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Mahnaz ABDOLLAHI [1], Momir TABAKOVIĆ[1], Karl BERGER[2]
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The Renewable Energy Expansion Act (Erneuerbare-Ausbau-Gesetz - EAG) is a federal law on the expansion of energy from renewable sources. This provides for an increase in the annual electricity generation from renewable sources by 27 TWh by 2030. 11 TWh are to be generated from photovoltaic (PV) systems. The PV areas required for this cannot be covered by building-based PV systems alone.
This makes the expansion of ground-mounted PV systems increasingly urgent. Since the usable potential of non-agricultural land is small, the combined usage of by agriculture and photovoltaics makes sense. Agriphotovoltaics (APV) allows energy to be generated from Photovoltaics on land that continues to allow agricultural production. The concept and research on the subject have been around since the 1980s. Research activities have so far focused on the technical framework. The effects on crop production behavior under APV systems are not deeply examined yet. APV can also be an effective climate change adaptation measure by reducing heat stress and drought stress in plants.
The aim of this work is to present the possibilities, potentials, technical requirements, and prerequisites of agricultural photovoltaic systems, as well as to compare different system design variants. This will provide the basis for an interdisciplinary study in which aspects of crop cultivation, grid feeding and use of electrical energy, details of the legal framework for a specific agricultural operation will be investigated to plan the construction of a demonstration plant. The results of the master thesis can therefore on the one hand be used directly in the interdisciplinary study, on the other hand, the technical variants can also be used to make generalized statements and recommendations for APV.
Scientific questions that must have been answered for the master thesis are: How can agrophotovoltaic systems in rural areas be designed:

- To achieve a suitable energy yield (technical design, yield analysis for variants, potential analysis for a site in the foothills of the Alps in Lower Austria), and
- To present a good compatibility with the given boundary conditions from technical, agricultural, and legal side

This work was carried out in the framework of an exploratory study based on a concrete example, calculation and simulation of various scenarios using Q-GIS (terrain formation on 1m grid) as input for PV planning available PV-Sol and PVGIS (PV planning tools), strategies and recommendations are developed, which are relevant for the designation of suitable zones for the construction of the plants, and their technical aspects. The different scenarios / technical variants calculated and simulated with the help of software programs, to be used as a basis for discussion of strategies.
***Key words**: renewable energy, photovoltaic, agriculture*

AGRIFOTOVOLTAIKA – ENERGETSKI PRINOS RAZLIČITIH VARIJANTI KOMBINOVANE UPOTREBE POLJOPRIVREDE I SOLARNE ELEKTRANE U ALPSKOM PODNOŽJU DONJE AUSTRIJE

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Zakon o proširenju obnovljive energije (EAG) je savezni zakon o proširenju energije iz obnovljivih izvora. Ovo predviđa povećanje godišnje proizvodnje električne energije iz obnovljivih izvora za 27 TVh do 2030. godine. 11 TVh će biti proizvedeno iz fotonaponskih (PV) sistema. PV oblasti koje su potrebne za ovo ne mogu se pokriti samo fotonaponskim sistemima zasnovanim na zgradama (Fechner, 2020).
Ovo čini širenje zemaljskih fotonaponskih sistema sve hitnijim. Pošto je upotrebni potencijal nepoljoprivrednog zemljišta mali, kombinovano korišćenje poljoprivrednog i fotonaponskog zemljišta ima smisla. Agrifotovoltaika (APV) omogućava proizvodnju energije iz fotonapona na zemljištu koje i dalje omogućava poljoprivrednu proizvodnju. Koncept i istraživanja na ovu temu postoje od 1980-ih. Istraživačke aktivnosti su se do sada fokusirale na tehnički okvir. Efekti na ponašanje u proizvodnji useva pod APV sistemima još uvek nisu detaljno ispitani. APV takođe može biti efikasna mera prilagođavanja klimatskim promenama smanjenjem toplotnog stresa i stresa od suše u biljkama.
Cilj ovog rada je da se predstave mogućnosti, potencijali, tehnički zahtevi i preduslovi poljoprivrednih fotonaponskih sistema, kao i da se uporede različite varijante projektovanja sistema. Ovo će obezbediti osnovu za interdisciplinarnu studiju u kojoj će se ispitati aspekti uzgoja useva, napajanja mreže i korišćenja električne energije, detalji pravnog okvira za konkretnu poljoprivrednu operaciju kako bi se planirala izgradnja demonstracionog postrojenja. Rezultati magistarskog rada se stoga mogu direktno koristiti u interdisciplinarnoj studiji s jedne strane, as druge strane, tehničke varijante se mogu koristiti i za davanje generalizovanih izjava i preporuka za APV.
Naučna pitanja na koja se mora odgovoriti za rad su: Kako se mogu projektovati agrofotonaponski sistemi u ruralnim područjima:

- Da se postigne odgovarajući energetski prinos (tehnički dizajn, analiza prinosa za varijante, analiza potencijala za lokaciju u podnožju Alpa u Donjoj Austriji), i
- Da predstavi dobru kompatibilnost sa datim graničnim uslovima sa tehničke, poljoprivredne i pravne strane

Ovaj rad je obavljen u okviru istraživačke studije zasnovane na konkretnom primeru, proračunu i simulaciji različitih scenarija koristeći K-GIS (formiranje terena na mreži od 1m) kao ulaz za PV planiranje dostupnih PV-Sol i PVGIS (alati za PV planiranje).), razvijaju se strategije i preporuke koje su relevantne za određivanje pogodnih zona za izgradnju postrojenja i njihovih tehničkih aspekata. Različiti scenariji/tehničke varijante izračunate i simulirane uz pomoć softverskih programa, koji se koriste kao osnova za diskusiju o strategijama.
Ključne reči: *obnovljiva energija, fotonapon, poljoprivreda*

BIOENERGY CONVERSION TECHNOLOGIES: A CASE STUDY

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The conversion of organic waste and energy crops into fuel would help society by producing clean fuel from the regenerative feedstock. Industrial biofuels may be non-polluting and sustainable if properly linked with natural ecological cycles. A common method of producing heat and power from bioenergy is biomass gasification. Furthermore, pyrolysis and hydrothermal carbonization are promising thermochemical processes for converting biomass into liquefied fuels and chemicals. Anaerobic digestion is another well-established method that successfully transforms organic waste matter into biogas. The purpose of the study is to review current bioenergy conversion technologies and to provide quantitative data and interpretation of the heating value, proximate and elemental analysis and product yields specific to bioenergy recovery from some selected biomass materials such as olive mill waste and cotton stalks. The hypothesis is that the resulting data will be consistent with past research proving that biomass residues have a high potential for use as an energy source. Moreover, some products from the conversion (e.g. biochar from pyrolysis) can be used as a soil additive to recover nutrients and carbon in the soil. The latter can additionally act as water storage. This subject is important because there are significant quantities of waste from agricultural production globally, which is a potential source of revenue. Furthermore, other risks associated with cotton waste such as farm hygiene by pesticide remnants and soil-borne pathogens can be addressed. Therefore, utilizing biomass has the potential to be a significant source of energy and an opportunity to reduce environmental issues and financial costs. This study contributes to the needed understanding of energy derived from thermal and biological conversion products of biomass. In this context, according to the characteristics of different kinds of biomass, appropriate utilization methods should be applied to produce bioenergy to realize environmental, economic and energy benefits. The study concluded with some comments on the future potential of these processes.

