



ZBORNİK APSTRAKATA

VII NAUČNO-STRUČNI SIMPOZIJUM SA MEĐUNARODNIM UČEŠĆEM  
“PIVO, PIVARSKE SIROVINE I TRŽIŠTE”

Zrenjanin, Srbija  
24 – 25.10.2024. godine  
[www.simpozijumopivu-zrenjanin.org](http://www.simpozijumopivu-zrenjanin.org)





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VII NAUČNO – STRUČNI SIMPOZIJUM SA MEĐUNARODNIM UČEŠĆEM “PIVO, PIVARSKE SIROVINE I TRŽIŠTE”

VII Naučno-stručni simpozijum sa međunarodnim učešćem  
“PIVO, PIVARSKE SIROVINE I TRŽIŠTE”

**ZBORNİK APSTRAKATA**

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## VII NAUČNO – STRUČNI SIMPOZIJUM SA MEĐUNARODNIM UČEŠĆEM “PIVO, PIVARSKE SIROVINE I TRŽIŠTE”

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## VII NAUČNO – STRUČNI SIMPOZIJUM SA MEĐUNARODNIM UČEŠĆEM “PIVO, PIVARSKE SIROVINE I TRŽIŠTE”

Poštovani,

Velika mi je čast i zadovoljstvo da sedmu godinu zaredom, Institut za ratarstvo i povrtarstvo Novi Sad – Institut od nacionalnog značaja za Republiku Srbiju, bude jedan od organizatora simpozijuma „Pivo, pivarske sirovine i tržište“ u gradu Zrenjaninu.

Zajedničkim trudom, izuzetno kvalitetnom saradnjom, Institut od nacionalnog značaja za Republiku Srbiju i grad Zrenjanin, pokazali su koliko međusobno razumevanje i podrška mogu da daju odlične rezultate, a njihova kruna je Simpozijum koji iz godine u godinu privlači sve veći broj kako domaćih tako i svetskih stručnjaka iz ove oblasti.

Manifestacija je izvanredna prilika da posetioci čuju najnovija naučna dostignuća eminentnih stručnjaka koji se bave tehnologijom proizvodnje piva i sirovina. Institut za ratarstvo i povrtarstvo Novi Sad – Institut od Nacionalnog značaja za Republiku Srbiju već osam i po decenija razvija programe oplemenjivanja sorti pivskog ječma i hmelja na šta smo veoma ponosni.

U godinama koje su pred nama, nadam se da će Simpozijum nastaviti da se održava, razvija i privlači sve veći broj stručnjaka, kao i da će u doglednoj budućnosti prerasti u prvi kongres koji će na ovu temu biti održan u gradu Zrenjaninu.

Prof. dr Dragana Latković  
v.d. Direktora Instituta za ratarstvo i povrtarstvo,  
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VII NAUČNO – STRUČNI SIMPOZIJUM SA MEĐUNARODNIM UČEŠĆEM “PIVO, PIVARSKE SIROVINE I TRŽIŠTE”



## PLENARNA PREDAVANJA



VII NAUČNO – STRUČNI SIMPOZIJUM  
“PIVO, PIVARSKE SIROVINE I TRŽIŠTE”



## KONZUMIRANJE PIVA I ZDRAVLJE: DA LI JE ALKOHOL ZAISTA NEOPHODAN DA BI SE UŽIVALO U PIVU?

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### Sažetak:

Pivo je najstarije, a neki bi rekli i najpoznatije alkoholno piće. Od integracije u kulturu i trgovinu, ono je su igralo važnu ulogu, ne samo na regionalnom, već i na globalnom nivou. Različiti razlozi su uticali na istoriju u tehnologiji, poslovanju ali i zdravstvenim posledicama. Alkoholna pića su sastavni deo ljudskog života u mnogim regionima i kontinentima, a i obogaćuju i verske i plemenske obrede. Dakle, nije čudno da su ljudi od davnina koristili pivo i u verskim ritualima i u porodičnim obredima, uglavnom sa velikim poštovanjem. Porastom bogatstva i socijalizacije pivo je ušlo i u krugove nižih klasa. Iskustvo i znanje obrazovanih zajednica pripisivalo je razne zdravstvene prednosti pivu, ali i vinu i drugim fermentisanim pićima. Obilne studije u prošlom veku dale su rezultate od naučnog i praktičnog značaja. Klasično pivo ima sličan efekat na zdravlje kao vino, iako sadrži otprilike polovinu količine antioksidanata. Blagotvorno dejstvo piva potkrepljuju dve činjenice, mala količina alkohola, kao i prisustvo drugih jedinjenja, kao što su vitamini, minerali, elementi u tragovima, antioksidansi i fitoestrogeni, a objašnjenje je vrhunska apsorpcija i veća bioraspoloživost fenolnih kiselina piva i jedinstven sastav specijalnih prenilflavonoida dobijenih iz hmelja. Pivo je koristan deo zdrave ishrane, ali i kao osvežavajući napitak sa niskim sadržajem alkohola koji može pozitivno utiče na zdravlje, ako se konzumira na odgovoran način. Nedavni dokument o konsenzusu (2016) objavio je da redovna i umerena konzumacija piva pruža sličnu kardiovaskularnu zaštitu kao vino, ali veću od žestokih pića. Nisko-umerena (do 1 piće dnevno za žene, do 2 za muškarce), ne preterano konzumiranje piva, smanjuje rizik od kardiovaskularnih bolesti. Ovaj efekat je sličan onom kod vina, u uporedivim količinama alkohola. Međutim, ako konzumiranje pređe nivo koji je naučno i iskustveno priznat od strane medicinskih, nutricionističkih i društvenih nauka kao racionalan i zdrav, sekundarni efekti, uglavnom zasnovani na alkoholu, mogu naneti štetu zdravlju čoveka kao pojedinca, ali, nažalost, i društva u celini.

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**Ključne reči:** pivo, polifenoli, alkohol, zdravlje



## BEER CONSUMPTION AND HEALTH: IS THE ALCOHOL REALLY NECESSARY TO ENJOY THE PLEASURE OF BEER?

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### Summary:

Beer is the oldest and some would speculate the most famous alcohol beverage. Since integration into the culture and trade, they have played important roles, not just regionally, but also globally. With diverse origin, background impacted the history in technology, business but also in health consequences. The alcoholic beverages are the constituent part of human life in many regions and continents enhanced also by religious and tribe rites. So, it is not strange that from the ancient times, people have used also beer in religious rituals and in family ceremonies, mainly on very respected way. With growth of wealth and socialization beer entered common circles of lay people as well. The experience and knowledge of educated communities attributed a variety of health benefits to beer, but also wine and other fermented beverages. The abundant studies in last century have delivered results of scientific and practical importance. Classic beer has similar effect on health as wine, although it contains approximately only half the amount of antioxidants. Beneficial effects of beer are supported by two facts, the small amount of alcohol, and the presence of other compounds, such as vitamins, minerals, trace elements, antioxidants and phytoestrogens. explanation is superior absorption and higher bioavailability of the beer phenolics and unique composition of special prenylflavonoids derived from hops. Beer is useful part of a healthy diet and also as a refreshing drink with a low alcohol content that can promote well-being if consumed in a responsible manner. The recent consensus document (2016) published that regular and moderate consumption of beer confers similar cardiovascular protection as wine but greater than spirits. Low-moderate (up to 1 drink per day in women, up to 2 in men), non-bingeing beer consumption, reduces the risk of cardiovascular disease. This effect is similar to that of wine, at comparable alcohol amounts. However, if the consumption jumps over the level scientifically and experientially recognized by medical, nutrition and social sciences as rational and healthy, the secondary effects, mainly based on alcohol can cause harm to human health as individual, but unfortunately also to society as whole.

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Keywords: beer, polyphenols, alcohol, health





## KONZUMIRANJE PIVA I ZDRAVLJE: DA LI NAPREDNA ANALITIKA MOŽE DA PRUŽI PRAVE ODGOVORE TEHNOLOZIMA I POTROŠAČIMA?

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### Sažetak:

Pivo je napitak staro više od 8000-6000 godina, a proces proizvodnje se nije mnogo promenio tokom vekova, iako pivo koje se danas konzumira ima veoma drugačiji ukus od njegovih drevnih predaka.

Sadašnje vreme nudi različite tehnologije i tipove proizvodnje i kuvanja piva u cilju zadovoljenja potreba potrošača i rastuće nutritivne potrebe sa novim vrstama piva, uključujući dijetetske biljne proteine, niskokalorična piva, voćna piva, piva koja sadrže funkcionalne agense, piva bez glutena, domaća piva – u malim pivarama (u svim mogućim značenjima), nisko- i bezalkoholna piva (NAB), gde se koriste nove žitarice kao što su pirinač, sirak, proso i novi bezalkoholni kvasci (*Saccharomices* hibrids), visoko isparljivi fenoli koji proizvode *S. cerevisiae* var. *diastaticus* i cvetni ukus koji proizvodi ne-*Saccharomices* kvasac i izotoničnih piva. Pivo, bilo alkoholno ili bezalkoholno, je hranljiva materija specifičnog sastava. Rezultat je mnoštva molekula piva; neki od njih promovisu zdravlje, a neki čak i zadovoljstvo; među njima su molekuli ukusa i arome. Kvalitet piva je takođe vođen prisustvom nezdravih molekula sa negativnim senzornim atributima - među njima acetaldehida, diacetila, 3-Me-2-buten-1-tiola i biogenih amina. Biološki kvalitet piva se sastoji od njegovog senzornog profila i hemijskog sastava, čime dobija nutritivnu vrednost. Zamršeni trougao između tehnologije, nutritivne vrednosti (promovisanje zdravlja) i dopadanja potrošača (promovisanje zadovoljstva, hedonizam) mora da se garantuje i kontroliše, jer je to gradivni blok kvaliteta, originalnosti, porekla ili čak autentičnosti (terroir). Ako je tako – stiglo se do eudaimonije. Kako garantovati i pratiti? Uz ostavljanje ličnog otiska, koristeći hemijske, biomolekularne ili izotopske metode uz pomoć hemometrije i algoritama mašinskog učenja - uz naprednu analitiku. Napredna analitika može da nam pomogne u traženju konačnog odgovora - diskriminacije između "lošeg" i "dobrog" i u zadovoljenju i tehnologa i potrošača. Ali da bismo procenili, moramo tačno da znamo ko ili šta treba da bude vođa.

**Ključne reči:** napredna analitika, pivo, biološki kvalitet, hemijski sastav, ukus, originalnost, NAB



## BEER CONSUMPTION AND HEALTH: CAN ADVANCED ANALYTICS DELIVER THE RIGHT ANSWERS TO TECHNOLOGISTS AND CONSUMERS?

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### Summary:

Beer is a beverage with more than 8000-6000 years of history, and the process of brewing has not changed much over the centuries though the beer consumed today tastes very different than its ancient predecessors. Present times offer diverse technologies and beer manufacture and brewing types to fulfill the consumers' and growing nutritional demands with new types of beer, including dietary plant proteins, low-calorie beers, fruit beers, beers containing functional agents, gluten-free beers, craft-produced beers (in every possible meaning), low- and non-alcoholic beers (NAB), with new cereals being used like rice, sorghum, millet, and new non-alcoholic yeasts (*Saccharomyces* hybrids), high volatile phenols producing *S. cerevisiae* var. *diastaticus* and floral flavor producing non-*Saccharomyces* yeasts and isotonic beers. Beer, either alcoholic or non, is a nutrient with a specific composition. The result is a plethora of beer molecules; some of them are health-promoting, and some are even pleasure-promoting; among them are flavor–aroma molecules. The quality of the beer is also guided by the presence of non-health molecules with negative sensory attributes – among them acetaldehyde, diacetyl, 3-Me-2-butene-1-thiol, and biogenic amines. The biological quality of the beer is composed of its sensory profile and chemical composition, thus gaining nutritional value. The entangled triangle between technology, nutritional value (health-promoting), and consumer liking (pleasure-promoting, hedonia) must be guaranteed and monitored as it is a building block of quality, genuineness, origin, or even authenticity (terroir). If so – the eudaimonia is reached. How to guarantee and monitor? With fingerprinting, using chemical, biomolecular, or isotopic methods with the aid of chemometrics and machine learning algorithms – with advanced analytics. Advanced analytics can help us in seeking the ultimate answer – discrimination between “bad” and “good” and satisfy both technologists and consumers. But to assess, we have to know exactly who or what is to be the master!

**Keywords:** advanced analytics, beer, biological quality, chemical composition, flavor, genuineness, NAB



## PAKOVANJE PIVA – TRENDOMI ZA BUDUĆNOST

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### Sažetak:

Pivo se najčešće pakuje u staklenu, metalnu i polimernu (PET) ambalažu, koja predstavlja samo pasivnu barijeru u njegovoj zaštiti od spoljašnjih uslova sredine (kiseonik, svetlost, vlaga, mikroorganizmi). Trendovi u pakovanju pića podrazumevaju promenu strukture ambalažnih materijala i primenu novih aktivnih, inteligentnih i ekološki prihvatljivih rešenja. Proizvođači ambalaže i industrija piva sve više ulažu u održive tehnologije kako bi smanjili potrošnju energije i ugljenični otisak (upotreba laganog stakla, recikliranog aluminijuma, biorazgradive plastike, recikliranog papira, kartona, eko dizajn ambalaže). Aktivno pakovanje (AP) se odnosi na sisteme u kojima su ambalaža, proizvod i okruženje u interakciji, a dizajnirano je tako da se u tradicionalnu ambalažnu jedinicu na različite načine inkorporiraju odgovarajuće aktivne supstance. Za industriju piva značajni su apsorberi kiseonika, koji se mogu ugrađivati u strukturu jednoslojnih PET boca (ugrađuju se u polimernu smolu koja formira zid boce) ili se inkorporiraju u višeslojne boce (u sendviču između slojeva). Takođe, aktivne supstance se mogu umetati u unutrašnju stranu krunskih zatvarača, sa ulogom da “hvataju” kiseonik u parovazdušnom prostoru (headspace-u) sprečavajući neželjene oksidativne reakcije, koje dovode do degradacije kvaliteta piva. U proizvodnji limenki razvijaju se tzv. samohladeće limenke, sa duplim zidovima, u kojima se izaziva endotermna reakcija koja treba da oduzme toplotu od proizvoda (piva) i tako ga ohladi. Inteligentno pakovanje (IP) kreirano je sa namerom da nadgleda stanje upakovanog proizvoda, kako bi dalo informaciju o njegovom kvalitetu i bezbednosti, tokom roka trajanja. Sistemi IP podrazumevaju primenu različitih indikatora, senzora i identifikaciju pomoću nosača podataka (čipova). U industriji piva u primeni su indikatori ciljane temperature, koji se postavljaju na etiketu ambalaže sa svrhom da informišu potrošače kada je pivo na optimalnoj temperaturi za piće. Trendovi u pakovanju pića pokazuju jasan pravac ka održivosti uz primenu ekoloških rešenja i ambalažnih materijala koji se mogu reciklirati. Očekuje se da će potražnja za aktivnom i inteligentnom ambalažom biti u porastu u budućnosti, jer može doprineti smanjivanju bacanja hrane i pića i poboljšavanju njihovog kvaliteta i bezbednosti.

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**Ključne reči:** Održivost, aktivno i inteligentno pakovanje, pivo, kvalitet, bezbednost.



## BEER PACKAGING – TRENDS FOR THE FUTURE

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### Summary:

Beer is most commonly packaged in glass, metal and polymer (PET) packaging, which in turn provides a passive barrier for protection against external environmental conditions (oxygen, light, moisture, microorganisms). Trends in the beverage packaging sector include a change in the structure of packaging materials and the use of active, intelligent and environmentally friendly solutions. Packaging manufacturers and the beer industry are increasingly investing in sustainable technologies to reduce energy consumption and the carbon footprint (use of lightweight glass, biodegradable plastic, recyclable aluminum cans, recycled paper, cardboard, eco-design in packaging). Active packaging (AP) refers to systems in which packaging, product and environment interact and are designed to integrate appropriate active ingredients into a conventional packaging unit in different ways. For the beer industry oxygen absorbers are important and can be integrated into the structure of single-layer PET bottles (they are incorporated into the polymer resin that forms the bottle walls) or into multi-layer bottles (in a sandwich between the layers). Active ingredients can also be placed to the inside of crown caps to "scavenger" oxygen in the headspace, preventing unwanted oxidative reactions that lead to a deterioration in beer quality. One trend in can production is so-called self-chilling cans with double walls, which trigger an endothermic reaction that removes heat from the product (beer) and thus cools it down. Intelligent packaging (IP) has been developed with the aim of monitoring the condition of the packaged product to provide information on its quality and safety during the shelf life. IP systems involve the use of various indicators, sensors and identification by data carrier (tags). In the beer industry, target temperature indicators are used, which are placed on the packaging label in order to inform the consumer when the beer has reached the optimum drinking temperature. The trends in beverage packaging are clearly moving towards sustainability with the use of ecological solutions and recyclable packaging materials. The demand for active and intelligent packaging is expected to increase in the future as it can help reduce waste and improve quality and safety of food and beverages.

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**Keywords:** Sustainability, active and intelligent packaging, beer, quality, safety.



