analyze total polyphenol and monomeric anthocyanin content in five commercially available fruit and herbal teas: mint, green, forest fruit, cranberry, and apple-cinnamon tea. Differences in bioactive compound profiles among these teas were examined.

Polyphenols, plant secondary metabolites found in fruits, vegetables, and teas, exhibit strong antioxidant properties by neutralizing free radicals. Anthocyanins, a subgroup of polyphenols responsible for coloration, contribute to these benefits, though their stability and bioavailability are sensitive to temperature, pH, and light. The total polyphenol content is expressed as milligrams of gallic acid equivalents per gram of sample (GAE/g). Total polyphenols ranged from  $84.59 \pm 0.52$  GAE/g (apple-cinnamon tea) to  $145.96 \pm 0.60$  GAE/g (cranberry tea). Anthocyanin content ranged from  $0.100 \pm 0.03$  mg/L (mint tea) to  $8.032 \pm 0.17$  mg/L (cranberry tea), reflecting pigment concentration in raw materials.

These results enhance understanding of tea's chemical profile, highlighting nutritional value and bioactive properties. The study provides a foundation for future research on pharmacological effects and the development of functional foods and nutraceuticals.

*Keywords: tea, polyphenols, anthocyanins, antioxidants*

### **Introduction**

Tea, the second most consumed beverage in the world after water, plays a prominent role in dietary culture worldwide. Its popularity, originating in

ancient China, arises not only from its distinctive sensory qualities - appealing aroma and taste - but also from its widely recognized potential health benefits (Hollman, Tijburg & Yang, 1997). These beverages represent a rich source of bioactive compounds such as polyphenols and anthocyanins, whose antioxidant properties contribute to reducing the risk of chronic diseases (Rusak, Komes, Likić, et al., 2008; Komes, Horžić, Belščak, et al., 2010). Polyphenols, as important plant secondary metabolites, are primarily ingested through fruit, vegetables, and tea. They exhibit strong antioxidant properties by neutralizing harmful free radicals. Anthocyanins, a subgroup of polyphenols responsible for red, purple, and blue colors of fruits and flowers, also contribute to these health benefits. The analysis was conducted to enhance understanding of the chemical composition and nutritional–pharmacological value of the examined teas, providing a basis for further research in the development of functional foods and nutraceuticals.

### **Experimental**

In this study samples of commercially available herbal and fruit tea were analyzed:

- Green tea (*Camellia sinensis* L., *folium*);
- Mint tea (Dark Mint) (*Mentha* × *piperita* L., *folium*);
- Forest fruit tea (*Rubus fruticosus* L., *Fragaria vesca* L., *Vaccinium myrtillus* L., *fructus*);
- Cranberry tea (*Vaccinium macrocarpon* Aiton, *fructus*);
- Apple-cinnamon tea (*Malus domestica* Borkh., *fructus*; *Cinnamomum verum* J. Presl, *cortex*).

Samples were purchased from a local store. Extraction of bioactive compounds from each tea type was performed using the standardized hot infusion method (the International Organization for Standardization-ISO 3103, 2019).

### **Chemicals**

Potassium chloride buffer pH 1.0 (potassium chloride 0.025 M);

Sodium acetate buffer pH 4.5 (sodium acetate 0.4 M);

Folin-Ciocalteu reagent;

Gallic acid;

Ethanol (96%);

Saturated sodium carbonate solution.

### **Equipment**

UV-VIS spectrophotometer (UV-1800, Shimadzu);

Water bath;

Analytical balance.

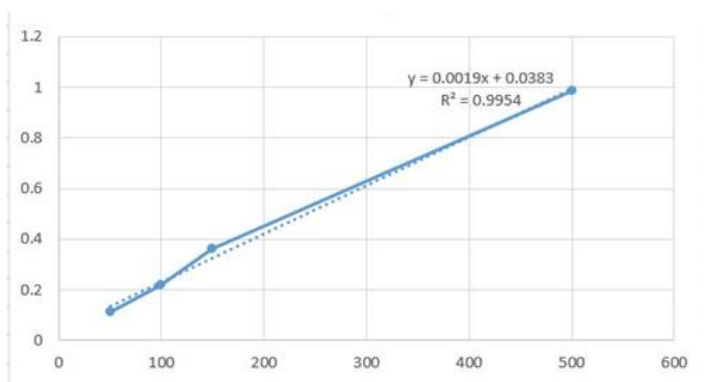
Glassware and laboratory tools

### Sample preparation

Tea bags were infused with 200 mL of boiling water (100°C). The samples were covered and left to stand for 5–8 minutes. After this time, the tea bags were squeezed, and the obtained tea was cooled to room temperature before analysis.