***Key words**: Biomass, bioenergy technologies, biofuels*

TEHNOLOGIJE KONVERZIJE BIOENERGIJE: STUDIJA SLUČAJA

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Pretvaranje organskog otpada i energetskih useva u gorivo pomoglo bi društvu proizvodnjom čistog goriva iz obnovljivih sirovina. Industrijska biogoriva mogu biti nezagađujuća i održiva ako su pravilno povezana sa prirodnim ekološkim ciklusima. Uobičajeni metod proizvodnje toplote i energije iz bioenergetskih izvora je gasifikacija biomase. Štaviše, piroliza i hidrotermalna karbonizacija su obećavajući termohemijski procesi za pretvaranje biomase u tečna goriva i hemijska jedinjenja. Anaerobna digestija je još jedan dobro uspostavljen metod koji uspešno transformiše organske otpadne materije u biogas. Svrha studije je da se pregledaju trenutne tehnologije konverzije bioenergije i da se obezbede kvantitativni podaci i interpretacija toplotne vrednosti, približne i elementarne analize i prinosa proizvoda specifičnih za dobijanje bioenergije iz nekih odabranih materijala biomase kao što su otpad od prerade maslina i stabljike pamuka. Hipoteza je da će dobijeni podaci biti u skladu sa ranijim istraživanjima koja dokazuju da ostaci biomase imaju visok potencijal za upotrebu kao izvor energije. Štaviše, neki proizvodi iz konverzije (npr. biougalj iz pirolize) mogu se koristiti kao poboljšivač kvaliteta zemljišta za obnavljanje hranljivih materija i ugljenika u zemljištu. Ovo poslednje može dodatno da služi kao unapređenje skladišne moći vode. Ova tema je važna jer u svetu postoje značajne količine otpada iz poljoprivredne proizvodnje, što je potencijalni izvor prihoda. Štaviše, mogu se rešiti i drugi rizici povezani sa otpadom pamuka, kao što je higijena farme od ostataka pesticida i patogena koji se prenose iz zemlje. Stoga, korišćenje biomase ima potencijal da bude značajan izvor energije i prilika za smanjenje ekoloških problema i finansijskih troškova. Ova studija doprinosi potrebnom razumevanju energije dobijene iz toplotnih i bioloških proizvoda konverzije biomase. U tom kontekstu, u skladu sa karakteristikama različitih vrsta biomase, treba primeniti odgovarajuće metode korišćenja za proizvodnju bioenergije kako bi se ostvarile ekološke, ekonomske i energetske koristi. Studija je zaključena nekim komentarima o budućem potencijalu ovih procesa.

Ključne reči: *biomasa, bioenergetske tehnologije, biogoriva*

SUSTAINABLE ENERGY AND CHEMICALS FROM AGRICULTURAL BY-PRODUCTS

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Extracting energy and chemicals from agricultural by-products/biomass is considered as part of the solution to achieving net-zero targets by 2050. However, there are many barriers in valorisation of lignocellulosic biomass due to its recalcitrant structure; therefore, innovative solutions are needed to make these processes economically viable. This talk will cover two key aspects related to lignocellulosic processing: pretreatment of lignocellulosic materials and process intensification of ethanol production.

The first part covers a novel and scalable pretreatment technology to breakdown lignocellulosic material using renewable energy. This involves the design, characterisation, modelling and applications of a novel plasma-microbubble reactor that forms a dielectric barrier discharge (DBD) at the gas–liquid interface to facilitate the transfer of highly reactive species, both short-lived and long-lived, from the gas plasma into the liquid phase. The use of fluidic oscillation mediated microbubbles enabled efficient dispersion of long-lived reactive species in the liquid and UVC-induced oxidation reactions are triggered by the plasma radiation at the gas-liquid interface. A numerical model was developed to understand the dynamics of the reactor, and the model predictions were compared with the experimental measurements. The potential of this approach was demonstrated by pretreating a 5% (w/w) miscanthus suspension for 3 h, which yielded 0.5% acid soluble lignin and 26% sugar release post hydrolysis. The process consumed 20-fold less energy compared to steam explosion. Furthermore, anaerobic digestion of plasma microbubble pretreated maize produced 18% greater biogas yield in comparison to untreated raw samples.

The second part focuses on process intensification. Product inhibition is a main barrier to the production of bioethanol at industrial scale and is responsible for dilute product streams which are energy intensive to purify. The potential of hot-microbubble clouds generated by fluidic oscillation to continuously remove ethanol from bioreactors at lab scale is presented. Parageobacillus thermoglucosidasius (TM242), a thermophilic organism that can utilize a range of sugars derived from lignocellulosic biomass, was selected for this study as future bioethanol production needs to be based on sustainable feedstocks. First, a custom-made microbubble gas-stripping unit containing dilute ethanol-water mixtures was tested in batch and continuous mode to identify the effect of operating parameters on the stripping process. Then, in situ and ex situ microbubble stripping from the fermentation broth was carried out while monitoring the residual ethanol concentration in a bioreactor operated in fed-batch and continuous mode. In all cases, residual ethanol concentration was maintained below the inhibition threshold for TM242, which is ~2%(v/v), while allowing an ethanol productivity up to 14.9 g L^{-1} h^{-1}.