## PIVARSKI SEKTOR SRBIJE U ODNOSU NA SEKTOR PIVARSTVA ZAPADNOG BALKANA I EVROPSKE UNIJE

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### Sažetak:

Proizvodnja piva je veoma važan privredni segment kako u državama EU tako i u Republici Srbiji. Prihod od proizvodnje piva u Evropi iznosi više od 50 milijardi evra godišnje, od kojih, preko 42 milijarde, pripada poreskim prihodima. Učinak na ime akcize u Srbiji, u 2022. godini je veći od 130 miliona evra na ime plaćene akcize, dok je ukupni učinak preko 280 miliona evra. Pivarski sektor Srbije je vodeći sektor na Zapadnom Balkanu, a u odnosu na države EU taj sektor, sa svih proizvodnih aspekata, se nalazi na 14, 15 ili 16 mestu. U pivarskom sektoru Srbije direktno je angažovano oko 2.430 zaposlenih, što je za oko 10% više u odnosu na 2020. godinu i sa aspekta broja angažovanih to predstavlja jedan vid oporavka ovog sektora. U 2022. godini proizvedeno je 5,65 miliona hektolitara piva, što je 2,25% više u odnosu na proizvodnju ostvarenu u 2021. godini. U 2023. godini, po mesečnom istraživanju RZS, proizvodnja piva je iznosila 5,85 miliona hektolitara, na osnovu čega možemo pretpostaviti da će, kada dobijemo podatke iz godišnjeg istraživanja (krajem novembra), rast proizvodnje u odnosu na 2022. godinu biti veći. Pandemija COVID-19 u 2020. godini i delom u 2021. godini, je drastično uticala na pad poslovanja pivarske industrije zbog ograničenja rada ugostiteljskih objekata, organizacije muzičkih i drugih dešavanja, kao i zbog pada realizacije u turističkom sektoru, što se vidi iz statističkih podataka RZS i podataka iz Registra proizvođača piva, koji vodi Ministarstvo poljoprivrede, šumarstva i vodoprivrede.

**Ključne reči:** proizvodnja piva, poslovanje pivarskog sektora u Srbiji na osnovu podataka dobijenih iz Registra proizvođača i uslužnih punioca piva, Republičkog zavoda za statistiku i Uprava carine



## THE BREWING SECTOR OF SERBIA IN RELATION TO THE BREWING SECTOR OF THE WESTERN BALKANS AND THE EUROPEAN UNION

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### Summary:

Beer production is a very important economic segment both in EU countries and in the Republic of Serbia. The income from beer production in Europe amounts to more than 50 billion euros per year, of which over 42 billion belongs to tax revenues. The effect on behalf of excise duty in Serbia in 2022 is greater than 130 million euros on behalf of paid excise duty, while the total effect is over 280 million euros. Serbia's brewing sector is the leading sector in the Western Balkans, and in relation to EU countries, that sector, from all production aspects, is in 14th, 15th or 16th place. About 2,430 employees are directly employed in the brewing sector of Serbia, which is about 10% more than in 2020, and from the aspect of the number of employees, this represents a type of recovery of this sector. In 2022, 5.65 million hectoliters of beer were produced, which is 2.25% more than the production achieved in 2021. In 2023, according to the RZS monthly survey, beer production amounted to 5.85 million hectoliters, based on which we can assume that, when we receive the data from the annual survey (at the end of November), the growth in production compared to 2022 will be higher.

The COVID-19 pandemic in 2020 and partly in 2021 drastically affected the decline in the business of the brewing industry due to restrictions on the operation of catering facilities, the organization of musical and other events, as well as due to the decline in realization in the tourism sector, which can be seen from statistical data RZS and data from the Register of Beer Producers, which is managed by the Ministry of Agriculture, Forestry and Water Management.

**Keywords:** beer production, operations of the brewing sector in Serbia based on data obtained from the Register of Beer Producers and Service Bottlers, the Statistical Office of the Republic of Serbia and the Customs Administration



## **PRAKTIČNO ISKUSTVO KOORDINACIJE HORIZON 2020 I EJD KONZORCIJUMA I OSTVARIVANJA WIN:WIN PROCESOM POTPUNO INTEGRISANE SE EVROPE**

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### **Sažetak:**

Jugoistočna Evropa je suštinski deo Evrope. Ciljevi Evrope za budućnost neće biti ostvareni bez pune integracije Jugoistočne Evrope. Naučnici i entuzijasti iz oblasti pivarstva iz Centralne i Jugoistočne Evrope dali su svoje ideje i postavili glavne ciljeve na ovo putovanje koje je upravo počelo sa novoosnovanim Konzorcijumom na Beogradskom samitu, čiji je domaćin Poljoprivredni fakultet u Zemunu, Srbija. Ovaj konzorcijum će ubrzati opšte ciljeve Evrope i dovesti u direktne veze celokupnu industriju hrane i pića, akademsku zajednicu i buduće generacije koje tek treba da dođu. Ova prezentacija će govoriti o Horizontu 2020, praktičnom iskustvu koordinatora grupe i predsednika EJD (European Joint Doctorate Program Food Consortium). Prezentovaće praktične primere, važne savete, sugestije za dalje korake i ideje kako u potpunosti zaokružiti integraciju čitavog regiona Jugoistočne Evrope.

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## **PRACTICAL EXPERIENCE OF COORDINATING HORIZON 2020 AND EJD CONSORTIUM AND ACHIEVING WIN:WIN WITH PROCESS OF COMPLETELY INTEGRATED SE EUROPE**

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### **Summary:**

South-Eastern Europe is an essential part of Europe. Europe's goals for the future will not be accomplished, without full integration of South-Eastern Europe. The beer scientists and enthusiasts from Central and SE Europe have contributed their ideas and put their main goals on this journey which has just started with the newly established Consortium at Belgrade summit, hosted by Faculty of Agriculture in Zemun, Serbia. This consortium will accelerate Europe's overall goals and bring direct links in the entire Food and beverage industry, academia and the future generations which will follow. This presentation will talk about Horizon 2020, the practical experience of the coordinator of the group and the president of the EJD (European Joint Doctorate Program Food Consortium). Will be given practical examples, important tips, suggestions for further steps, and ideas of how to fully complete the integration of the entire region of South-Eastern Europe.

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## ŠTA SE DEŠAVA SA HMELJOM TOKOM SKLADIŠTENJA I KAKO SE TO ODRAŽAVA NA PIVO

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### Sažetak:

Kvalitet hmelja počinje da opada odmah nakon žetve; stoga je važno održati najviši mogući kvalitet. Dobar pokazatelj svežine hmelja je indeks skladištenja hmelja (HSI). Evaluiran je uticaj odležanog hmelja na kvalitet i intenzitet arome i gorčine piva u hmeljanom pivu i u suvim hmeljenim pivima. Povećanje vremena ključanja može smanjiti razliku između uzoraka odležanog hmelja različitih vrednosti HSI, što sugeriše da produženje vremena ključanja uzrokuje gubitak nekih poželjnih jedinjenja, a istovremeno prikriva određene nepravilnosti u aromi hmeljnog piva. Ako se ključanje odvija dovoljno dugo, onda odležani hmelj nije toliko problematičan sa stanovišta gorčine, jer bi negativan ukus izazvan produktima oksidacije mogao biti maskiran izo-alfa kiselinama. Uzorci piva suvog hmelja sa hmeljem sa višim HSI imaju smanjen nivo komponenti hmeljnog ulja; pa je i intenzitet hmeljne arome manji. Sa povećanjem proizvoda oksidacije, kvalitet arome takođe počinje da opada. Kvalitet gorčine je takođe smanjen, a visok HSI je takođe doveo do neželjenog izlivanja.

**Ključne reči:** hmelj, starenje, skladištenje (odležano), HSI, sensorika piva

**Priznanje:** Rad je deo istraživačkog rada u okviru projekta br. PI-0242 osnivač ARIS.



## WHAT HAPPENS TO THE HOPS DURING STORAGE AND HOW THIS IS REFLECTED IN THE BEER?

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### Summary:

The quality of hops begins to decrease immediately after harvesting; therefore, maintaining the highest possible quality is important. A good indicator of hop freshness is the hop storage index (HSI).

The impact of aged hops on the quality and intensity of beer aroma and bitterness in kettle hopped and in dry hopped beers was evaluated. Increasing the boiling time can decrease the difference between samples hopped with hops of different HSI values, suggesting that extending the boiling time causes a loss of some desirable compounds while also hiding some irregularities in hoppy beer aroma. If boiling is conducted for a long enough time, then aged hops are not so problematic from the view of bitterness, since the negative aftertaste caused by oxidation products could be masked by iso-alpha-acids.

Beer samples dry hopped with higher-HSI hops have decreased levels of hop oil components; therefore, the intensity of the hop aroma is lower. With the increase in oxidation products, the quality of the aroma also begins to decline. The quality of bitterness was also reduced and high HSI also led to undesirable gushing.

**Keywords:** hops, aging, hopping, HSI, beer sensorics

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## NAJBOLJE PRAKSE U DEFINISANJU SENZORIKE PIVA

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### **Sažetak:**

Za potrošače piva i za pivare, svežina je na prvom mestu. Od želje da se pojavite na putovanju otkrivanja ukusa i različitih tehnika iz celog sveta do povezivanja sa ljudima koristeći dodir društvenog maziva, može biti mnogo različitih motivatora u pozadini konzumiranja piva. Međutim, postoji jedna istina koja ih ujedinjuje; Sveže pivo ima najbolji ukus. Kao i svaki napravljeni proizvod, postoje određeni standardi kvaliteta i specifikacije koje se moraju ispuniti. Pivarska industrija je puna specifikacija i metoda koje mere sve aspekte proizvoda kako bi se donela uniformnost i nivo doslednosti na tehnološkom nivou. Ipak, još uvek nedostaje jedan standard kvaliteta i industrije; Svežina. Dok mnoga pića ostaju stabilna po ukusu do godinu dana, znamo da pivo gubi svežinu usled oksidacije i promene ukusa u roku od nekoliko nedelja od pakovanja. Rok trajanja je dati industrijski standard, ali to ne meri potencijal svežine kako bi se osiguralo da pivo ostane „sveže dok se ne konzumira“. Prethodni tehnološki radovi su izveštavali o mogućim uzrocima i rešenjima, od optimizacije procesa, dizajna postrojenja i specifikacija sirovina. Iako je tehnologija elektronske spin rezonance dobro uspostavljena, njena primena za produženje roka trajanja, u skladu sa stručnim senzornim panelima, je nova. Ovaj rad će se fokusirati na poboljšanja svežine napravljenim od nekoliko studija o pivarstvu, koje uključuju merenje slobodnih radikala u toku procesa pivarstva i kombinovanje instrumentalnih i senzornih metoda, kako sada možemo primeniti jednu, lako prepoznatljivu vrednost za vek trajanja svežine. Novi industrijski standard. Autor će predstaviti podatke prikupljene od brojnih pivara, koji pokazuju direktnu korelaciju između slobodnih radikala i senzornih vrednosti, dajući nam koncizan pristup određivanju roka trajanja svežine.

Radionica će sadržati praktičnu sesiju, sa prezentacijom 4 različita GMP referentna standarda za pivo koji predstavljaju probleme piva tokom skladištenja.

**Ključne reči:** Svežina piva, rok trajanja i senzornost



## BEER SENSORY BEST PRACTICES

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**DOI:** 10.5937/PIVOS24007G

### Summary:

Freshness is front of mind for consumers of beer and brewers alike. From a desire to become immersed in a journey of discovery of flavours and different techniques from around the world to connecting with people using a touch of social lubricate, there can be many different motivators behind consuming beer. But there is one unifying truth; Fresh Beer tastes best. Like any product made, there are certain quality standards and specifications that must be met. The brewing industry is full of specifications and methods measuring all aspects of the product to bring uniformity and a level of consistency on a technical level. However, there is one quality and industry standard still missing; Freshness. Whilst many beverages remain flavour stable for up to a year, we know that beer loses freshness due to oxidation and flavour change within a few weeks of packaging. A Best Before date is a given industry standard, but this does not measure the Freshness potential in ensuring that a beer remains 'fresh until consumed'. Previous technical papers have reported on possible causes and solutions, from process optimisation, plant design and raw material specifications. Although the technology of electron spin resonance is well established, its application to deliver increased shelf-life, in-line with expert sensory panels is novel. This paper will focus on the freshness improvements made from several brewery studies involving the measurement of free radicals across the brewing process and through combining instrument and sensory methods, how we can now apply one, easily recognised value for Freshness Shelf-life. A new industry standard. The author will present data collected from a number of breweries, showing a direct correlation between free radicals and sensory values, giving us a concise approach to determining Freshness Shelf-life.

Workshop will contain practical session, with a presentation of 4 different GMP Beer Reference Standards representing problems of beers during storage.

**Keywords:** Beer Freshness, Shelf-life, Sensory



## PREDAVANJA PO POZIVU



VII NAUČNO – STRUČNI SIMPOZIJUM  
“PIVO, PIVARSKE SIROVINE I TRŽIŠTE”



## MAPA ZANATSKIH PROIZVOĐAČA PIVA U SRBIJI

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**DOI:** 10.5937/PIVOS24008S

### Sažetak:

Rad daje prikaz aktivnosti unutar projekta mapiranja svih zanatskih pivara u Srbiji, koje podrazumeva kreiranje sveobuhvatne i ažurne geografske i informativne baze podataka svih lokalnih malih i nezavisnih pivara. Ovaj projekat uključuje identifikaciju lokacija ovih pivara, kategorizaciju na osnovu njihove ponude i specifičnosti i integraciju svih informacija od značaja za krajnjeg korisnika. Ciljevi projekta su: Podizanje svesti o zanatskim pivarima u Srbiji i njihovoj raznolikosti; pružanje korisnih informacija turistima i ljubiteljima piva; podrška razvoju lokalne industrije piva i promocija mikro i malih preduzeća; kao i kreiranje resursa koji će olakšati povezivanje između pivara i krajnjeg potrošača. Ovaj projekat će igrati ključnu ulogu u razvoju i promociji zanatskog piva u Srbiji, doprinoseći rastu i razvoju ove dinamične industrije.

Kratkoročni rezultati su:

1. Sveobuhvatna baza podataka sa informacijama o svim zanatskim pivarima u Srbiji, uključujući njihove lokacije, kontakt podatke i vrste piva koje proizvode
2. Razvijena i dostupna mapa koja vizualizuje lokacije pivara i omogućava korisnicima da lako pronalaze pivare u njihovoj blizini.
3. Promocija zanatske proizvodnje piva: organizovane promotivne aktivnosti i kampanje za podizanje svesti o značaju zanatske proizvodnje piva, uključujući događaje, društvene mreže i medijske objave.

Dugoročni rezultati:

1. Razvoj industrije zanatskog piva kroz povećanu vidljivost i podršku zanatskim pivarima, što vodi do većeg interesovanja potrošača i većeg rasta industrije.
2. Jačanje lokalne zajednice putem podrške lokalnim preduzećima i uticaj na razvoj lokalnih ekonomija kroz promociju malih zanatskih pivara.
3. Povećana dostupnost informacija o zanatskim pivarima, što poboljšava iskustvo potrošača i njihovu sposobnost da razlikuju zanatsko u odnosu na industrijska piva i otkriju nova piva i nezavisne male pivare.
4. Dugoročna promocija i integracija kroz stalnu promociju i integraciju projekta u širu gastronomsku i turističku ponudu Srbije, uključujući saradnju sa turističkim organizacijama i agencijama.

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## MAP OF THE CRAFT BREWERS IN SERBIA

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**DOI:** 10.5937/PIVOS24008S

### Summary:

The paper presents the activities within the mapping project of all craft breweries in Serbia, which entails compiling of a comprehensive and up-to-date geographical and informational database of all local small and independent breweries. This project includes the identification of the locations of these breweries, the categorization based on their offer and specificity and the integration of all information relevant to the end user. The goals of the project are: Raising awareness about craft breweries in Serbia and their diversity; providing useful information to tourists and beer lovers; support for the development of the local beer industry and promotion of micro and small enterprises; as well as creating the resources that will facilitate the connection between the brewer and the end consumer. This project plays a key role in the development and promotion of craft beer in Serbia, contributing to the growth and development of this dynamic industry.

The short-term results are:

1. Comprehensive database with information about all craft breweries in Serbia, including their location, contact information and types of beer they produce
2. Developed and accessible map that visualizes brewery locations and allows users to easily find breweries near them.
3. Promotion of craft beer production: organized promotional activities and campaigns to raise awareness of the importance of craft beer production, including events, social networks and media announcements.

Long-term results:

1. Development of the craft beer industry through increased visibility and support for craft brewers, leading to greater consumer interest and greater industry growth.
2. Strengthening the local community by supporting local businesses and influencing the development of local economies through the promotion of small craft breweries.
3. Increased availability of information on craft beer, which improves the consumer experience and their ability to differentiate between craft and industrial beers and discover new beers and independent small breweries.
4. Long-term promotion and integration through constant promotion and integration of the project into the wider gastronomic and tourist offer of Serbia, including cooperation with tourist organizations and agencies.