### Determination of total polyphenols

The Folin-Ciocalteu method (Singleton & Rossi, 1965) was used to determine the total phenol content. This method is based on spectrophotometric measurement of the total phenol content in a reaction mixture containing the tested extract, distilled water, Folin-Ciocalteu reagent (a mixture of phosphomolybdic and phosphotungstic acid), and a 20% sodium carbonate solution. During this process, a complex polymeric ion is formed with phosphomolybdic acid ( $\text{H}_3\text{PMo}_{12}\text{O}_{40}$ ) and phosphotungstic acid ( $\text{H}_3\text{PW}_{12}\text{O}_{40}$ ). This reagent oxidizes polyphenolic compounds while being reduced to a mixture of tungstates ( $\text{W}_8\text{O}_{23}$ ) and molybdates ( $\text{Mo}_8\text{O}_{23}$ ). The reaction solution develops an intense blue color, and the intensity of the color is proportional to the concentration of phenolic compounds. The total phenol concentration was calculated using the calibration curve equation obtained in Excel, with gallic acid concentration (mg/L) plotted on the x-axis and absorbance values measured at 765 nm using a UV-1800 Shimadzu spectrophotometer (Graph 1).



**Graph 1.** Calibration curve of gallic acid

### Quantification of monomeric anthocyanins

The pH differential method was used to quantify monomeric anthocyanins. Concentrations were expressed in milligrams per liter of extract (mg/L). The reaction was set up in two parallel test tubes per sample. Into each test tube, 0.5 mL of the prepared sample was pipetted. Then:

- 2.0 mL of buffer with pH 1.0 was added to the first test tube.
- 2.0 mL of buffer with pH 4.5 was added to the second test tube.

After adding the buffers, the tubes were left at room temperature for 20 minutes to stabilize. Absorbance was then measured at wavelengths of 520 nm and 700 nm for each test tube. The concentration of monomeric anthocyanins in the sample was calculated as cyanidin-3-glucoside equivalents (mg/L) according to the formula:

$$A \times MW \times DF \times 10^3 / (\epsilon \times l)$$

Where: A = (A520nm – A700nm)pH=1.0 – (A520nm – A700nm)pH=4.5;

MW = molecular weight (449.2 g/mol for cyanidin-3-glucoside, 463.3 g/mol for malvidin-3-glucoside);

DF = dilution factor;

$10^3$  = conversion factor from g to mg

$\epsilon$  = molar absorptivity (26,900 L/mol·cm for cyanidin-3-glucoside, 28,000 L/mol·cm for malvidin-3-glucoside);

l = path length of cuvette (1 cm).

### Results and discussion

The results are presented below in Table 1, which summarizes the obtained values and comparative analysis of the examined samples.

**Table 1.** Total polyphenol and monomeric anthocyanin content in selected tea samples

	Sample	Total polyphenols (GAE/g)	Monomeric anthocyanins (mg/l)
1	Green tea	125,81 ± 0,36	0,183 ± 0,01
2	Mint	110,74 ± 0,30	0,100± 0,03
3	Forest fruit	106,53 ± 0,30	6,896±0,14
4	Cranberry	145,96 ± 0,60	8,032±0,17
5	Apple-cinnamon	84,59 ± 0,52	2,438 ±0,05

Sample analysis revealed significant differences in the content of total phenols (expressed as gallic acid equivalents per gram—GAE/g) and anthocyanins (mg/L) among the examined tea samples (Table 1).

Cranberry tea exhibited the highest total phenolic content ( $145.96 \pm 0.60$  GAE/g) and anthocyanin concentration ( $8.032 \pm 0.17$  mg/L), confirming its potential as a rich source of natural antioxidants. This observation is consistent with previous studies reporting *Vaccinium species* as exceptionally rich in polyphenols and anthocyanins (Prior, Cao, Martin et al., 1998).

Green tea showed high total phenolic content ( $125.81 \pm 0.36$  GAE/g) but low anthocyanin levels ( $0.183 \pm 0.01$  mg/L), indicating that its antioxidant potential is primarily due to flavonoids and phenolic acids rather than anthocyanins, which aligns with literature reports (McKay & Blumberg, 2006).