Key words: *biomass, pretreatment technology, lignocellulosic waste, plasma-microbubble reactor, ethanol*

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Proizvodnja energije i hemikalija iz poljoprivrednog otpada i biomase se smatra delom rešenja za ostvarenje cilja nulte emislije do 2050. Postoje mnoge barijere u iskorišćenju lignoceluloznog otpada zbog njegove strukture. Ovo iziskuje inovativna rešenja kako bi se process učinio ekonomski isplativim. Ova prezentacija pokriva dva ključna aspekta tretmana lignoceluloznog otpada: pretretman lignoceluloznog materijala i poboljšanje procesa proizvodnje etanola.

Prvi deo pokriva inovativnu i adaptabilnu tehnologiju za razgradnju lignoceluloznog materijala koristeći obnovljivu energiju. Ovo uključuje dizajn, karakterizaciju, modelovanje i primenu inovativnih plazma reaktora sa mikro mehurima koji formiraju dielektrično barijerno pražnjenje na mestu kontakta gasne i tečne faze sa ciljem transfera visoko reaktivnih kratko i dugo živećih vrsta. Fluidne oscilacije mikro mehurića omogućavaju efikasnu disperziju dugoživećih radikalskih vrsta u tečnosti i UVC indukovane oksidacione reakcije izazvane plazmom u zoni kontakta gasa i tečnosti. Razvijen je numerički model sa ciljem boljeg razumevanja dinamike reaktora i rezultati predviđeni modelom su upoređeni sa eksperimentalnim rezultatima. Potencijal ovog prisutpa je potvrđen u postupku pretretmana suspenziju miskantusa 5% (w/w) tokom 3h – dobijeno je 0.5% kiselo rastvornog lignina i oslobođeno je 26% šećera nakon hidrolize. Ovaj proces je zahtevao 20 puta manje energije u poređenju sa tretmanom primenom eksplozije vodene pare. Takođe, u procesu anaerobne digestije kukuruza pretretiranog plazmom u istom tipu bioreaktora postignut je 18% viši prinos biogasa u poređenju sa netretiranim, sirovim uzorcima kukuruza.

Drugi deo prezentacije se fokusira na unapređenje produktivnosti procesa. Formiraje inhibitornih jedinjenja je prepreka u industrijskoj fermentacionoj proizvodnji bioetanola i često je zbog visokih razblaženja u procesu potreban utrošak velike količine energije za koncentrisanje i prečišćavanje. U ovom delu ćemo razmatrati potencijal vrelih mikromehurova generisanih oscilacijama fluida kao Sistema za kontinualno uklanjanje etanola iz bioreaktora u laboratorijskim uslovima. *Parageobacillus thermoglucosidasius* (TM242), termofilni organizam koji može da razgrađuje šećer proizveden iz lignocelulozne biomase, je izabran za ovo istraživanje usled potrebe da proizvodnja bioetanola u budućnosti bude zasnovana na obnovljivim materijalima. Prvo, namenski napravljena jedinica za generisanje mikromehurova iz razblažene smeše vode i etanola, je testirana u šaržnom i kontinualnom režimu u cilju utvrđivanja efekta operativnih parametara na efikasnost procesa. Zatim, izveden je *in situ* i *ex situ* proces uklanjanja etanola mikro mehurićima iz fermentacione tečnosti, uz uporedno praćenje koncentracije zaostalog etanola u bioreaktoru u dolivnom i kontinualnom režimu. Rezultati pokazuju da je koncentracija zaostalog etanola održavana ispod inhibitornog nivoa za TM424, koji je 2% (v/v), uz produktivnost etanola od 14.9 g L^{-1} h^{-1}.

Ključne reči: *biomasa, pretretman, lignocelulozni otpad, plazma reaktor sa mikromehurima, etanol*