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## UVIDI U RAZVOJ NOVIH SOJEVA PIVSKOG KVASCA KROZ ADAPTIVNU LABORATORIJSKU EVOLUCIJU

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**Sažetak:**

Industrija zanatskog piva sve više istražuje alternativne sirovine kako bi stvorila nove stilove piva. Heljda, pseudožitarica bez glutena, bogata llineralima i bioaktivnim jedinjenjima, predstavlja obećavajuću opciju. Međutim, fermentacija heljdine sladovine predstavlja izazove, posebno u pogledu performansi kvasca. U ovoj studiji izalovali smo divlje sojeve *Saccharamices cerevisiae* izolovane iz slavenačke fermentacije kao i iz prirodnog okruženja, a na osnovu skrininga odabrali smo soj koji je dodatno prilagođen za fermentaciju heljde i ječmene sladovine u stresnim uslovima pivarstva korišćenjem adaptivne laboratorijske evolucije (A.pE). Preko 30 uzastopnih fermentacija, populacije kvasca su bile izložene hidrostatičkom pritisku i CO<sub>2</sub> stresu, simulirajući industrijske uslove. Genomske analize su otkrile značajne događaje gubitka heterozigotnosti (LOH) i aneuploidiju kod evoluiranih klonova, posebno na manjim hromozomima, što sugerise da su ove promene igrale ključnu ulogu u poboljšanju iskorišćenja maltoze i maltatrioze, posebno u heljdinoj sladovini. Štaviše, klonovi prilagođeni heljdi pakazali su veću hromozomsku nestabilnost, uključujući gubitak mitohondrijske DNK, što je rezultiralo fenotipovima sa respiratornim nedostatkom. Studija naglašava složene genomske mehanizme koji su u osnovi adaptacije kvasca na alternativne supstrate za pivare, nudeći uvid u razvoj sojeva kvasca optimizovanih za proizvodnju piva bez glutena.

**Ključne reči:** heljdin slad, autohtoni kvasci, adaptivna laboratorijska evolucija (ALE), genomika

**Priznanje:** Rad je podržala Slovenačka istraživačka arencija (ARRS J4-4652 i MRIC IC-ZIM).



## INSIGHTS INTO THE DEVELOPMENT OF NOVEL BREWING YEAST STRAINS THROUGH ADAPTIVE LABORATORY EVOLUTION

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### Summary:

The craft beer industry is increasingly exploring alternative raw materials to create novel beer styles. Buckwheat, a gluten-free pseudocereal rich in minerals and bioactive compounds, presents a promising option. However, fermenting buckwheat wort poses challenges, especially regarding yeast performance. In this study, we isolated wild *Saccharomyces cerevisiae* strains isolated from Slovenian fermentations as well as from natural environments, and based on screening we selected a strain that was further adapted for buckwheat and barley wort fermentations under stressful brewing conditions using adaptive laboratory evolution (ALE). Over 30 successive fermentations, yeast populations were exposed to hydrostatic pressure and CO<sub>2</sub> stress, simulating industrial conditions. Genomic analyses revealed significant loss-of-heterozygosity (LOH) events and aneuploidy in evolved clones, particularly on smaller chromosomes, suggesting that these changes played a key role in improving maltose and maltotriose utilization, especially in buckwheat wort. Furthermore, clones adapted to buckwheat exhibited higher chromosomal instability, including mitochondrial DNA loss, resulting in respiratory-deficient phenotypes. The study highlights the complex genomic mechanisms underlying yeast adaptation to alternative brewing substrates, offering insights into the development of yeast strains optimized for gluten-free beer production.

**Keywords:** buckwheat wort, autochthonous yeasts, adaptive laboratory evolution (ALE), genomics

**Acknowledgement:** The work has been supported by Slovenian Research Agency (ARRS J4-4552 and MRIC IC-ZIM).



## PROBIOTIKACIJA I FUNKCIONALNOST PIVA

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### Sažetak:

Funkcionalna hrana dobija pažnju od potrošača, koji zahtevaju hranu koja može da ispuni nutritivne potrebe, pomaže u održavanju uravnotežene ishrane i takođe imaju blagotvoran uticaj na zdravlje ljudi.

Pivo je gazirano alkoholno piće koje je prihvaćeno na svetskom nivou i njegova umerena konzumacija je povezana sa antiinflamatornim i antioksidativnim svojstvima, prednostima za gustinu kostiju i prevenciju koronarnih bolesti. Pivo takođe ima bolji nutritivni sastav u odnosu na većina alkoholnih pića, koja sadrže dovoljnu količinu hranljivih materija poput ugljenih hidrata, proteina i aminokiselina, minerala, vitamina i polifenola, bez dodatka veštačkih aditiva ili konzervansa. Polifenoli, nastali iz slada i hmelja, glavni su prirodni antioksidansi u pivu koji doprinose njegovim funkcionalnim svojstvima. U cilju daljeg povećanja ovih karakteristika piva, danas, specijalna piva, poput niskoalkoholnih ili čak bezalkoholnih piva, piva bez glutena, zanatskih piva, nepasterizovanih, nefiltriranih, sa dodatkom voća, sokova, biljnih ekstrakata itd., dostupni su na tržištu ili se istražuju. Još jedna važna karakteristika funkcionalne hrane je njihova povezanost sa prisustvom probiotika. Međutim, jedan od glavnih izazova uticaja probiotika na zdravlje je održavanje visoke održivosti (> 100 CFUig) tokom obrade i skladištenja hrane. Međutim, kako pivo sadrži iso-alfa-kiseline, etanol i nizak pH, koji sprečavaju rast i opstanak probiotičke bakterije mlečne kiseline, upotreba novih strategija, kao što je inkapsulacija, je ključna kako bi se održao njihov opstanak. Stoga su u ovoj studiji istaknute glavne nutritivne karakteristike i funkcionalne karakteristike piva (običnih i posebnih piva), u kombinaciji sa nedavnim istraživačkim aktivnostima na terenu. Uzimajući u obzir proizvodnju piva u Grčkoj, neki noviji eksperimentalni radovi su predstavljeni sa fokusom na dodavanje voćnih sokova u proizvodnju piva, korišćenje mikrokapsuliranja za poboljšanje probiotika u pivu i proceni potencijalne superiornost zanatskih i bezalkoholnih piva u poređenju sa običnim pivom. Ovaj rad naglašava veliki potencijal piva (posebno ne-alkoholnog) u svrhu funkcionalne hrane i sredstva za unošenje probiotika.

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**Ključne reči:** zanatsko pivo, probiotik, inkapsulacija, antioksidans, ishrana



## BEER PROBIOTICATION AND FUNCTIONALITY

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### Summary:

Functional foods are gaining the attention of consumers, who demand foods that can fulfil nutritional needs, help maintain a balanced diet and also possess a beneficial impact on human health. Beer is a carbonated alcoholic beverage with worldwide acceptance and its moderate consumption has been associated with anti-inflammatory and antioxidant properties, benefits for bone density, and the prevention of coronary heart disease. Beer also presents better nutritional composition compared to the majority of alcoholic beverages, containing sufficient amount of nutrients like carbohydrates, protein and amino acids, minerals, vitamins, and polyphenols, without the addition of artificial additives or preservatives. Polyphenols, originated from malt and hops are the major natural antioxidants in beer that contribute to its functional properties. In order, to further increase these beer characteristics, nowadays, special beers, like low-alcohol or even non-alcoholic beers, gluten-free beers, craft beers, unpasteurized, unfiltered, with the addition of fruits, juices, plant extracts etc., are available in the market or under research. Another important feature of functional foods is their association with the presence of probiotics. However, one of the main challenges of exerting probiotics' health effects, is the maintenance of high viability ( $> 10^6$  CFU/g) during food processing and storage. However, as beer typically contains hop iso- $\alpha$ -acids, ethanol, and low pH, which prevent the growth and survival of probiotic lactic acid bacteria, the use of new strategies, like encapsulation, is crucial to retain their survival. Therefore, in the present study the main nutritional features and functional characteristics of beers (both regular and special beers) are highlighted, in combination with the recent research activities in the field. Taking into account the beer production in Greece some recent experimental works are presented focusing on the addition of fruit juices in beer production, the use of microencapsulation to enhance beer probiotication, and evaluating the potential superiority of craft and non-alcoholic beers compared to regular beers. The present work highlights the great potential of beer (especially non-alcoholic) to serve as functional food and vehicle of probiotic delivery.

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**Keywords:** craft beer, probiotic, encapsulation, antioxidant, nutrition



## PIVO KAO FUNKCIONALNO PIĆE?

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### Sažetak:

Ekspanzija pivske industrije otvorila je brojne mogućnosti u smislu poboljšanja okusa, mirisa i funkcionalnosti ovog pića. Problemi vezani uz zdravlje i opća želja za zdravijim stilom života rezultirali su povećanom potražnjom za funkcionalnim pivima. Dodavanje različitih biljaka ili dodataka sladovini ili pivu poznato je stoljećima. Međutim, današnje tehnologije omogućuju lakše načine za to i nude dodatna funkcionalna svojstva za zdravstvene prednosti i senzorne prilagodbe klasičnog piva. Medicinski, vjerski ili trendovski razlozi za izbjegavanje određenih spojeva u pivu ili potreba za uključivanjem novih u recepturu piva proširili su tržište za pivarsku industriju i učinili pivo dostupnijim potrošačima koji su do sada izbjegavali pivo. Slabo-alkoholna, bezalkoholna, piva ili/i radleri danas su sve popularniji među potrošačima. Ne samo pivo je prepoznato kao platforma za funkcionalna pića, već i sladovina. U nekim se zemljama tradicionalno konzumiraju pića na bazi sladovine, a ovaj trend traži put i na regionalno tržište. Mnoge su pivovare počele proizvoditi mješavine pića na bazi sladovine s različitim okusima i sokovima koji im daju dodatnu vrijednost.

**Ključne reči:** pivo; funkcionalno piće; sladovina; suvremeni potrošač;



## BEER AS A FUNCTIONAL BEVERAGE?

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### Summary:

The expansion of the beer industry has enabled many possibilities for improvement regarding the taste, aroma and functionality of this drink. Health-related issues and a general wish for healthier lifestyles has resulted in increased demand for functional beers. The addition of different herbs or adjuncts in wort or beer has been known for centuries. However, today's technologies provide easier ways to do this and offer additional functional properties for the health benefits and sensory adjustments of classical beer. Medicinal, religious or trendy reasons for avoiding certain compounds in beer or the need to involve new ones in the brewing recipe has broadened the market for the brewing industry and made beer more accessible to consumers who, till now, avoided beer. Low-alcohol, non-alcohol, radlers are today's craze among consumers. Not only beer has been recognized as a platform for functional beverages, but wort as well. In some countries wort-based beverages are traditionally consumed, and this trend seeks its way into regional market as well. Many breweries started producing wort-based beverage mixtures with different flavors and juices which add value to it.

**Keywords:** beer; functional beverages; wort; modern consumer;



## UTJECAJ STUPNJA USITNJENOSTI ZRNA NA ODNOS FERMENTABILNOG I NEFERMANTABILNOG EKSTRAKTA U KOMINAMA DOBIVENIM OD JEČMNOG SLADA, NESLAĐENE PŠENICE I PŠENIČNOG SLADA

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DOI: 10.5937/PIVOS24012K

### Sažetak:

Ovaj rad je dio šireg istraživanja primjene “hard red winter” tipa pšenica, bilo kao neslađene sirovine bilo kao slada, iz domaćeg sortimenta ali i stranih sorti uvedenih u uzgoj, budući da su pokazale vrlo dobra pivarska svojstva. One osim navedenog imaju i brojne agrotehničke prednosti pri uzgoju. Karakterizira ih mješovita (mramorirana) tekstura endosperma zrna te iako pripadaju “hard” tipu tijekom procesuiranja pokazuju mnoge osobine svojstvene “soft” tipu pšenice. Ispitivan je utjecaj pripreme zrna za usipak (izmeljavanje) posljedično utječe na sve daljnje procese u proizvodnji piva. Cilj je bio ustanoviti utjecaj granulacije zrna na sastav usipka i njegovu fermentabilnosti, tj. odnos fermentabilnog i nefermantabilnog ekstrakta u kominama. Za istraživanje je odabrane pšenična sorta koja je u prethodnim istraživanjima dala izvrsne rezultate i kao neslađena i kao slad, te su tijekom pripreme komina kombinirane sa ječmenim sladom (50:50). Proizvedene su komine/sladovine koje su analizirane standardnom pivarskom analitikom (EBC, MEBAK). Kod pšeničnih uzoraka rezultati pokazuju da bez obzira na polaznu razliku za ukupne proteine (TP) su koncentracije ukupnih topljivih proteina (TSP) i visokomolekulske proteinske frakcije (HMW N) slične, pšenični slad prati vrijednosti dobivene kod pšenice uz niži TP i slične vrijednosti za TSP, dok je za ječmeni slad unatoč značajno nižem TP koncentracija TSP bila značajno viša u odnosu na pšenicu i pšenični slad. Razlika koja se javlja u polaznim koncentracijama TP za pšenicu i pšenični slad je razlika u koncentraciji netopljivih proteinskih frakcija koja se tijekom ukomnjavanja eliminiraju. Nadalje, povećanjem finoće mljevenja zrna ( $\emptyset$  : 1 mm  $\rightarrow$  0,2 mm  $\rightarrow$   $\emptyset$  0.2 mm) tijekom ukomnjavanja dolazi do veoma značajnog porasta srednjemolekulske proteinske frakcije (MMW N) kod pšenice sa nižim i višim polaznim TP dok su za pšenične sladove karakteristične viša vrijednosti za visokomolekulske proteinske frakcije (HMW N) i slične vrijednosti za MMW N. Ovaj porast je kod pšenice sa nižom TP izraženiji, iako su polazne koncentracije TSP kod fine ( $\emptyset=0.2\text{mm}$ ) i najfinije meljave ( $\emptyset=0.2\text{ mm}$ ) bile slične. Kod ove pšenice, iako ima višu koncentraciju finog ekstrakta u komini u odnosu na pšenicu sa značajno višom polaznom koncentracijom proteina, također dolazi do značajnog pada fermentabilnosti kod najfinije granulacije usipka. Ječmeni slad je imao značajno više vrijednosti za HMW N i više vrijednosti za MMW N u odnosu na pšenice i pripadajuće pšenične sladove. Povećanjem finoće meljave zrna dolazi do značajnog porasta finog ekstrakta u komini ali i značajnog porasta MMW N frakcija u njoj što posljedično dovodi ili do značajnog smanjenja fermentabilnosti ili do zadržavanja fermentabilnosti na približno istoj razini kod fine granulacije usipka ( $\emptyset$  0,2 mm) za pšenicu i nešto manje izraženo za pšenične sladove. Ovaj efekat je izraženiji za pšenicu sa nižim polaznim TP. MMW N proteinske frakcije pšenice i pšeničnih sladova pokazuju značajno veći afinitet prema vezanju sa



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taninskom kiselinom u odnosu na ječmeni slad. Povećanje finoće meljave zrna nije uzrokovalo porast viskoznost ni kod pšenica sa nižim ni sa višim udjelom TP.

**Ključne reči:** slad; pšenica, pošenični slad, stupanj užitjavanja usipka; fermentabilnost komine





## THE INFLUENCE OF MILLING GRANULATION ON THE PROPORTION OF FERMENTABLE AND NON-FERMENTABLE INGREDIENTS IN MASH OBTAINED FROM BARLEY MALT, UNMALTED WHEAT AND WHEAT MALT

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### Summary:

This work is part of a wider research on the application of "hard red winter" type wheat, either as unmalted raw material or as malt, from the domestic assortment as well as foreign varieties introduced into cultivation, since they have shown very good brewing properties. In addition to the above, they also have numerous agrotechnical advantages during cultivation. They are characterized by a mixed (marbled) texture of the grain endosperm, and although they belong to the "hard" type, during processing they show many characteristics characteristic of the "soft" type of wheat. The influence of the preparation of grains for grinding (grinding) was examined, which consequently affects all further processes in the production of beer. The goal was to establish the influence of grain granulation on the composition of the mash and its fermentability, i.e. the ratio of fermentable and non-fermentable extract in wort. A wheat variety was chosen for the research, which in previous research gave excellent results both as unmalted and as malted, and during the preparation of the mash, they were combined with barley malt (50:50). The mashes/worts were produced and analyzed by standard brewing analysis (EBC, MEBAK). In the case of wheat samples, the results show that regardless of the initial difference for total proteins (TP), the concentrations of total soluble proteins (TSP) and high molecular weight protein fraction (HMW N) are similar, wheat malt follows the values obtained in wheat with lower TP and similar values for TSP, while for barley malt, despite a significantly lower TP, the concentration of TSP was significantly higher compared to wheat and wheat malt. The difference that occurs in the starting concentrations of TP for wheat and wheat malt is the difference in the concentration of insoluble protein fractions that are eliminated during milling. Furthermore, by increasing the grain fineness ( $\emptyset$ : 1 mm  $\rightarrow$  0.2 mm  $\rightarrow$   $\emptyset$  0.2 mm) during mashing, there is a very significant increase in the medium molecular protein fraction (MMW N) in wheats with lower and higher initial TP, while for wheat malts they are characteristically higher values for high molecular weight protein fractions (HMW N) and similar values for MMW N. This increase is more pronounced in wheat with lower TP, although the initial concentrations of TSP in fine ( $\emptyset=0.2$ mm) and the finest ground meal ( $\emptyset=0.2$  mm) were similar. With this wheat, although it has a higher concentration of fine extract in the pomace compared to wheat with a significantly higher starting protein concentration, there is also a significant drop in fermentability at the finest granulation of the grain. Barley malt had significantly higher values for HMW N and higher values for MMW N compared to wheat and associated wheat malts. By increasing the fineness of ground grains, there is a significant increase in the fine extract in the mash, but also a significant increase in the MMW N fractions in it, which consequently



leads to either a significant decrease in fermentability or to keeping fermentability at approximately the same level in the case of fine granulation ( $\emptyset$  0.2 mm) for wheat and somewhat less pronounced for wheat malts. This effect is more pronounced for wheat with a lower initial TP. MMW N protein fractions of wheat and wheat malts show a significantly higher affinity for binding with tannic acid compared to barley malt. An increase in the fineness of the milled grain did not cause an increase in viscosity either in wheat with a lower or higher TP content.