Mint tea contained a substantial amount of total phenols ( $110.74 \pm 0.30$  GAE/g) but negligible anthocyanins ( $0.100 \pm 0.03$  mg/L), reflecting the lack of colored pigments in *Mentha* leaves and highlighting the species-specific phytochemical profile (McKay et al, 2006).

Forest fruit tea ( $106.53 \pm 0.30$  GAE/g;  $6.896 \pm 0.14$  mg/L) and apple-cinnamon tea ( $84.59 \pm 0.52$  GAE/g;  $2.438 \pm 0.05$  mg/L) exhibited moderate phenolic and anthocyanin contents. The higher anthocyanin levels in forest fruit tea compared to apple-cinnamon tea suggest that berry-based blends provide more bioactive pigments, consistent with previous findings on mixed fruit infusions (Kulling & Rawel, 2008).

Overall, the results demonstrate that both the total phenolic content and anthocyanin concentration vary considerably among commercially available teas, reflecting differences in plant species and composition. Cranberry and forest fruit teas stand out as particularly rich sources of antioxidants, while green tea and mint offer high phenolic content with low anthocyanins, emphasizing that antioxidant potential depends on the full phytochemical profile. These findings support the importance of selecting tea types according to their bioactive compound content and encourage further studies on the bioavailability and stability of these compounds (Chakraborty, Paul, Sharma et al., 2016).

## **Conclusion**

The analysis of polyphenol and anthocyanin content in commercially available fruit teas was conducted to determine differences in the profile of bioactive compounds. The analysis of the samples revealed significant variations in the total phenolic and anthocyanin content among the examined plant species. Among the five analyzed tea types (green tea, mint, forest fruit, cranberry, and apple-cinnamon), cranberry stood out as the richest source of both phenolic compounds and anthocyanins. Mint and green tea showed a high polyphenol content; however, their anthocyanin levels were very low. This research significantly contributes to the understanding of the chemical profile of the analyzed teas and confirms their exceptional nutritional and bioactive potential. The identified characteristics indicate that teas represent a valuable source of bioactive compounds that may have beneficial effects on human health. Furthermore, this study provides a solid foundation for future characterization of the pharmacological effects of teas and their application in the development of functional foods and nutraceuticals.

**Author Contributions:** Conceptualization, J.B. and A.K.; methodology, J.B.; investigation, A.K. and A.G.; writing—original draft preparation, J.B.; writing—review and editing, A.K. and A.G.; visualization, S.H. and N.I.; supervision, J.B. and H.N.; writing—finalization, S.H.; translation, literature

search, and data organization, A.G.; data formatting and referencing, N.I. All authors have read and agreed to the published version of the proceeding.

**Acknowledgments:** The authors thank MA Dženita Alibegić, v. ass. (Department of Pharmacy, “Džemal Bijedić” University of Mostar) for her assistance and support in the laboratory work.

## **References**

Chakraborty, S., Paul, S., Sharma, P., Mahato, S. (2016). Factors affecting polyphenol extraction from plant-based foods: a review. *Food Reviews International*, 32(5), 451–470.

Hollman, P. C. H., Tijburg, L. B. M., & Yang, C. S. (1997). Bioavailability of flavonoids from tea. *Critical Reviews in Food Science and Nutrition*, 37(8), 719–738

International Organization for Standardization (ISO). ISO 3103:2019 – Tea – Preparation of liquor for use in sensory tests. 2nd ed. Geneva: ISO; 2019.

Komes, D., Horžić, D., Belščak, A., Kovačević Ganić K., & Vulić I. (2010). Green tea preparation and its influence on the content of bioactive compounds. *Food Res Int* 43, 167-176

Kulling, S.E., Rawel, H. M. (2008). Chokeberry (*Aronia melanocarpa*) – a review on the characteristic components and potential health effects. *Molecular Nutrition & Food Research*, 52(1), 51–62

McKay, D.L., Blumberg, J. B. (2006). A review of the bioactivity and potential health benefits of peppermint tea (*Mentha piperita* L.). *Phytotherapy Research*, 20(8), 619–633

Prior, R.L., Cao, G., Martin, A., Sofic, E., McEwen, J., O'Brien, C., Lischner, N., Ehlenfeldt, M., Kalt, W., Krewer, G., Mainland, C.M. (1998). Antioxidant capacity as influenced by total phenolic and anthocyanin content, maturity, and variety of *Vaccinium species*. *Journal of Agricultural and Food Chemistry*, 46(7), 2686–2693

Rusak, G., Komes, D., Likić S., Horžić, D., & Kovač M. (2008). Phenolic content and antioxidant capacity of green and white tea extracts depending on extraction conditions and the solvent used. *Food Chem* 110(4), 852-858

Singleton, V. L., & J. A. Rossi (1965): Colorimetry of total phenols with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, 16(3)144-158.