SELECTIONG 100 BEST LOCATIONS FOR THE BIGGER PHOTOVOLTAIC POWER PLANTS IN SERBIA

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Previous energy strategies for Serbia had various goals in terms of renewable energy sources with the quantification of type of power plants by type, but the national energy planning did not go to the level of determining specific locations for power plants, namely photovoltaic. This caused difficulties for the responsible ministry and public companies to decide which power plants will be connected and which not. Additionally, due to a drop in investment costs, connection requests dramatically increased. In the beginning of 2023 applications for the construction of power plants totaling 14 GW in capacity were under review at public transmission company which further caused delays and stagnation in the construction of these power plants. At the same time, electricity prices for households and industries had increased by 18 and 27% respectively. During the year 2022, only 6 MW of new power plants were realized even with granting the monthly net-metering to the industry and households, which is far below the possible and realistic dynamic of Serbia's energy transition implementation. It was announced in early 2023, with the changes in legislative towards implementing the auctions principles, that the first permits will be issued for the construction of large photovoltaic power plants on land to progress towards meeting an overall capacity goal of 2-3 GW. To guide in selecting sites that will help meet this goal, we mapped 100 suitable photovoltaic power plant locations prioritized not only by energy yield, but also to prevent possible conflicts with other activities (i.e., agriculture, protected areas and cultural heritage). The mapping was carried out using available energy yield data, and geographically specific data of importance for the construction of larger photovoltaic power plants up to 10 MW in size. The 100 locations were selected as best among a much larger number of possible ones. These 100 sites occupy less than 25 km^2 of land and would be enough to cover about 5% of household consumption in Serbia.
Key words*: energy planning, photovoltaic power plant, GIS, Serbia*

ODABIR 100 NAJBOLJIH LOKACIJA ZA POSTAVLJANJE VEĆIH FOTONAPONSKIH ELEKTRANA U SRBIJI

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Dosadašnje energetske strategije Srbije su imale različite ciljeve u pogledu obnovljivih izvora energije sa kvantifikacijom pojedinih tipova elektrana, ali nacionalno energetsko planiranje nije išlo do nivoa određivanja konkretnih lokacija, posebno za fotonaponske elektrane. Ovo je izazvalo poteškoće nadležnom ministarstvu i javnim preduzećima jer je pad investicionih troškova ohrabrio veliki broj aplikanata za dozvole za izgradnju elektrana na pogodnim lokacijama od ukupno 14 GW, što je dodatno izazvalo zastoje i stagnaciju u izgradnji ovih elektroenergetskih objekata na zemlji. U isto vreme došlo je do poskupljenja troškova snabdevanja električnom energijom za domaćinstva 18% i 27% za privredu tokom 2022. a iste godine kroz mehanizam neto-merenja realizovano je samo oko 6 MW novih elektrana što je kao rezultat daleko ispod mogućeg, realnog nivoa i neophodne brzine sprovođenja energetske tranzicije Srbije. Početkom 2023. godine, uz izmene zakona u pravcu sprovođenja aukcija, najavljeno je da će biti izdate prve dozvole za izgradnju velikih fotonaponskih elektrana na zemljištu i ulaganja u projekte veličine nekoliko (2-3) GW. Stoga je potrebno izvršiti mapiranje i odabiranje 100 lokacija fotonaponskih elektrana kako bi se bolje razumele pogodne lokacije ne samo sa stanovišta prinosa energije, već i kako bi se predupredili eventualni konflikti sa drugim aktivnostima (poljoprivreda, zaštićena područja, kulturno nasleđe). Mapiranje je sprovedeno korišćenjem raspoloživih podataka o energetskim prinosu, kao i geografski specifičnih podataka od značaja za izgradnju većih fotonaponskih elektrana do 10 MW. Odabrano je 100 najboljih lokacija među mnogo većim brojem mogućih. Količina proizvedene energije na površini koja zauzima manje od 25 km^2 bila bi dovoljna da pokrije oko 5% potrošnje domaćinstava u Srbiji.
***Ključne reči**: energetsko planiranje, fotonaponske elektrane, GIS, Srbija*

TOWARDS THE DESIGN OF STRAWBERRY BASED FUNCTIONAL FOODS BY 3D PRINTING

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Three-dimensional printing (3DP) technology, also known as additive technique, is a new method that provokes the great interest of researchers, industry and the public due to its various applications such as medicine, gastronomy, engineering, food industry, etc. The main feature of this technology is the addition of material layer-by-layer. This enables the production of complex product geometries that would be difficult or impossible to achieve using conventional production methods.

3DP technology has been the focus of much innovative research in the food sector in recent years. This technology enables the computerized production of 3D-molds of food products of various compositions, which stands out from many other emerging technologies due to numerous advantages, such as customized food design, personalized nutrition, simplification of the supply chain, and expansion of uses for available food materials. As far as the food sector is concerned, this technology offers a wide range of potential applications, from the production of food for the elderly and children, to the production of functional foods and confectionery, to use in space missions.

One area of particular interest in the application of this technology is in the production of functional foods. With the aim of increasing the daily consumption of fruits and vegetables, this technology has good prospects for products with different food combinations with these raw materials, focusing not only on the rheological and sensory properties but also on the nutritional and bioactive aspects.