**Keywords:** barley malt; wheat, wheat malt, grist milling degree; mash fermentability



## EVALUACIJA OSOBINA KVALITETA I PRINOSA NS SORTI JEČMA U VEGETACIONOJ SEZONI 2023/24

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### Sažetak:

Oplemenjivanje pivarskog ječma u Institutu za ratarstvo i povrtarstvo u Novom Sadu ima tradiciju dužu od sedamdeset godina. Tokom ovog perioda je stvoren i registrovan veliki broj sorti ječma ozimog i jarog tipa, koje su se izdvojile po visokom genetskom potencijalu za prinos i dobrim karakteristikama tehnološkog kvaliteta potrebnim za proizvodnju slada. Cilj ovoga rada je bio da se ispituju sorte dvoredog ozimog ječma koje su u poslednjih 10 godina stvorene u Institutu za ratarstvo i povrtarstvo i registrovane za potrebe industrije slada. Ukupno je ispitivano 6 NS sorti na lokalitetu Rimski šančevi u 2023/24. godini. Ogljed je postavljen po slučajnom blok dizajnu na 10 m<sup>2</sup> u četiri ponavljanja uz primenu standardnih agrotehničkih mera. Kod tri ponavljanja su primenjeni svi potrebni tretmani za zaštitu od bolesti, dok je četvrto ponavljanje poslužilo kao kontrola, odnosno tretiranje je izostavljeno. Tokom vegetacione sezone i nakon žetve beležena su važna agronomska svojstva: klasanje, broj klasova po m<sup>2</sup>, pojava bolesti, poleganje, prinos zrna, sadržaj proteina i svi važni parametri tehnološkog kvaliteta dobijeni u procesu mikroskladovanja. Sve ispitivane sorte su imale ujednačeno klasanje u vremenskom intervalu od tri dana (10. 4 – 13. 4. 2024.). Sadržaj proteina u tretiranom bloku se kretao od 9,4% do 11,2%, dok su se proteini kod sorti u netretiranom bloku bili viši i kretali su se od 9,9% do 13,3%. Zrno I klase je kod svih sorti iznosilo preko 95%. Vrednosti suvog ekstrakta su se kretale od 76,7%, do 80,3%. Kolbahov indeks je varirao od 33,4 do 42,1, a vrednost Hartonga je iznosila od 33,2% do 40,7%. Sve sorte su pokazale odličnu otpornost na poleganje. Sve veći zahtevi industrije i potražnja za novim ukusima piva, kako u velikim multinacionalnim kompanija tako i u malim zanatskim pivarama, predstavljaju odličnu mogućnost za upotrebu novosadskih sorti pivarskog ječma u proizvodnji slada čime bi se obezbedila veća divergentnost postojećeg dostupnog sortimenta, izvrsnost, stvorili novi izazovi i posebnost u proizvodnji piva.

**Ključne reči:** agronomske karakteristike, kvalitet, mikroskladovanje, sorte ječma

**Zahvalnica:** Rad je deo projekta finansiran od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, evidencioni broj 451-03-66/2024-03/200032.



## EVALUATION OF QUALITY TRAITS AND YIELD IN NS BARLEY VARIETIES DURING THE 2023/24 GROWING SEASON

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### Summary:

Breeding of malting barley at the Institute of Field and Vegetable Crops in Novi Sad has a tradition spanning more than seventy years. During this period, a large number of winter and spring barley varieties have been developed and registered, which have stood out for their high genetic yield potential and good technological quality required for malt production. The aim of this study was to examine two-row winter barley varieties that have been developed at the Institute of Field and Vegetable Crops over the past 10 years and registered for the malt industry. A total of six NS varieties were tested at the Rimski šančevi location in the 2023/24 season. The experiment was set up in a randomized block design on 10 m<sup>2</sup> plots with four replications, applying standard cultivation practices. All necessary pathogen control treatments were applied in three replications, while the fourth replication served as a control and was untreated. During the growing season and after harvesting, important agronomic traits were recorded: heading, number of ears per m<sup>2</sup>, disease occurrence, lodging resistance, grain yield, protein content, and all important technological quality parameters obtained from the micro-malting process. All tested varieties had uniform heading within a three-day interval (April 10–13, 2024). Protein content in the treated block ranged from 9.4% to 11.2%, while protein levels in the untreated block were higher, ranging from 9.9% to 13.3%. The percentage of first-class grain for all varieties was over 95%. Dry extract values ranged from 76.7% to 80.3%. The Kolbach index varied from 33.4 to 42.1, and the Hartong value ranged from 33.2% to 40.7%. All varieties demonstrated excellent lodging resistance. Increasing demands from the industry and the growing demand for new beer flavors, both in large multinational companies and small craft breweries, present an excellent opportunity for the use of NS malting barley varieties in malt production, which would ensure greater diversity in the available assortment, excellence, and create new challenges and uniqueness in beer production.

**Keywords:** agronomic traits, barley varieties, micro-malting, quality

**Acknowledgement:** The research is part of a project funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, record number 451-03-66/2024-03/200032.



## POREKLO NOVE SORTE HMELJA IZ BAČKOG PETROVCA ZA PRIMENU U INDUSTRIJI ZANATSKOG PIVA

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### Sažetak:

U Srbiji je proizvodnja hmelja (*Humulus lupulus* L.) rapidno opala tokom poslednje 2 decenije (878t u 2001., <10t u 2021.), a oplemenjivanje i razvoj novih sorti hmelja prestalo je 2010. godine. Međutim, Srbija ne samo da se odlikuje klimom koja je optimalna za proizvodnju hmelja (između 35 i 55 stepena geografske širine), već poseduje i izuzetno važan genetički resurs koji je danas potpuno neiskorišćen: divlji hmelj, kao i poludivlji hmelj, nastao naturalizacijom komercijalnih sorti nekad gajenih na danas napuštenim hmeljarnicama. Divlji i poludivlji hmelj ne samo da imaju visok potencijal za primenu u industriji zanatskog piva (primer: američka pivara Sierra Nevada), već se zbog specifičnog hemijskog sastava šišarica nastalog u lokalnim klimatskim uslovima, mogu koristiti za proizvodnju ekskluzivnog piva jedinstvenog i prepoznatljivog ukusa (terroir), koje će biti cenjeno od strane konzumenata zanatskog piva prefinjenog ukusa. U Srbiji su danas registrovane 3 internacionalne i 3 domaće sorte hmelja. Naši ciljevi su da obnovimo kako oplemenjivanje tako i proizvodnju hmelja putem razvoja nove sorte aromatičnog hmelja koja je pogodna za gajenje na našem području. U okviru projekta finansiranog od strane Fonda za inovacionu delatnost Republike Srbije (Hopseeker, ID projekta 51815), klonski je umnoženo 18 divljih i poludivljih genotipova hmelja iz Vojvodine sakupljenih iz prirode, procenjen je hemijski sastav njihovih šišarica u odnosu na relevantna jedinjenja koja određuju kvalitet i ekskluzivnost piva, šišarice su iskorišćene za proizvodnju piva u 12 lokalnih zanatskih pivara, a proizvedeno pivo ocenjeno je kako od strane profesionalaca tako i od strane potrošača. Na ovaj način su odabrane biljke hmelja (genotipovi) čije šišarice su korišćene za proizvodnju piva najboljih karakteristika, i podnet je zahtev Ministarstvu poljoprivrede, šumarstva i vodoprivrede Republike Srbije za njihovu registraciju kao nove sorte hmelja u našoj zemlji. Genetičke analize svih 18 genotipova hmelja korišćenih u projektu primenom jedarnih mikrosatelita i njihovo poređenje sa oko 600 genotipova komercijalnih sorti i divljih hmeljeva pokazale su da se radi isključivo o poludivljim hmeljevima koji su nastali hibridizacijom sa komercijalnim sortama i koji su usled toga stekli nove osobine. Determinisani jedinstveni genetički profili nove sorte hmelja koja će imati zaštićenu oznaku porekla i koja će biti registrovana u Srbiji, poslužiće za zaštitu prava proizvođača kao i žiga.

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**Ključne reči:** divlji i poludivlji aromatični hmelj, lokalno adaptirani genotipovi, zapostavljen genofond hmelja, zanatsko pivo, intelektualna svojina

**Zahvalnica:** Projekat finansira Fond za inovacionu delatnost iz Pretpristupnih fondova Evropske unije i budžeta Republike Srbije sa razdela Ministarstva prosvete, nauke i tehnološkog razvoja, naziv projekta Hopseeker, broj projekta 51815.



## AN ORIGIN OF THE NEW AROMA HOP VARIETY FROM BAČKI PETROVAC FOR CRAFT BREWERIES

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### Summary:

In Serbia, the production of hops (*Humulus lupulus* L.) declined rapidly during the last 2 decades (878t in 2001, <10t in 2021), and breeding and development of new hop varieties stopped in 2010. However, Serbia is not only characterized by a climate that is optimal for the production of hops (between 35 and 55 degrees latitude), but also possesses an exceptionally important genetic resource that is completely unused today: wild hops, as well as semi-wild hops, created by the naturalization of commercial varieties once grown on today's abandoned hop fields. Wild and semi-wild hops not only have a high potential for use in the craft beer industry (example: the American brewery Sierra Nevada), but due to the specific chemical composition of cones formed in local climatic conditions, they can be used for the production of exclusive beer with a unique and recognizable taste (terroir), which will be appreciated by consumers of craft beer with a refined taste. Today, 3 international and 3 domestic varieties of hops are registered in Serbia. Our goals are to renew both breeding and production of hops by developing a new variety of aromatic hops that is suitable for cultivation in our area. Within the project financed by the Serbian Innovation Fund (Hopseeker, project ID 51815), 18 wild and semi-wild genotypes of hops from Vojvodina were collected from nature and clonally propagated, the chemical composition of their cones was evaluated in relation to the relevant compounds that determine the quality and exclusivity of beer, cones were used for the production of beer in 12 local craft breweries, the produced beer was evaluated by both professionals and consumers. In this way, hop plants (genotypes) whose cones were used for the production of beer with the best characteristics were selected, and a request was submitted to the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia for their registration as a new hop variety in our country. Genetic analyzes of all 18 hop genotypes used in the project with nuclear microsatellites and their comparison with about 600 genotypes of commercial varieties and wild hops showed that they are exclusively semi-wild hops that were created by hybridization with commercial varieties and which, as a result, acquired new properties. The determined unique genetic profiles of the new variety of hops, which will have a protected designation of origin and which will be registered in Serbia, will serve to protect the breeder's rights as well as trademark.

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**Keywords:** wild and semi-wild aromatic hops, locally adapted genotypes, neglected hop gene pool, craft beers, intellectual property

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## FITOESTROGENI HMELJA: OD OČEKIVANJA DO PRIMENE

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### Sažetak:

Fitoestrogeni su jedinjenja koja se nalaze u različitim biljnim vrstama i u različitim delovima biljaka, prevashodno u listovima i cvetovima. Ove komponente pokazuju estrogensku aktivnost, kako u in vitro, tako i u in vivo uslovima. Hemijski se odnose na klase izoflavona, flavanona, kumestransa i laktona resorcinne kiseline. Fitoestrogeni su poznati po zdravstvenim blagotvornim efektima u prevenciji raka dojke, postmenopauzalnog sindroma, osteoporoze i ateroskleroze. Međutim, efekti većine ovih jedinjenja su relativno niski u poređenju sa humanim estrogenima (npr. 17-estradiol). Hmelj (*Humulus lupulus* L.) se vekovima koristi kao esencijalna sirovina u tehnologiji piva dajući mu gorčinu i ukus. U poslednjih nekoliko godina, hmelj privlači sve veću naučnu pažnju kao izvor prenilflavonoida koji pripadaju podklasi polifenola. Prenilflavonoidi su prisutni u lupulinskim žlezdama, koje se nalaze u ženskim šišarkama hmelja. U ovoj grupi, prenilhalkoni (uglavnom ksantohumol) i prenilflavanoni, posebno 8-prenilnaringenin (8-PN) imaju najveći značaj zbog svojih specifičnih bioaktivnih efekata. Smatra se da je novootkriveni 8-PN najmoćniji fitoestrogen koji je trenutno poznat. Preliminarne studije o estrogenskoj snazi hmelja i njegovog 8-PN su, međutim, pokazale kontradiktorne rezultate. Neke studije su ukazale na jaku estrogensku aktivnost, dok je u drugim eksperimentima estrogena aktivnost bila slaba, što je verovatno uzrokovano varijabilnošću sirovina i hemijskog sastava ekstarkata hmelja, kao i zbog različitih metodskih postupaka i tehnika koje su primenjivane. Najnoviji podaci ukazuju na moguću bakterijsku modifikaciju i stvaranje 8-PN iz otpada (istrošenog) hmelja, kao i na potrebu za inkapsulacijom 8-PN radi njegove poboljšane bioaktivnosti i ciljane isporuke u odgovarajuća tkiva. Naš rad ima za cilj da istakne aktuelna interesovanja za prenilflavanone hmelja, kao i da ukaže na glavne izazove u izolaciji, kvantifikaciji i inkapsulaciji 8-PN, kao i budućnost primene ovog jedinjenja u različitim biljnim suplementima i dijetskim proizvodima.

**Ključne reči:** izoflavoni, 8-prenilnaringenin, biaktivnost, inkapsulacija



## PHYTOESTROGENS OF HOPS: FROM EXPECTATION TO APPLICATION

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### Summary:

Phytoestrogens are compounds occurring in different plant species and in different plant parts, mainly leaves and flowers. These components exhibit an estrogenic activity both in vitro and in vivo conditions. Chemically, they refer to the classes of isoflavones, flavanones, coumestrans and resorcylic acid lactones. Phytoestrogens are known for health beneficial effects in the prevention of breast cancer, post-menopausal syndrome, osteoporosis and atherosclerosis. However, the potency of most of these compounds is relatively low compared to human estrogens (e.g. the 17-estradiol). Hops (*Humulus lupulus* L.) is used for centuries as an essential raw material in beer brewing providing bitterness and flavor to beer. In the past few years, the plant has gained increasing attention as a source of prenylflavonoids, a subclass of polyphenols. These are present in the lupulin glands, found in the female hop cones. In this group, the prenylchalcones (mainly xanthohumol) and prenylflavanones, especially the 8-prenylnaringenin (8- PN) are among the most attractive due to their specific bioactive effects. The newly discovered 8-PN is thought to be the most potent phytoestrogen currently known. However, the preliminary studies on estrogenic potency of hop and its 8-PN showed contradictory results. Some studies revealed a strong estrogenic activity, while others found no or low estrogenic activity, possibly due to the varieties of extracts and the nature of performed used assays. Recent data indicate the possible bacterial production of 8-PN from spent hops, as well as the needs for encapsulation of 8-PN for its improved bioactivity and target delivery. Our paper aims at highlighting the current interests in hops prenylflavanones, the main challenges in isolation, quantification and encapsulation, as well as the future of application in different plant-based supplements and dietary products.

**Keywords:** isoflavones, 8-prenylnaringenin, bioactivity, encapsulation





## PONAŠANJE POTROŠAČA NA TRŽIŠTU PIVA U SLOVAČKOJ

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### Sažetak:

Pivo je najpopularnije alkoholno piće na svetu. Tržište piva ima ogroman udeo na državni budžet svake zemlje u svetu. Slovačka se često naziva pivskom zemljom jer pivo je jednim od najpopularnijim alkoholnih pića ima čvrstu i dugu tradiciju. U Slovačkoj imamo 4 velike pivare i 64 zanatske ili kraft pivare. Velike Slovačke pivare pokušavaju da održe svoj tržišni udeo poslovanjem smanjenjem troškova i cena ili proizvodnjom novih vrsta piva. Uprkos svim preprekama, ove pivare posluju u Slovačkoj već veliki broj godina. Mnoge male pivare su zatvorene od 2020-2023. godine. Svake godine se na tržištu pojavljuju nove vrste piva, koje imaju za cilj privlačenje sve više novih kupaca. Možemo smatrati sve popularnijem bezalkoholnim pivima i radlerima što Slovačku čini jednu od najpopularnijom zemljom po proizvodnji bezalkoholnog piva u okviru Evropske unije.