## **Analiza sadržaja polifenola i antocijana u komercijalno dostupnim voćnim i biljnim čajevima**

Jasmina BEGOVIĆ<sup>1\*</sup> Arna KLJUČO<sup>1</sup> Nejira IDRIZOVIĆ<sup>1</sup> Sajra  
HAJDAROVIĆ<sup>1</sup> Anisa GOSTO<sup>1</sup> Haris NIKŠIĆ<sup>2</sup>

<sup>1</sup>Studij Farmacija, Univerzitet „Džemal Bijedić“ u Mostaru, Sjeverni logor b.b., 88104  
Mostar, Bosna i Hercegovina

<sup>2</sup>Farmaceutski fakultet, Univerzitet u Sarajevu, Zmaja od Bosne 8, 71000 Sarajevo, Bosna i  
Hercegovina

\*Autor za korespondenciju: Jasmina Begović, [begovicj6@gmail.com](mailto:begovicj6@gmail.com)

### **Sažetak**

Čajni napitak, koji po globalnoj potrošnji zauzima drugo mjesto odmah iza vode, ima važnu ulogu u prehrambenim običajima i kulturama širom svijeta. Popularnost proizilazi iz privlačne arome, okusa i priznatih zdravstvenih koristi. Cilj istraživanja bio je kvantitativna analiza ukupnih polifenola i monomernih antocijana u pet komercijalno dostupnih voćnih i biljnih čajeva: menta, zeleni, šumsko voće, brusnica i jabuka s cimetom. Ispitivane su razlike u profilu bioaktivnih spojeva.

Polifenoli, biljni sekundarni metaboliti u voću, povrću i čajevima, imaju snažna antioksidativna svojstva neutraliziranjem slobodnih radikala. Antocijani, podskupina polifenola odgovorna za boju, doprinose tim svojstvima, ali njihova stabilnost i bioraspoloživost ovise o temperaturi, pH i svjetlosti. Količina ukupnih polifenola izražena je kao miligram ekvivalenta galne kiseline po gramu uzorka (GAE/g). Ukupni polifenoli kretali su se od  $84,59 \pm 0,52$  GAE/g (jabuka s cimetom) do  $145,96 \pm 0,60$  GAE/g (brusnica). Sadržaj antocijana od  $0,100 \pm 0,03$  mg/l (menta) do  $8,032 \pm 0,17$  mg/l (brusnica) odražava koncentraciju pigmenata u sirovinama.

Rezultati poboljšavaju razumijevanje hemijskog profila čajeva, naglašavaju nutritivnu vrijednost i bioaktivna svojstva. Istraživanje pruža temelj za buduća ispitivanja farmakoloških učinaka i razvoj funkcionalne hrane i nutraceutika.

*Ključne riječi: čaj, polifenoli, antocijani, antioksidansi*



*SPONZORI KONGRESA*



**ROYAL ReVita<sup>®</sup> Jelly**  
Čuva zdravlje i podiže imunitet!

Matična mliječ sa ginsengom!  
**ZA REVITALIZACIJU  
ORGANIZMA I POBOLJŠANJE  
PAMĆENJA**

**BOSNALIJEK**  
*Prvo zdravlje!*

ROYAL ReVITA<sup>®</sup> Jelly  
1000 mg

84101201.05



DOX PHARM





## ***PRIJATELJI KONGRESA***



Federalno ministarstvo  
poljoprivrede, vodoprivrede  
i šumarstva

Bosna i Hercegovina  
Federacija Bosne i Hercegovine



**KANTON SARAJEVO**

MINISTARSTVO ZA NAUKU,  
VISOKO OBRAZOVANJE I MLADE

***Agencija za sigurnost hrane  
Bosne i Hercegovine  
Агенција за безбједност хране  
Босне и Херцеговине***



**MUZIČKA AKADEMIJA**  
UNIVERZITET U SARAJEVU



**Štamparija FOJNICA**  
D.O. FOJNICA|DESIGN & PRINT