**Ključne reči:** pivarska industrija, tržište, pivo.



## CONSUMER BEHAVIOR ON THE BEER MARKET IN SLOVAKIA

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### Summary:

Beer is the most popular alcoholic drink in the world. The beer market has a huge share in the national budget of every country in the world. Slovakia is often called the country of beer because beer is one of the most popular alcoholic beverages and has a solid and long tradition. In Slovakia, we have 4 large breweries and 64 craft or craft breweries. Large Slovak breweries are trying to maintain their market share by doing business by reducing costs and prices or by producing new types of beer. Despite all the obstacles, these breweries have been operating in Slovakia for many years. Many small breweries are closed from 2020-2023 year. Every year, new types of beer appear on the market, which aim to attract more and more new customers. We can consider the increasingly popular non-alcoholic beers and radlers, which makes Slovakia one of the most popular non-alcoholic beer producing countries within the European Union.

**Keywords:** brewing industry, market, beer.



## USMENA IZLAGANJA



VII NAUČNO – STRUČNI SIMPOZIJUM  
“PIVO, PIVARSKJE SIROVINE I TRŽIŠTE”



## PRIMENA LIOFILIZACIJE ZA IMOBILIZACIJU ĆELIJA KVASCA U POLISAHARIDNE NOSAČE

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### Sažetak:

Imobilisane ćelije kvasca imaju veliki potencijal primene u fermentaciji alkoholnih pića zbog svojih tehničkih i ekonomskih prednosti u odnosu na sisteme sa slobodnim ćelijama. Polisaharidni nosači su se pokazali kao efikasno rešenje za unapređenje vijabilnosti i zaštitu ćelija tokom fermentacionih procesa. Ovaj rad ima za cilj imobilizaciju ćelija kvasca *Saccharomyces pastorianus* primenom tehnike liofilizacije. Suspenzije su pripremljene mešanjem natrijum-alginata i maltodekstrina (1.5%) sa ćelijama izdvojenim u ranoj ekspanzionalnoj fazi rasta. Nakon liofilizacije, prahovi su analizirani u pogledu prinosa, vijabilnosti ćelija, sadržaja vlage, prečnika čestica i  $\zeta$  potencijala. Mikrostruktura nosača ispitana je pomoću skenirajuće elektronske mikroskopije (SEM). Sadržaj vlage i rastvorljivost oba tipa nosača bili su slični, a nizak sadržaj vlage ukazuje na mikrobiološku stabilnost polisaharidnih nosača, što ih čini pogodnim za primenu u prehrambenoj industriji. Vijabilnost imobilisanih ćelija u nosačima bila je znatno viša (>74.3%) u poređenju sa slobodnim ćelijama (64.2%). Prosečan prečnik čestica bio je  $7.4 \pm 0,2 \mu\text{m}$  za alginat i  $7.2 \pm 1.2 \mu\text{m}$  za maltodekstrin. Površinsko naelektrisanje svih uzoraka mereno je u cilju potvrde fizičko-hemijske stabilnosti nosača, pri čemu je u svim uzorcima zabeleženo negativno naelektrisanje. Niske vrednosti kod kontrolnog uzorka ukazuju na sklonost slobodnih ćelija ka agregaciji, ističući značaj nosača u očuvanju stabilnosti sistema. SEM mikrofografije su pokazale uspešnu imobilizaciju ćelija i manju poroznost kod nosača sa maltodekstrinom. Ovi rezultati potvrđuju efikasnost polisaharidnih nosača u imobilizaciji i zaštiti ćelija, kao i njihov potencijal za industrijsku upotrebu.

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**Ključne reči:** imobilizacija, pivski kvasac, polisaharidni nosači, tehnika sušenja smrzanjem.

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## APPLICATION OF LYOPHILIZATION FOR IMMOBILIZATION OF YEAST CELLS IN POLYSACCHARIDE CARRIERS

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### Summary:

Immobilized yeast cells have significant potential for application in the fermentation of alcoholic beverages due to their technical and economic advantages over free-cell systems. Polysaccharide carriers have proven to be an effective solution for improving cell viability and protection during fermentation processes. This study aims to immobilize *Saccharomyces pastorianus* yeast cells using the lyophilization technique. Suspensions were prepared by mixing sodium alginate and maltodextrin (1.5%) with cells harvested during the early exponential growth phase. After lyophilization, the powders were analyzed for yield, cell viability, moisture content, particle size, and  $\zeta$  potential. The microstructure of the carriers was examined using scanning electron microscopy (SEM). The moisture content and solubility of both types of carriers were similar, and the low moisture content indicates the microbiological stability of polysaccharide carriers, making them suitable for application in the food industry. The viability of immobilized cells in the carriers was significantly higher (>74.3%) compared to free cells (64.2%). The average particle diameter was  $7.4 \pm 0.2 \mu\text{m}$  for alginate and  $7.2 \pm 1.2 \mu\text{m}$  for maltodextrin. The surface charge of all samples was measured to confirm the physicochemical stability of the carriers, with negative charges observed in all samples. The low values in the control sample indicate the tendency of free cells to aggregate, highlighting the role of carriers in maintaining system stability. SEM micrographs demonstrated successful cell immobilization and reduced porosity in the carriers containing maltodextrin. These results confirm the effectiveness of polysaccharide carriers in cell immobilization and protection, as well as their potential for industrial use.

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**Keywords:** immobilization, brewery yeast, polysaccharide-based carriers, freeze-drying technique

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## ANALIZA PROFILA SAHARIDA, METABOLITA I AKUMULACIJE ALFA KISELINE U INTENZIVNIM CIKLUSIMA VRENJA SA MIKROZRNCIMA KVASCA

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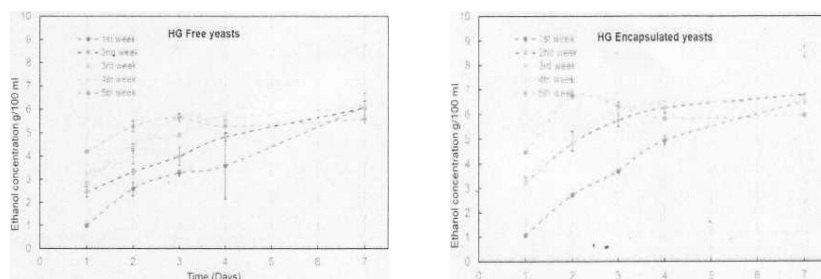
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### Sažetak:

Uslovi okoline značajno utiču na preživljavanje ćelija kvasca tokom alkoholne fermentacije. Ova studija je pokušala da proceni zaštitne efekte različitih inkapsuliranih nosača na bazi alginata i ciklodekstrina na kvasce pod standardnom gravitacijom (10,4% ekstrakt, 35 JBU) i visokom gravitacijom (17,0% ekstrakt, 55 IBU), koristeći 30% izomerizovanih alfa kiselina hmelja ekstrahovanih iz Hopštajnera, Nemačka. Na početku, pivski kvasac SafAle US-05 (Fermentis Lesaffre, Francuska) je inkapsuliran u optimizovanom inkapsularom nosaču (1,5 % alginata) i testiran u standardnom i visokogravitacionom ekstraktu slada kao medijumu. Nakon toga, istražili smo dvokomponentne nosače (1,5% alginata sa 0,2% bilo nativnih, citratom modifikovanih ili maleatom modifikovanih beta ciklodekstrina) u uslovima visoke gravitacije. Sve fermentacije su vršene paralelno sa slobodnim kvascima kao kontrolnim. Proces fermentacije je obuhvatio pet ciklusa (5 nedelja) sa periodičnim uklanjanjem i dopunom ekstrakta slada. Studija je pratila gustinu suspendovanih/ odvojenih ćelija, pH, profile šećera (maltoza, maltotrioza, glukoza, fruktoza) (HPLC), sadržaj izo alfa kiselina (HPLC), kao i evoluciju etanola (HPLC) i aromata (izopentilni alkohol, butil etar, 3-metil-4-heptanon, 1-decen, etil heksanoat, 1-dodecen) (GC-MS).



Slika 1-Proizvodnja etanola u suspendovanoj kulturi i kvascima inkapsuliranim u 1,5 alginatnih mikroznaca

Rezultati su otkrili minimalne razlike između slobodnog i inkapsuliranog kvasca u pogledu OD i pH, što sugerise da je ciklus izvodljiv sa inkapsuliranim kvascem. Međutim, nastali proizvodi ukazuju na metaboličku promenu, o čemu svedoče razlike u proizvodnji etanola (slika 1) i specifičnih isparljivih materija (izopentilni alkohol, butil etar) posebno tokom fermentacije visoke gravitacije.

## ANALYZING SACCHARIDE, METABOLITE PROFILES AND ALPHA ACID ACCUMULATION IN INTENSIVE BREWING CYCLES WITH YEAST MICROBEADS

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### Summary:

Environmental conditions significantly affect yeast cell survival during alcoholic fermentation.<sup>1</sup> This study sought to assess the protective effects of various alginate and cyclodextrin-based encapsulation carriers on yeasts under both standard gravity (10.4% extract, 35 IBU) and high gravity (17.0% extract, 55 IBU), utilizing 30% isomerized alpha acids hop extract from Hopsteiner, Germany. Initially, brewer's yeast SafAle US-05 (Fermentis Lesaffre, France) was encapsulated in an optimized encapsulation carrier (1.5 % alginate) and tested in standard and high gravity malt extract as a medium. Subsequently, we explored two-component carriers (1.5 % alginate with 0.2 % either native, citrate-modified or maleate-modified beta cyclodextrins) at high gravity conditions. All fermentations were conducted in parallel with free yeasts as controls. The fermentation process spanned five cycles (5 weeks) with periodically removal and replenishment of the malt extract. The study monitored suspended/detached cell density, pH, sugar profiles (maltose, maltotriose, glucose, fructose) (HPLC), iso alpha acids content (HPLC), as well as ethanol (HPLC) and aromatics evolution (isopentyl alcohol, buthyl ether, 3-methyl -4-heptanone, 1-decene, ethyl hexanoate, 1-dodecene) (GC-MS).

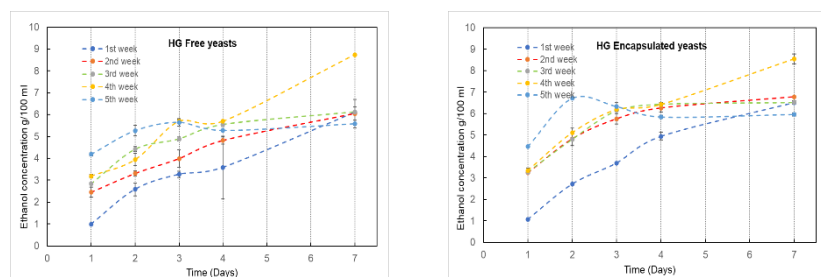


Fig 1. Ethanol production in suspended culture and yeasts encapsulated in 1.5 alginate microbeads

The results revealed minimal differences between free and encapsulated yeasts in terms of OD and pH, suggesting that cycling is feasible with encapsulated yeasts. However, the evolved products indicate a metabolic shift, as evidenced by differences in ethanol production (Fig. 1) and specific volatiles (isopentyl alcohol, buthyl ether) particularly during high gravity fermentation.





## APIGENIN – ANTIFUNGALNA AKTIVNOST FLAVONOIDA PRISUTNOG U PIVU I VINU

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### Sažetak:

Flavonidi su bioaktivna jedinjenja prisutna u različitim biljkama, a neki od njih, poput apigenina, nalaze se i u pićima, pivu i vinu. Apigenin je poznat po različitim biološkim aktivnostima, najčešće su to antiinflamatorna i antioksidantna. Cilj našeg istraživanja je bio da steknemo detaljniji uvid u njegov antifungalni potencijal. Mikrodilucionom metodom utvrđene su minimalne inhibitorne (MIK) i minimalne fungicidne koncentracije (MFK) apigenina prema različitim vrstama roda *Candida* i kretale su se u rasponu 0.10 – 0.15 mg/mL za MIK i 0.15-0.30 mg/mL za MFK. Pored inhibicije planktonskog rasta, apigenin je sprečavao rast mikroorganizama u formi biofilma (više od 50% inhibicije primenom sub-inhibitornih koncentracija apigenina). Sposobnosti formiranja biofilмова kao i mogućnost promene morfologije i to prelazak iz kvasolikog u hifalni oblik su osobine gljiva koje im omogućavaju da dovedu do bolesti. Sposobnost *Candida albicans* da formira hife je primenom apigenina opala sa 33% na 19%. Utvrđen je mehanizam antifungalnog delovanja apigenina koji je delimično zasnovan na remećenju integriteta ćelijske membrane koje dolazi do izražaja nakon 30 min tretmana. Apigenin je pokazao obećavajući antifungalni potencijal i potrebno je dalje ispitivanje u cilju produbljivanja saznanja o njegovoj bioaktivnosti.

**Ključne reči:** apigenin, flavonoid, bioaktivnost.



## APIGENIN – ANTIFUNGAL ACTIVITY OF FLAVONOID COMMONLY FOUND IN BEER AND WINE

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### Summary:

Flavonoids are bioactive compounds present in various plants, and some of them, such as apigenin, are also found in beverages including beer and wine. Apigenin is known for various biological activities, such as anti-inflammatory and antioxidant, and the goal of our research was to gain a more detailed insight into its antifungal potential. Using the microdilution method, the minimum inhibitory (MIC) and minimum fungicidal concentrations (MFC) of apigenin against different species of the *Candida* were determined and ranged from 0.10 to 0.15 mg/mL for MIC and 0.15-0.30 mg/mL for MFC. In addition to inhibiting planktonic growth, apigenin also prevented the growth of microorganisms in the form of biofilms (more than 50% inhibition using sub-inhibitory concentrations of apigenin). Among the properties of fungi that allow them to cause disease, in addition to the ability to form biofilms, is the possibility of changing morphology, from a yeast-like to a hyphal form. With the application of apigenin, the ability of *Candida* to form hyphae dropped from 33% to 19%. The mechanism of the antifungal action of apigenin has been determined, and is partially based on the disruption of the integrity of the cell membrane, which becomes apparent after 30 minutes of treatment. Apigenin has shown promising antifungal potential and should be further investigated in order to deepen the knowledge of its bioactivity.

**Keywords:** apigenin, flavonoid, bioactivity.

**Acknowledgment:** This research was funded by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia, grant number 451-03-66/2024-03/200007.



## UTICAJ PRIMENE PROBIOTSKOG KVASCA NA TOK FERMENTACIJE PIVSKE SLADOVINE

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### Sažetak:

Primena probiotskih mikroorganizama u prehrambenoj industriji postaje sve značajnija zbog njihovih brojnih blagotvornih efekata na ljudsko zdravlje, uključujući potencijal za unapređenje funkcionalnih karakteristika proizvoda. U ovom istraživanju ispitan je uticaj probiotskog kvasca *Saccharomyces cerevisiae* var. *boulardii* na proces fermentacije pивske sladovine, pri čemu je ovaj kvasac upoređen sa tradicionalnim pivskim kvascima, kao što je *Saccharomyces cerevisiae* (AEB®, Italija). Sladovina korišćena u eksperimentu potiče iz standardne industrijske proizvodnje, dok je fermentacija sprovedena u strogo kontrolisanim laboratorijskim uslovima. Praćenje rasta mikroorganizama tokom fermentacije izvršeno je primenom standardnih mikrobioloških tehnika, dok su fizičko-hemijske karakteristike, uključujući gustinu, pH vrednost i koncentraciju ekstrakta, mereni tokom ključnih faza procesa. Dobijeni nalazi otvaraju mogućnosti za razvoj inovativnih funkcionalnih piva sa probiotskim svojstvima, što bi moglo unaprediti nutritivne vrednosti i tržišnu privlačnost proizvoda.

**Ključne reči:** probiotski kvasac, pivski kvasac, fermentacija, sladovina, funkcionalna hrana



## EFFECTS OF PROBIOTIC YEAST APPLICATION ON THE FERMENTATION OF WORT

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### Summary:

The application of probiotic microorganisms in the food industry is becoming increasingly significant due to their numerous beneficial effects on human health, including the potential to enhance the functional characteristics of products. In this study, the impact of the probiotic yeast *Saccharomyces cerevisiae* var. *boulardii* on the fermentation process of beer wort was examined, with this yeast being compared to traditional brewing yeasts such as *Saccharomyces cerevisiae* (AEB®, Italy). The wort used in the experiment originated from standard industrial production, while fermentation was carried out under strictly controlled laboratory conditions. The growth of microorganisms during fermentation was monitored using standard microbiological techniques, and physicochemical characteristics, including density, pH value, and extract concentration, were measured during key phases of the process. The obtained findings open up possibilities for the development of innovative functional beers with probiotic properties, which could enhance the nutritional value and market appeal of the product.

**Keywords:** probiotic yeast, brewer's yeast, fermentation, wort, functional food.

**Acknowledgment:** This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No. 451-03-65/2024-03/200135).



## FIZIČKE, HEMIJSKE I SENZORNE OSOBINE IPA PIVA

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### Sažetak:

Pivo je alkoholni napitak koji nastaje alkoholnim vrenjem pivske sladovine. Kao potpuno prirodan i biološki uravnotežen proizvod predstavlja odličnu osnovu za dobijanje novih vrsta piva. U poslednje vreme kraft pivarstvo doživljava veliku ekspanziju, kako u svetu tako i kod nas. Jedno od najznačajnijih i najprodavanijih kraft piva je IPA (Indian Pale Ale). IPA pivo potiče iz Engleske, a ime Indian Pale Ale potiče od slanja piva sa visokim sadržajem alkohola i hmelja iz Engleske u Indiju tokom kolonijalnog perioda. Ovaj stil piva je poznat po svojim karakterističnim hmeljnim aromama, izraženoj gorčini i često voćnim i cvetnim notama. Dodavanjem veće količine hmelja pomoglo je da se pivo bolje očuva tokom dužeg vremena stajanja. Cilj ovoga rada je da se prikaže tehnološki proces proizvodnje IPA piva, kao i njegove fizičko-hemijske i senzorne osobine. Od hemijskih parametara analizirani su pH, polifenoli, sadržaj ekstrakta i alkohol. Od fizičkih i senzornih parametara analizirana je boja, mutnoća, gorčina i pena od 3cm.

**Ključne reči:** kraft pivo, IPA, fizičko-hemijska svojstva, senzorna svojstva.



## PHYSICAL, CHEMICAL AND SENSORY PROPERTIES OF IPA BEER

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### Summary:

Beer is an alcoholic beverage produced by alcoholic fermentation of beer wort. As a completely natural and biologically balanced product, it represents an excellent basis for obtaining new types of beer. Recently, craft brewing has been experiencing a great expansion, both in the world and in our country. One of the most important and best-selling craft beers is IPA (Indian Pale Ale). IPA beer originated from England and the name Indian Pale Ale comes from the shipping of high alcohol beer and hops from England to India during the colonial period. This style of beer is known for its characteristic hop aromas, emphasized bitterness and often fruity and floral notes. Adding more hops helps to preserve the beer better during a longer standing time. The aim of this paper is to present the technological process of IPA beer production, as well as its physical-chemical and sensory properties. Among the chemical parameters, pH, polyphenols, extract content and alcohol were analyzed. From the physical and sensory parameters, the colour, turbidity, bitterness and foam of 3 cm were analyzed.

**Keywords:** craft beer, IPA, physico-chemical properties, sensory properties



## STARE SORTE PŠENICE KAO POTENCIJALNA SIROVINA ZA PROIZVODNJU PIVA

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### Sažetak:

Iako se pšenica vekovima koristila za proizvodnju piva, dugo je bila u senci ječma iz koje je izašla poslednjih decenija da svoje mesto pod suncem više ne ustupi. U nepreglednoj paleti raznovrsnih piva, pšenična piva imaju svoje posebno mesto, a naklonjenost svojih ljubitelja duguje brojnim specifičnostima, između ostalim, prepoznatljivoj mutnoći usled odsustva filtriranja gornjeg kvasca, svojstvenoj aromatičnosti, blagom, osvežavajućem ukusu, gustoj peni i načinu točenja. Iako pšenica sadrži više proteina od ječma, za tehnologiju proizvodnje pogodnije su one sorte koje imaju manji sadržaj proteina u korist većeg sadržaja skroba od kojeg se fermentacijom dobija etanol i ugljen dioksid. Pored ovog svojstva, krupno ujednačeno zrno se smatra poželjnom osobinom da bi se obezbedilo ravnomerno klijanje u procesu proizvodnje slada. Izbor sorte za proizvodnju piva zasniva se na tehnološkim i agronomskim osobinama, a poseban značaj bi trebalo dati njenom poreklu. Marginalizacija starih tradicionalnih sorti uticala je na smanjenje agrobiodiverziteta i ugrozila stabilnost poljoprivredne proizvodnje. Sve veća svest o ekološkim, zdravstvenim i ekonomskim prednostima raznovrsnih lokalnih proizvoda naspram tendenciji globalne uniformnosti doprinosi prepoznavanju vrednosti starih sorti sa našeg podneblja i njihovom boljem korišćenju. U Institutu za ratarstvo i povrtarstvo ocenjeni su osnovni morfološki i hemijski parametri 60 starih sorti pšenice tokom dve vegetacione sezone (2021/2022 i 2022/2023) u cilju sužavanja izbora sorti potencijalno pogodnih za proizvodnju slada. Ispitivana je masa hiljadu zrna, sadržaj proteina i krupnoća zrna. Velika varijabilnost utvrđena je za masu hiljadu zrna koja se kretala od 24 g do 48 g, pri čemu je najveća masa zrna zabeležena kod sorti Rumska crvenka i Ševićeva šišulja, i kod lokalnih populacija Beograd 1, 701-VI/7, 7-I/3-B i 110-III/1-A. Deset sorti imalo je sadržaj proteina ispod 11% od kojih su sorte Partizanka i Crnozrna. Nekoliko sorti i populacija izdvojilo se po krupnoći zrna sa preko 30% zrna veličine >2,8 mm (Rumska crvenka, Beograd 1 i Ševićeva šišulja) i oko 60% zrna veličine između 2,8 mm i 2.5 mm (Beograd 1 i Crnozrna). Nesumnjiv potencijal domaćih genetičkih resursa zahteva detaljnija istraživanja kako bi se na tržištu pojavila nova pšenična piva od starih sorti prepoznatljiva po kvalitetu, sa osobenim pečatom i ličnom zanimljivom pričom.

**Ključne reči:** genetički resursi, lokalne populacije, pšenica, stare sorte.

**Zahvalnica:** Fond za raspodelu dobrobiti Međunarodnog ugovora o biljnim genetičkim resursima za hranu i poljoprivredu PR-166-Serbia - GRAINEFIT; Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije, evidencioni broj 451-03-66/2024-03/200032, Centar izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na promene klime - Climate Crops, Institut za ratarstvo i povrtarstvo, Novi Sad, Srbija



## TRADITIONAL WHEAT VARIETIES AS A POTENTIAL MATERIAL FOR BEER PRODUCTION

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### Summary:

Although wheat has been used for centuries in beer production, it has long been considered secondary to barley. However, in recent decades, wheat has begun to assert its significance within the brewing industry. Among the diverse array of beers, wheat beers occupy a distinctive position, esteemed for several distinct qualities, including characteristic cloudiness resulting from the absence of upper yeast filtration, a characteristic aroma, a mild and refreshing taste, and the foamy texture achieved during the pouring. Generally, wheat contains more protein than barley; however, varieties with lower protein and higher starch content are more suitable for beer production, as starch is converted into ethanol and carbon dioxide during fermentation. Additionally, large, uniform grains are desirable to ensure even germination during malting. The choice of variety is based on technological and agronomic characteristics, but special consideration should be given to its origin. The marginalization of traditional varieties has led to reduced agrobiodiversity, threatening agricultural stability. Growing awareness of ecological, health, and economic benefits of diverse local products—contrasting with the trend of global uniformity—has fostered a renewed interest for traditional varieties suited to local climate. At the Institute of Field and Vegetable Crops the basic morphological and chemical parameters of 60 traditional wheat varieties over two growing seasons (2021/2022 and 2022/2023) were measured to identify those suitable for malt production. Thousand-grain weight, protein content, and grain size were examined. Significant variability was found in thousand-grain weight, ranging from 24 g to 48 g, with the highest weight recorded in the varieties Rumska crvenka and Ševićeva šišulja, as well as in local landraces Belgrade 1, 701-VI/7, 7-I/3-B, and 110-III/1-A. Ten varieties had a protein content of less than 11%, including Partizanka and Crnozna. Several varieties exhibited notable grain size, with over 30% of grains measuring over 2.8 mm (Rumska crvenka, Belgrade 1, and Ševićeva šišulja), and about 60% measuring between 2.8 mm and 2.5 mm (Beograd 1 and Crnozna). The undeniable potential of local genetic resources requires further research to bring new wheat beers from old varieties to market—beers that stand out for their quality and tell their curious personal stories.

**Keywords:** genetic resources, landraces, old varieties, wheat.

**Acknowledgment:** The Benefit-Sharing Fund of the International Treaty on Plant Genetic Resources for Food and Agriculture PR-166-Serbia - GRAINEFIT; Ministry of Science, Technological Development and Innovations of Republic of Serbia, contract number 451-03-66/2024-03/200032 and Centre of Excellence for Innovations in Breeding of Climate-Resilient Crops - Climate Crops, Institute of Field and Vegetable Crops, Novi Sad, Serbia





## SIRAK KAO SIROVINA U PROIZVODNJI PIVA

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### Sažetak:

Proizvodnja piva, kao jednog od najpopularnijih pića obuhvata samo četiri sastojka: kvasac, vodu, hmelj i slad. Kao primarni izvor žitarica za proizvodnju piva koristi se sladni ječam, dok alternativne sirovine poput sirka, usled njegovog fermentativnog kapaciteta, postaju sve popularnije. Sirkov slad se kao primarna sirovina u proizvodnji piva tradicionalno koristi u Africi, Indiji i Severnoj Americi. Pivo od sirka se dobija tradicionalnim i industrijskim metodama preko spontane ili usmerene fermentacije i u zavisnosti od regiona ili etničke grupe poznato je pod različitim lokalnim nazivima. Korišćenje sirka u proizvodnji slada i različitih piva se proširilo u mnoge zemlje širom sveta. Ova žitarica se pokazuje kao praktična alternativa standardnim sirovinama pre svega u situaciji kada klimatske promene sve više utiču na sistem biljne proizvodnje. Sirkov slad se u proizvodnji lager tip piva u Meksiku koristi standardno, dok se u SAD kao dodatak koristi od 1980-tih godina. Ovaj artikal predstavlja novinu na profilisanom tržištu Evrope. Laboratorijsko testiranje različitih varijanti upotrebe sirka u pivarstvu je pokazalo da se najkvalitetniji rezultat dobija uključivanjem 60% sirkovog slada i 40% nesladovanog sirka. Dobijeno sirkovo pivo ima nizak sadržaj alkohola, složeni, aromatični, blago gorko-kiseli ukus i manje stabilnu penu. Konvencionalne sirovine za dobijanje piva su ječmeni ili pšenični slad, ali osobe sa osetljivošću na gluten ili sa dijagnozom celijakije ne mogu da konzumiraju ovo piće. Najsigurniji metod za proizvodnju piva bez glutena je upotreba žitarica bez glutena, kao što je sirak. Bezglutensko pivo je alternativa ne samo osobama koje ne tolerišu gluten, već i onima koji su zainteresovani za razne nove proizvode koji se plasiraju na tržište. Prema izveštaju koji je objavio Fior Markets, globalno tržište piva bez glutena će do 2025. godine porasti na 18,7 milijardi dolara, sa godišnjom stopom rasta od 16,3%.

**Ključne reči:** bez glutena, sirak, slad, pivo



## SORGHUM AS A RAW MATERIAL IN BEER PRODUCTION

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### Summary:

The production of beer, as one of the most popular drinks, includes only four ingredients: yeast, water, hops and malt. Malted barley is used as the primary source of grain for beer production, while alternative raw materials such as sorghum, due to its fermentative capacity, are becoming more and more popular. Sorghum malt is traditionally used as the primary raw material in beer production in Africa, India and South America. Sorghum beer is obtained by traditional and industrial methods through spontaneous or directed fermentation and depending on the region or ethnic group is known by different local names. The use of sorghum in the production of malt and various beers has spread to many countries around the world. This grain is proving to be a practical alternative to standard raw materials, especially in a situation where climate change is increasingly affecting the plant production system. Sorghum malt is used as a standard in the production of lager type beer in Mexico, while in the USA it has been used as an additive since the 1980s. This article is a novelty on the profiled market in Europe. Laboratory testing of different variants of sorghum use in brewing has shown that the best quality result is obtained by including 60% sorghum malt and 40% unmalted sorghum. The resulting sorghum beer has a low alcohol content, a complex, aromatic, slightly bitter-sour taste and less stable foam. Conventional raw materials for obtaining beer are barley or wheat malt, but people with gluten sensitivity or diagnosed with celiac disease cannot consume this drink. The safest method for making gluten-free beer is to use gluten-free grains, such as sorghum. Gluten-free beer is an alternative not only for gluten-intolerant people, but also for those who are interested in various new products launched on the market. According to a report published by Fior Markets, the global gluten-free beer market will grow by the year 2025 to USD 18.7 billion, with an annual growth rate of 16.3%.

**Keywords:** gluten-free, sorghum, malt, beer.



## KAKO NUTRITIVNE OSOBINE SEMENA JEČMA UTIČU NA RAZVIĆE PIRINČANOG ŽIŽKA (*Sitophilus oryzae* L.)?

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### Sažetak:

Pirinčani žižak, *Sitophilus oryzae* (L.) je primarna štetočina žitarica, od rastućeg značaja. Poslednjih godina predstavlja ograničavajući faktor tokom skladištenja strnih žita u Srbiji. Ima izraženu preferentnost prema pšenici, ali u značajnoj meri oštećuje i zrna ječma. S obzirom da su primećene razlike u podložnosti genotipova ječma na napad žižaka, od velikog je značaja definisati osobine semena koje utiču na tolerantnost prema ovoj štetočini, kako bi se mogla utvrditi međusortna razlika. Genetski potencijal za tolerantnost prema štetočinama uskladištenih proizvoda je ključan za smanjenje kvantitativnih i kvalitativnih gubitaka zrna tokom skladištenja. Stoga je i informacija o tolerantnosti određenog genotipa važna za unapređenje programa kontrole ove grupe štetočina i za razvoj novih strategija oplemenjivanja. Cilj istraživanja je bio da se: i) identifikuje pogodnost sorti ječma (27 genotipova) za razvoj pirinčanog žižaka, ii) u korelaciji sa nutritivnim osobinama zrna i iii) identifikuje gubitak mase semena. Pratili smo produkciju potomstva žižaka (broj novoispilelih jedinki) nakon jedne, dve i tri generacije i intenzitet ishrane (% konzumiranog zrna) nakon tri generacije (~ 90 dana), u testu „bez izbornosti“ u kontrolisanim uslovima. Nutritivne osobine kao što su sadržaj proteina, skroba i vlakana (%) su određene NIR spektroskopijom. Među ispitivanim sortama, NS Talos, Novosadski 331, Novosadski 525, NS Golijat, Nonius, NS Lala, NS Mile i NS Marko su se pokazale kao pogodne za razvoj pirinčanog žižaka, kako u pogledu produkcije potomstva tako i po intenzitetu ishrane. S druge strane, sorte NS Parip, NS Izdan, NS Deran, NS Brka, Novosadski 565 i NS Asteriks su ispoljile tolerantnost i u pogledu razvoja žižaka (produkcije potomstva) i ishrane. Pirinčani žižak je prouzrokovao 2,5-62,0% gubitaka semena ječma, što ukazuje na značajnu razliku u tolerantnosti genotipova na napad žižaka. NIR analizom utvrđene su značajne razlike u sadržaju vlakana koji je bio u negativnoj korelaciji sa intenzitetom ishrane i sadržajem skroba koji je bio u pozitivnoj korelaciji sa navedenom osobinom. Generalno, sorte koje su ispoljile određeni nivo tolerantnosti prema ovoj štetočini treba uzeti u obzir u budućim programima oplemenjivanja, pogotovo ukoliko prihvatimo činjenicu da će problem sa pirinčanim žižkom biti sve veći, a mere suzbijanja sve oskudnije.

**Ključne reči:** štetočine semena, produkcija potomstva, intenzitet ishrane, sadržaj skroba, sadržaj proteina



## HOW DOES THE NUTRITIVE QUALITY OF BARLEY SEEDS AFFECT DEVELOPMENT OF THE RICE WEEVIL (*Sitophilus oryzae* L.)?

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### Summary:

The rice weevil, *Sitophilus oryzae* (L.) is a primary pest of cereals, with growing importance. In the last few years, it represents a limiting factor in a post-harvest storage of small grains in Serbia. It has strong preference for wheat, but damages barley grains at certain extent as well. As differences in susceptibility of barley genotypes to the weevil attack have been recorded, it is of great interest to define seed traits responsible for tolerance, so as to be able to differentiate suitable and/or tolerant varieties. Genetic potential to resist storage pests is crucial to minimize quantitative and qualitative grain losses during storage. Thus, further knowledge on the tolerance of a specific genotype, is important for improving pest management programs and developing new breeding strategies. The aim of the study was to: i) identify tolerance potential of barley varieties by testing suitability of 27 barley genotypes for the rice weevil development, ii) in correlation with nutritional traits, and to iii) identify the quantity loss of barley seeds. We monitored weevil progeny production (number of newly emerged adults) after one, two and three generations and feeding intensity (% of consumed grains) after three generations (~ 90 days), in a “no-choice” under controlled conditions. Nutritive traits such as protein, starch and fibre content (%) were determined using NIR analyser. Among tested varieties, NS Talos, Novosadski 331, Novosadski 525, NS Golijat, Nonius, NS Lala, NS Mile and NS Marko revealed good suitability for the rice weevil development, both in terms of progeny production and feeding intensity. On the other hand, varieties NS Parip, NS Izdan, NS Deran, NS Brka, Novosadski 565 and NS Asteriks showed lower suitability for the weevil development (progeny production) and feeding. The rice weevil caused 2.5-62.0% losses of barley seeds, which indicates a significant difference in genotypes tolerance to the weevil attack. NIR analysis detected significant differences in fibre content that was negatively correlated with feeding intensity and starch content that was in positive correlation with the mentioned trait. In generally, varieties that manifested tolerance potential to this pest should be considered in future breeding programs.

**Keywords:** seed pest, progeny production, feeding intensity, starch content, protein content.

**Acknowledgment:** This research was supported by the Science Fund of the Republic of Serbia, #6691, New biorational methods for stored seed pest control and protection: To serve and prevent - SafeSeed.



## MOGUĆNOSTI ZA FINANSIRANJE PROIZVODNJE HMEIJA U REPUBLICI SRBIJI IZ IPARD 3 PROGRAMA

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**DOI:** 10.5937/PIVOS24025R

### Sažetak:

Mogućnost finansiranja proizvodnje hmelja iz evropskih fondova po prvi put je uvedena u okviru IPARD 3 Programa. Finansijski instrument za pretpristupnu pomoć – IPARD 3 Program, za period 2021-2027. godina, usvojen je Zaključkom Vlade Republike Srbije 14. decembra 2023. godine. Ukupna vrednost ovog finansijskog instrumenta je 588 miliona evra, od čega je doprinos Evropske unije 280 miliona evra. Mogućnost za finansiranje proizvodnje hmelja postoji u okviru Mere 1 – Investicije u fizičku imovinu poljoprivrednih gazdinstava. Potencijalni korisnici ove finansijske podrške mogu da budu fizička lica – nosioci komercijalnog porodičnog poljoprivrednog gazdinstva, preduzetnici, privredna društva i poljoprivredne zadruge. Minimalni iznos investicije je 20.000 evra, a maksimalni 1.000.000 evra, s tim da korisnik može da ostvari pravo na maksimalnu finansijsku podršku od 2.000.000 evra u toku programskog perioda. Cilj rada je da predstavi koje su mogućnosti finansiranja razvoja proizvodnje hmelja u Republici Srbiji u okviru IPARD 3 Programa.

**Ključne reči:** finansiranje, razvoj proizvodnje hmelja, IPARD 3 Program, razvoj poljoprivrede, Republika Srbija.



## OPPORTUNITIES FOR FINANCING HOPS PRODUCTION IN THE REPUBLIC OF SERBIA FROM THE IPARD 3 PROGRAM

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### Summary:

The possibility of financing hop production from European funds was introduced for the first time within the IPARD 3 Program. Financial instrument for pre-accession assistance - IPARD 3 Program, for the period 2021-2027. year, was adopted by the Conclusion of the Government of the Republic of Serbia on December 14, 2023. The total value of this financial instrument is 588 million euros, of which the contribution of the European Union is 280 million euros. The possibility to finance the production of hops exists within Measure 1 - Investments in physical assets of agricultural holdings. Potential beneficiaries of this financial support can be natural persons - owners of commercial family farms, entrepreneurs, business companies and agricultural cooperatives. The minimum amount of investment is 20,000 euros, and the maximum is 1,000,000 euros, with the fact that the user can exercise the right to maximum financial support of 2,000,000 euros during the program period. The aim of the paper is to present the possibilities of financing the development of hop production in the Republic of Serbia within the framework of the IPARD 3 Program.

**Keywords:** financing, hop production development, IPARD 3 Program, agricultural development, Republic of Serbia.



## VODE U INDUSTRIJI PIVA - NAPOJNE VODE, PROCESNE, TEHNOLOŠKE I OTPADNE VODE

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### Sažetak:

Voda je jedna od osnovnih sirovina za proizvodnju piva. Kvalitet napojne vode jedan od važnijih faktora dobrog kvaliteta piva. Iako je kvalitet proizvoda, odnosno piva ključan faktor za proizvodnju, u ekološki održivom razvoju i uz primenu ekoloških principa upadljivo je velika potrošnja vode u pivskoj industriji. Poznat je podatak iz literature da je prosečna potrošnja vode od 5 do 8 L/L piva (finalnog proizvoda koji je spreman za korišćenje i u odgovarajućoj je ambalaži). Analizirajući potrošnju vode kod tehnoloških procesa u pivarama najviše vode se troši za čišćenje i dezinfekciju. Od ukupne potrošnje skoro 50% se potroši na ove procese. Voda koja se koristi za proizvodnju piva, predstavlja 25% od ukupne potrošnje. Veliki deo vode završi u otpadnoj vodi. Prema istraživanjima koje su radile pivare u Evropi za 1hL piva nastaje 2,2 do 3,3hL otpadnih voda. U cilju ostvarivanja ekološke održivosti, kao i usled rasta troškova za pripremu vode za piće i obradu otpadne vode procesna industrija nalazi se pred izazovima da pronađe nove načine za smanjenje potrošnje vode i za smanjenje proizvodnje otpada. Osim izmene procesne tehnologije postoji više pristupa za smanjenje potrošnje vode za piće koji se mogu realizovati. Prvi je ponovna upotreba odnosno regeneracija vode. U ovom radu je predstavljen niz mogućnosti ponovne upotrebe vode u šaržnim procesima za konkretan primer pivare. U prvom delu su identifikovani kritični procesi u tehnološkom procesu proizvodnje piva uz poređenje potrošnje vode i predlozima za ponovno korišćenje vode. Potrošnja vode bi se mogla smanjiti ponovnim korišćenjem izlaznog toka kod postupaka koji obuhvataju pranje (mašine za pranje boca, za pranje sanduka), prikupljanje i bolju raspodelu vode za ispiranje punjača za pivo.

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**Ključne reči:** voda, proizvodnja, otpad, regeneracija.



## WATER IN THE BEER INDUSTRY - FEED WATER, PROCESS AND WASTE WATER

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### Summary:

Water is one of the basic raw materials for beer production. The quality of the feed water is one of the most important factors of beer quality. Although the quality of the product, i.e. beer, is a key factor for production, in ecologically sustainable development and with the application of ecological principles, a large consumption of water is of concern. It is known from the literature that the average consumption of water is 5 to 8 L/L of beer, for the final product that is filled and packaged. Analyzing total water consumption in technological processes in breweries, the highest amount of water is used for cleaning and disinfection. Almost 50% of the total consumption is spent on these processes. The water used for beer production represents 25% of the total consumption. A large part of the water ends up in waste water. According to research conducted by breweries in Europe, 2.2 to 3.3 hL of waste water is produced for every hL of final beer. In order to achieve environmental sustainability, as well as due to the increase in costs for the preparation of drinking water and wastewater treatment, the process industry is facing challenges to find new ways to reduce water consumption and reduce waste production. In addition to changing the process technology, there are several approaches to reducing drinking water consumption that can be implemented. The first is reuse, ie regeneration and re-regeneration of water. This paper presents a series of water reuse possibilities in batch processes for a concrete example of a brewery. In the first part, critical processes in the technological process of beer production are identified, with a comparison of water consumption and suggestions for water reuse. Water consumption could be reduced by reusing the effluent in processes including washing (bottle washing machines, case washing), collection and better distribution of water for rinsing beer fillers.

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**Keywords:** water, production, waste, regeneration.





## PROFIL BIOAKTIVNA JEDINJENJA SLADOVINE OBOGAĆENE SEMENKAMA GROŽĐA

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### Sažetak:

Pivo je među najpoznatijim svetskim pićima, proizvedeno po standardizovanoj tehnologiji koja uključuje ječmeni slad, vodu, hmelj i pivski kvasac. Međutim, zahtevi konzumera za inovativnim i autentičnim pivom su doprineli razvoju mikropivara i proizvodnji zanatskog “craft” piva. Poslednjih godina je sve veći fokus na proizvodnji “funkcionalnih” craft piva sa jedinstvenim senzornim svojstvima koji sadrže druge nestandardne sirovine (koje nisu žitarice). Poseban izazov u dizajnu ovih “craft” piva je vezan za način i vreme dodavanja ovih sirovina u tehnološkom procesu proizvodnje piva (kuvanje sladovine, fermentacija, odležavanje ili pakovanje), kako bi se obezbedila bolja ekstrakcija bioaktivnih jedinjenja i njihova distribucija u finalni proizvod. Tako je cilj ove studije bio da se ohmeljena sladovina obogati semenakama grožđa kao izvorom fenolnih jedinjenja, potom sterilise i sastav bioaktivnih jedinjenja (fenolnih jedinjenja i gorkih kiselina hmelja) analizira primenom UHPLC Q-ToF MS tehnike. Sva jedinjenja su identifikovana na osnovu m/z tačne mase, tipičnih MS fragmenata i dostupnih literaturnih podataka. U analiziranim uzorcima sladovine sa/bez semenke grožđa je potvrđeno ukupno 28 fenolnih jedinjenja i 21 kiselina iz hmelja. Fenolna jedinjenja detektovana u kontrolnoj sladovini su dobijena iz hmelja ili slada i njihov ukupni sadržaj je bio 961.46 µg/100mL. Ukupni sadržaj kvantifikovanih fenolnih jedinjenja u sladovini obogaćenoj semenkama grožđa je bio značajno viši u poređenju sa kontrolnom sladovinom, odnosno 6579.77 µg/100mL (2.5% GS) i 8138.02 µg/100mL (5.0% GS). Glavna detektovana fenolna jedinjenja su hidroksibenzoeva kiselina, elaginska kiselina, flavan-3-oli i procijanidini, koji su tipična jedinjenja za semenku Prokupca. Ovo znači da većina fenolnih jedinjenja prelazi iz semenke u sladovinu tokom sterilizacije. (Izo)-α-kiseline su dominantno potvrđene u kontrolnoj sladovini, dok je udeo većine identifikovanih kiselina smanjen u sladovini koja je obogaćena semenkama grožđa. Sterilizacija ohmeljene sladovine obogaćene semenkana goržđa nakon kuvanja značajno doprinosi ekstrakciji fenolnih jedinjenja iz semenke grožđa i predstavlja ključni korak u proizvodnji funkcionalnog “craft” piva obogaćenog fenolnim jedinjenjima iz semenke grožđa.

**Ključne reči:** UHPLC Q-ToF MS, fenolna jedinjenja, (Izo)-α-kiseline, kuvanje sladovine.



## PROFILE OF BIOACTIVE COMPOUNDS OF WORT ENRICHED WITH GRAPE SEEDS

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### Summary:

Beer is one of the most famous beverages in the world, produced using a standardized technology that includes barley malt, water, hops and brewer's yeast. However, consumers demand for innovative and authentic beer have been contributed to the development of microbreweries and the production of craft beer. In recent years, there has been an increasing focus on the production of “functional” craft beers with unique sensory properties that contain non-cereal adjuncts. A particular challenge in the development of these craft beers is the manner and timing of the addition of adjuncts in the brewing process (wort boiling, fermentation, maturation or packaging) to ensure improved extraction of bioactive compounds and their distribution in the final product. The aim of this study was therefore to enrich hopped wort with grape seeds as a source of phenolic compounds, then sterilize it and analyze the composition of bioactive compounds (phenolic compounds and hop bitter acids) using the UHPLC Q-ToF MS technique. All compounds were identified based on m/z exact mass, typical MS fragments and available literature data. In total, 28 phenolic compounds and 21 hop acids were confirmed in the analyzed wort samples with/without grape seed. Phenolic compounds detected in control wort were originated from hops or malt and their total content was 961.46 µg/100mL. Total quantified phenolics in the wort enriched with grape seed was significantly higher compared to control wort, that is 6579.77 µg/100mL (2.5% GS) and 8138.02 µg/100mL (5.0% GS). The main detected phenolics were hydroxybenzoic acid, ellagic acid, flavan-3-ols and procyanidins, which are typical compounds for Prokupac grape seed. This means that most phenolic compounds are transferred from the seed to the wort during sterilization. (Iso)-α-acids were predominantly detected in the control wort, and the share of most identified acids was lower in the wort enriched with grape seeds. Sterilization of hopped wort contributes significantly to the extraction of phenolic compounds from grape seeds, and present the crucial step in the production of functional craft beer enriched with grape seed phenolics.

**Keywords:** UHPLC Q-ToF MS, phenolic compounds, (Iso)-α-acids, wort boiling.

**Acknowledgment:** This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Science and Technology Development programme—Research projects of the Republic of Serbia and the People's Republic of China), Contract No. 451-02-1236/2023-05), the Science Fund of the Republic of Serbia, #GRANT No. 7744714 and the Ministry of Science, Technological Development and Innovation grant No 451-03-65/2024-03/200116.



## ANALIZA PRODAJE PIVA U TRGOVINSKOJ KOMPANIJU: TRŽIŠNI TRENDOVI, AMBALAŽA I BRENDOVI U PERIODU OD 2021. DO 2024. GODINE

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### Sažetak:

Kategorija piva zauzima značajno mesto u strukturi prodaje alkoholnih pića na domaćem tržištu, pa je razumevanje potrošačkih trendova i dinamike prodaje od ključnog značaja za trgovinske kompanije. Istraživanje analizira prodaju piva u periodu od 2021. – 2024. godine u kompaniji koja posluje u Vojvodini i Beogradu, koristeći podatke iz internih baza. Posebno se fokusira na prodaju piva po vrstama ambalaže (nepovratna i povratna staklena ambalaža, limenke i PET), identifikujući preferencije potrošača. Takođe, analizirane su mesečne prodajne varijacije, kao i učešće top 5 brendova, pružajući uvid u dominantne brendove i njihov uticaj na tržište. Kako bi se dobila jasna slika o trendovima u prodaji piva, korišćene su osnovne statističke metode, kao što su analiza učešća, procentualne promene i komparacija mesečnih podataka. Rezultati pokazuju da pivo zadržava stabilan udeo od 73% u prodaji alkoholnih pića tokom perioda od 2021. do 2024. godine. PET ambalaža opada sa 9,6% u 2021. na 5,2% u 2024. godini, dok limenke beleže rast sa 44,2% na 54,7%, preuzimajući dominantan udeo. Nepovratna ambalaža beleži porast, dok povratna ambalaža opada sa 45,1% na 37,2%. Ovi podaci ukazuju na prelazak potrošača ka limenkama, verovatno zbog promena u preferencijama potrošača i tržišnim uslovima. Među vodećim brendovima, Jelen pivo je najdominantnije sa prosečnim udelom od 38% za period od 2021. do 2024. godine. Lowenbrau raste na 12,5%, dok je prodaja Lav piva stabilna sa 11,4% udela. Zaječarsko pivo je četvrto sa 9,6% udela u prodaji, dok Tuborg pivo sa 8,6% beleži ulazak među top 5 brendova, što može ukazivati na potencijalni rast internacionalnih brendova i interes potrošača za novim opcijama na tržištu. Prodaja piva pokazuje značajne sezonske varijacije tokom godine. Najveći udeo prodaje ostvaruje se u trećem kvartalu (31,4%), što je očekivano s obzirom na letnji period kada je potrošnja piva tradicionalno najviša zbog toplog vremena, odmora i društvenih događaja. Visok udeo prodaje je i u drugom kvartalu (27,8%), dok prvi (17,3%) i četvrti kvartal (23,5%) beleže niže prodajne rezultate, usled zimskih meseci. Na osnovu ovih analiza, istraživanje pruža detaljan pregled tržišnih kretanja i preferencija potrošača, što omogućava donošenje zaključaka o budućim strategijama prodaje i optimizaciji ponude u pivskoj kategoriji u maloprodajnim objektima.

**Ključne reči:** pivo, prodaja, potrošački trendovi, sezonske varijacije.



## ANALYSIS OF BEER SALES IN A TRADING COMPANY: MARKET TRENDS, PACKAGING, AND BRANDS IN THE PERIOD FROM 2021 TO 2024.

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### Summary:

The beer category holds a significant place in the sales structure of alcoholic beverages in the domestic market, so understanding consumer trends and sales dynamics is of key importance for trading companies. The research analyzes beer sales in the period from 2021 to 2024 in a company operating in Vojvodina and Belgrade, using data from internal databases. It specifically focuses on beer sales by packaging types (non-returnable and returnable glass packaging, cans, and PET), identifying consumer preferences. Additionally, monthly sales variations and the share of the top 5 brands are analyzed, providing insights into dominant brands and their market influence. In order to obtain a clear picture of beer sales trends, basic statistical methods were used, such as share analysis, percentage changes, and comparison of monthly data. The results show that beer maintains a stable share of 73% in the sales of alcoholic beverages during the period from 2021 to 2024. PET packaging declines from 9.6% in 2021 to 5.2% in 2024, while cans record an increase from 44.2% to 54.7%, taking a dominant share. Non-returnable packaging shows growth, while returnable packaging decreases from 45.1% to 37.2%. These data indicate a shift in consumer preference towards cans, likely due to changes in consumer preferences and market conditions. Among the leading brands, Jelen beer is the most dominant with an average share of 38% during the period from 2021 to 2024. Lowenbrau increases to 12.5%, while Lav beer maintains a stable share of 11.4%. Zaječarsko beer ranks fourth with a 9.6% sales share, while Tuborg beer, with 8.6%, enters the top 5 brands, indicating a potential growth of international brands and consumer interest in new options on the market. Beer sales show significant seasonal variations throughout the year. The highest sales share is achieved in the third quarter (31.4%), which is expected given the summer period when beer consumption is traditionally highest due to warm weather, vacations, and social events. There is also a high sales share in the second quarter (27.8%), while the first (17.3%) and fourth quarters (23.5%) record lower sales results due to the winter months. Based on these analyses, the research provides a detailed overview of market trends and consumer preferences, enabling conclusions to be drawn regarding future sales strategies and the optimization of the beer category offering in retail outlets.

**Keywords:** beer, sales, consumer trends, seasonal variations.



## ULOGA I ZNAČAJ MARKETINGA U RAZVOJU PIVARSKE INDUSTRIJE U SRBIJI SA POSEBNIM AKCENTOM NA KANALE DIGITALNE KOMUNIKACIJE

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### Sažetak:

Ovaj rad analizira značaj digitalnog marketinga u pivskoj industriji Srbije, sa posebnim fokusom na ključne digitalne kanale poput društvenih mreža, email marketinga, SEO/SEM-a i online reklama. Tradicionalni pristupi marketingu postepeno ustupaju mesto digitalnim strategijama koje omogućavaju precizno targetiranje i bolju interakciju sa potrošačima. Rad se bavi promenom ponašanja potrošača, naročito sa rastom popularnosti lokalnih i zanatskih pivara, koje koriste digitalne kanale za izgradnju autentičnog odnosa sa publikom. Takođe, analizirani su alati za praćenje efikasnosti kampanja, koji omogućavaju pivarskim brendovima veći povrat ulaganja i prilagodbu strategija. Zaključeno je da će digitalni marketing nastaviti da igra ključnu ulogu u diferencijaciji i konkurentnosti pivskih brendova na srpskom tržištu.

**Ključne reči:** digitalni marketing, pivska industrija, društvene mreže, SEO, SEM, online reklame, zanatske pivare, Srbija, potrošači.



## THE ROLE AND IMPORTANCE OF MARKETING IN THE DEVELOPMENT OF THE BREWING INDUSTRY IN SERBIA, WITH A SPECIAL FOCUS ON DIGITAL COMMUNICATION CHANNELS

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### Summary:

This paper analyzes the significance of digital marketing in Serbia's brewing industry, with a special focus on key digital channels such as social media, email marketing, SEO/SEM, and online advertising. Traditional marketing approaches are gradually giving way to digital strategies that enable precise targeting and better interaction with consumers. The paper examines changes in consumer behavior, particularly with the rise of local and craft breweries, which use digital channels to build authentic relationships with their audience. Additionally, it analyzes tools for tracking campaign effectiveness, allowing brewing brands to achieve higher returns on investment and adjust their strategies. The conclusion is that digital marketing will continue to play a crucial role in the differentiation and competitiveness of brewing brands in the Serbian market.

**Keywords:** digital marketing, brewing industry, social media, SEO, SEM, online advertising, craft breweries, Serbia, consumers



## GLOBALNI TRENDovi I BUDUĆE PROJEKCIJE NA TRŽIŠTU PIVA: ANALIZA PRODAJNIH KANALA, TRŽIŠTA I RASTA PRIHODA (2014-2028)

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### Sažetak:

Ovaj rad analizira globalne trendove i buduće projekcije na tržištu piva od 2014. do 2028. godine, fokusirajući se na kako alkoholne tako i nealkoholne segmente preko različitih prodajnih kanala. Studija koristi podatke iz Statista Consumer Market Insights kako bi ispitala rast prihoda, tržišta i promene u potrošačkom ponašanju u on-trade (van kuće) i off-trade (kod kuće) prodaji piva. Analiza pokazuje da je prihod u off-trade segmentu iznosio 290 milijardi dolara u 2022. godini, sa projekcijama koje ukazuju na rast na 340 milijardi dolara do 2027. godine. U međuvremenu, tržište nealkoholnog piva generisalo je prihod od 34,1 milijarde dolara u 2023. godini i očekuje se da će rasti na 50 milijardi dolara do 2028. godine. Ovi nalazi ističu značajne tržišne promene, poput povećanja prihoda od nealkoholnog piva i promene u potrošačkoj preferenciji prema off-trade konzumaciji. Rezultati naglašavaju važnost razumevanja ovih dinamika dok se globalno tržište piva razvija u odgovoru na ekonomske faktore, kulturne promene i nove potrošačke trendove. Impikacije za aktere u industriji uključuju potrebu za prilagođavanjem strategija kako bi se uskladili sa promenljivim tržišnim uslovima i iskoristili prilike za rast u oba segmenta piva, alkoholnom i nealkoholnom. Ovaj rad doprinosi znanju o globalnim tržišnim trendovima u industriji piva, pružajući uvide za istraživače, profesionalce iz industrije i donosiocima odluka zainteresovane za buduća kretanja u ovom sektoru.

**Ključne reči:** Trendovi tržišta piva, potrošačke preferencije, prodaja, nealkoholno pivo, dinamika tržišta.



## GLOBAL TRENDS AND FUTURE PROJECTIONS IN THE BEER MARKET: AN ANALYSES OF SALES CHANNELS, MARKET VOLUME AND REVENUE GROWTH (2014-2028)

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### Summary:

This paper analyzes global trends and future projections in the beer market from 2014 to 2028, focusing on both alcoholic and non-alcoholic segments across different sales channels. The study leverages data from Statista Consumer Market Insights to examine revenue growth, market volume, and shifts in consumer behavior in on-trade (out-of-home) and off-trade (at-home) beer sales. The analysis reveals that revenue in the off-trade segment stood at \$290 billion in 2022, with projections indicating a rise to \$340 billion by 2027. Meanwhile, the non-alcoholic beer market generated \$34.1 billion in revenue in 2023 and is expected to grow to \$50 billion by 2028. These findings highlight the significant market developments, such as the increasing revenue of non-alcoholic beer and the shifting consumer preference towards off-trade consumption. The results underline the importance of understanding these dynamics as the global beer market evolves in response to economic factors, cultural shifts, and emerging consumer trends. The implications for industry stakeholders include the need to adapt strategies to align with changing market conditions and capitalize on growth opportunities in both alcoholic and non-alcoholic beer segments. This paper contributes to the knowledge on global market trends in the beer industry, offering valuable insights for academics, industry professionals, and policymakers interested in the sector's future trajectory.

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**Keywords:** Beer market trends, Consumer Preferences, Sales, Non-Alcoholic Beer, Market Dynamics





## UTICAJ TRENDOVA PROIZVODNJE ŽITARICA U EU NA SNABDEVANJE JEČMOM ZA PROIZVODNJU PIVA U 2024. GODINI

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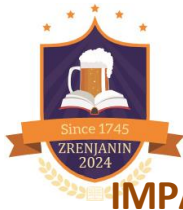
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**Sažetak:**

Ječam (*Hordeum vulgare*) je ključan za proizvodnju piva, a njegova proizvodnja u zemljama Jugoistočne Evrope značajno utiče na industriju piva. Bilans proizvodnje žitarica u EU za sezonu 2023/2024 naglašava ključne trendove koji utiču na ječam, sa prognozom ukupne proizvodnje žitarica u EU od 269,9 miliona tona. Ova brojka odražava pad od 3,9% u odnosu na petogodišnji prosek, ali porast od 1,2% u poređenju sa prethodnom godinom. Glavni cilj ove studije je da analizira i proceni efekte nedavnih trendova u proizvodnji žitarica u EU na dostupnost i cenu ječma. Istraživanje se fokusira na to kako fluktuacije u proizvodnji ječma, zajedno sa promenama u ukupnoj proizvodnji žitarica i prognozama trgovine, mogu uticati na industriju piva. Proučavanjem ovih trendova, istraživanje ima za cilj da identifikuje potencijalne izazove i ograničenja u snabdevanju sektora piva i pruži uvide u potrebne strategije prilagođavanja kako bi se obezbedila stabilnost i ublažili rizici unutar lanca snabdevanja pivom. Očekuje se da će proizvodnja ječma opasti za 0,7 miliona tona ove sezone, što dodatno otežava izazove za sektor piva koji se u velikoj meri oslanja na ovu žitaricu. Ova redukcija, zajedno sa ukupnim padom proizvodnje žitarica, signalizira potencijalna ograničenja u snabdevanju i pritiske na cene za proizvođače piva. Takođe, prilagođavanja u proizvodnji drugih žitarica uključuju smanjenje proizvodnje kukuruza za 1,9 miliona tona i pšenice za 1,1 milion tona, dok se očekuje povećanje proizvodnje durum pšenice za 0,5 miliona tona. Ažurirane prognoze trgovine ukazuju na veće izvoze pšenice i povećane uvoze kukuruza, što može dodatno uticati na dostupnost i cene ječma. Pad proizvodnje ječma naglašava potrebu za pažljivim praćenjem i strategijama prilagođavanja kako bi se očuvala stabilnost u lancu snabdevanja pivom u okviru promenljivih tržišnih dinamika.

**Ključne reči:** Ječam, proizvodnja piva, žitarice, prognoza, trgovina, poljoprivredni trendovi.



## IMPACT OF EU CEREALS PRODUCTION TRENDS ON BARLEY SUPPLY FOR BEER PRODUCTION IN 2024

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**Summary:**

Barley (*Hordeum vulgare*) is essential for beer production, and its cultivation in Southeastern European countries significantly impacts the brewing industry. The EU cereals balance sheet for the 2023/2024 season highlights critical trends affecting barley, forecasting a total EU cereals production of 269.9 million tonnes. This figure reflects a 3.9% decline from the five-year trimmed average but a 1.2% increase compared to the previous year. The primary goal of this research is to analyze and evaluate the effects of recent trends in EU cereals production on the availability and pricing of barley. The report focuses on how fluctuations in barley production, alongside changes in overall cereals production and trade forecasts, may impact the brewing industry. By examining these trends, the report aims to identify potential challenges and supply constraints for the beer sector and offer insights into necessary adaptive strategies to ensure stability and mitigate risks within the beer supply chain. Barley production is expected to decrease by 0.7 million tonnes this season, exacerbating challenges for the brewing sector that relies heavily on this grain. This reduction, combined with the overall drop in cereals production, signals potential supply constraints and cost pressures for beer manufacturers. Additionally, adjustments in other cereal crops include a reduction in maize production by 1.9 million tonnes and soft wheat by 1.1 million tonnes, while durum wheat production is projected to increase by 0.5 million tonnes. Updated trade forecasts indicate higher soft wheat exports and increased maize imports, which may further influence barley's availability and pricing. The decline in barley production underscores the need for careful monitoring and adaptive strategies to maintain stability in the beer supply chain amidst evolving market dynamics. The anticipated reduction in barley production highlights the need for proactive planning and flexibility in sourcing strategies to ensure stability and manage cost pressures in the brewing industry.

**Keywords:** Barley, Beer Production, Cereals, Forecast, Trade, Agricultural Trends.



## KONCEPT PAMETNOG SELA I KRAFT PIVARE

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### Sažetak:

Predmet rada je očuvanje kulturnog i prirodnog nasleđa na pametan način. Ekspanzija računarskih metoda, posebno inteligencije, rezultirala je formiranjem pametnih gradova i sela, kao i pametnih proizvodnih putanja i linija. Pametni procesi uključuju mogućnosti obrade velikih podataka, industrijske uređaje za povezivanje i robotske sisteme. Ovde razmatramo osnovne koncepte tehnika veštačke inteligencije u pametnom selu i njihove primene u nauci, plasmanu i tehnologiji piva usavršavanjem načina proizvodnje, isporuke i prodaje. Pregledom relevantne literature iz oblasti pivarstva, AI i pametnih sela, analizom i kvalitativnom metodologijom studija utvrđeno je da bi integracijom pametnih sistema u ruralna područja, koja čine veliki deo teritorije Republike Srbije, moglo doći do revitalizacije sela i oživljavanja turističkog potencijala kojim Republika Srbija obiluje. Umrežavanjem zanatskih pivara u okviru funkcionisanja pametnog sela stvorili bi se oblici društvenih zanatskih pivara, što bi doprinelo porastu obima poslovanja, uključivanju većeg broja aktera i kulturnih korena. Za razliku od tradicionalne industrijske proizvodnje piva, zanatsko pivarstvo podstiče ispitivanje različitih stilova piva i korišćenje lokalnih sastojaka. Na taj način se prepoznaje pivo i pivarske tehnologije starih autentičnih sorti piva kao nematerijalno kulturno nasleđe Srbije, što je započeto u prethodnim istraživanjima. Umrežavanjem se izbegava rizik da inicijative budu kontrolisane od strane jednog subjekta. Ruralno nasleđe postaje pametno kada je održivo i protkano kroz sve segmente zajednice.

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**Ključne reči:** AI; kraft pivare; nematerijalno kulturno nasleđe; pametno selo; Republika Srbija.



## THE SMART VILLAGE AND CRAFT BREWERY CONCEPT

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### Summary:

A smart way of the preservation of the cultural and natural heritage is the subject of this paper. The expansion of computing methods, especially intelligence, has resulted in the formation of smart cities and villages, as well as smart production paths and lines. Smart processes include big data processing capabilities, industrial connectivity devices and robotic systems. Here we discuss the basic concepts of artificial intelligence techniques in the smart village and their application in the science, marketing and technology of beer by improving the way of production, delivery and sales. A review of relevant literature in the field of brewing, AI and smart villages, analysis and qualitative study methodology determined that the integration of smart systems in rural areas, which make up a large part of the territory of the Republic of Serbia, could lead to the revitalization of villages and the revival of the potential of tourism with which the Republic of Serbia abounds. By networking craft breweries within the functioning of a smart village, forms of social craft breweries would be created, which would contribute to the growth of business volume, the inclusion of a greater number of actors and cultural roots. Unlike traditional industrial brewing, craft brewing encourages the exploration of different beer styles and the use of local ingredients. In this way, beer and brewing technologies of old authentic types of beer are recognized as the intangible cultural heritage of Serbia, which was started in previous research. Networking avoids the risk that initiatives are controlled by one entity. Rural heritage becomes smart when it is sustainable and interwoven through all segments of the community.

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**Keywords:** AI; craft breweries; intangible cultural heritage; smart village; Republic of Serbia.



## EDAMAME STIŽE NA PIVSKU ŽURKU U EVROPI

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### Sažetak:

Edamame je nezrelo zrno soje koje predstavlja popularnu grickalicu u Japanu i često se služi uz pivo. Visok nivo glutaminske kiseline u edamamu pruža prirodnu umami aromu koja savršeno dopunjuje gorčinu hmelja. Cenjen je zbog svojih nutritivnih prednosti, uključujući visok sadržaj proteina i bogatstvo bioaktivnih jedinjenja kao što su izoflavoni, esencijalne aminokiseline i antioksidansi, što sve doprinosi njegovoj nutritivnoj vrednosti i senzornoj privlačnosti. Međutim, trenutna proizvodnja edamame u Evropi je ograničena, pri čemu se većina useva uvozi iz azijskih zemalja. Kako potražnja za zdravim grickalicama nastavlja da raste širom Evrope, postoji značajna prilika za oplemenjivanje edamame prilagođene evropskim agro-klimatskim uslovima i tržištu. Napori u selekciji su usmereni na razvoj novih linija koje su dobro prilagođene ovim uslovima, sa fokusom na genetsko unapređenje osobina vezanih za prinos, kvalitet i nutritivni sadržaj, kako bi se zadovoljile potrošačke preferencije za ukusom i hranljivim vrednostima. U ovom istraživanju korišćena je senzorna evaluacija za analizu više od 60 genotipova edamame i senzorskih karakteristika koje su favorizovali potrošači, što je pomoglo u uspostavljanju kriterijuma za selekciju u oplemenjivanju. Senzorni podaci dobijeni iz ispitivanja ukusa (slatko, kiselo, slano, gorko, umami, orašasto i pasuljasto) korišćeni su za određivanje genotipova sa najboljim performansama na osnovu percepcije potrošača. Senzorna evaluacija se pokazala kao efikasan alat za usmeravanje oplemenjivača u povećanju tržišne privlačnosti i razvoju novih sorti edamame.

**Ključne reči:** soja, edamame, oplemenjivanje, zdrave grickalice, senzorna evaluacija.

**Zahvalnica:** Rad je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije, ugovor broj 451-03-66/2024-03/200032 i Centar izuzetnih vrednosti za leguminoze (CIVL).



## EDAMAME CRASHES EUROPE’S BEER PARTY

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### Summary:

Edamame, the immature soybeans harvested before they ripen, is a popular snack in Japan and is often served alongside beer. The high levels of glutamic acid in edamame provide a natural umami flavor that complements the bitterness of hops. It is valued for its nutritional benefits, including high protein content, rich in bioactive compounds such as isoflavones, essential amino acids, and antioxidants, all of which contribute to its nutritional value and sensory appeal. However, current edamame production in Europe is limited, with the majority of the crop being imported from Asian countries. As the demand for health-conscious snacks continues to rise across Europe, the potential for breeding edamame tailored to European climates and markets presents a significant opportunity. Breeding efforts have focused on developing new lines that are well-adapted to European agro-climatic conditions, emphasizing the genetic improvement of traits related to yield, quality, and nutritional content to meet consumer preferences for flavor and nutrition. In this study, sensory evaluation was employed to analyse more than 60 edamame genotypes and the sensory characteristics favored by consumers, aiding in the establishment of breeding selection criteria. The sensory data obtained from the screening study (sweet, sour, salty, bitter, umami, nutty and beany) were used to determine the top-performing genotypes based on consumer perception. Sensory evaluation serves as an effective tool for guiding breeders in enhancing market appeal and developing new edamame varieties.

**Keywords:** soybean, edamame, breeding, health-conscious snack, sensory evaluation.

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