Therefore, the aim of this work was to investigate the possibility of applying 3DP for the development of functional products based on strawberries. The influence of two different extrusion-based printing programs with the application of two different starch hydrocolloids (corn *vs*. wheat) in different proportions (10, 15 and 20%, w/w) on the stability of bioactive compounds (total phenols, hydroxycinnamic acids, flavonols, total flavonoids, anthocyanins and condensed tannins) and antioxidant capacity (DPPH and FRAP) were investigated.

Results showed that the type of starch significantly modified all determined bioactive compounds, and antioxidant capacity of the 3DP products tested. The starch content and the type of printing program also had a significant effect on the majority of the components studied. For the preservation of the bioactive profile and antioxidant capacity of the 3DP product, a starch content of 15 % and printing program 2 were found to be the most suitable. In summary, the results obtained show that three-dimensional printing can be considered as a technology with high potential for the development of innovative and customized functional fruit products.

Key words*: additive manufacturing, 3D printing, functional food, strawberry, bioactive compounds*

DIZAJN FUNKCIONALNE HRANE NA BAZI JAGODE PRIMJENOM TEHNOLOGIJE 3D PRINTANJA

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Tehnologija trodimenzionalnog printanja (3DP), također poznata i kao aditivna tehnologija, jest nova tehnologija koja plijeni veliki interes istraživača, industrije i javnosti sa svojim različitim područjima primjene poput medicine, gastronomije, inženjeringa, prehrambene industrije i dr. Glavno obilježje ove tehnologije jest dodavanje materijala sloj po sloj, čime je omogućena proizvodnja kompleksne geometrije proizvoda koju bi tradicionalnim načinima proizvodnje bilo teško ili nemoguće proizvesti.
3DP hrane posljednjih je godina u fokusu mnogih istraživanja prehrambenog sektora. Ova tehnologija omogućava računalno kontroliranu izradu trodimenzionalnih oblika hrane različitog sastava, koja se iz mnoštva novih inovativnih tehnologija ističe zbog višestrukih prednosti, kao što su prilagođeni dizajn hrane, kreiranje personaliziranih obroka, pojednostavljenje lanca opskrbe i proširenje dostupnih prehrambenih proizvoda jedinstvenih nutritivnih, teksturnih i senzorskih svojstava. U vidu prehrambenog sektora, tehnologija 3DP ima široku primjenu, od izrade hrane za starije osobe i djecu, proizvodnje funkcionalne hrane i konditorskih proizvoda, pa sve do uporabe u svemirskim misijama.
Poseban interes za primjenu ove tehnologije ogleda se u proizvodnji funkcionalne hrane. S ciljem povećanog dnevnog unosa voća i povrća, ova tehnologija ima perspektivu u proizvodnji proizvoda na bazi različitih kombinacija ovih vrsta, no pored reoloških i senzorskih obilježja, naglasak se stavlja i na nutritivni i biokativni aspekt. Stoga je cilj ovog rada bio ispitati mogućnost primjene 3DP u razvoju funkcionalnih proizvoda na bazi jagode. Istraživanje je provedeno ispitujući utjecaj dva različita programa ispisa temeljenih na ekstruziji, uz primjenu dva različita škrobna hidrokoloida (kukuruzni vs. pšenični) u različitim udjelima (10, 15 i 20 %, w/w) na stabilnost bioaktivnih spojeva (ukupni fenoli, hidroksicimetne kiseline, flavonoli, ukupni flavonoidi, antocijani i kondenzirani tanini) i antioksidacijski kapacitet (DPPH i FRAP).
Vrsta škroba značajno je modificirala sve određivane bioaktivne spojeve i antioksidacijski kapacitet analiziranih 3D printanih proizvoda. Udio škroba i tip programa ispisa također značajno utječu na većinu određivanih spojeva, a za očuvanje bioaktivnog profila i antioksidacijskog kapaciteta 3D printanog proizvoda najboljim se pokazao udio škroba od 15% i uporaba programa 2 za ispis. U zaključku, dobiveni rezultati pokazuju da se trodimenzijsko printanje može smatrati tehnologijom visokog potencijala za razvoj inovativnih i individualnih funkcionalnih proizvoda na bazi voća.
***Ključne reči**: aditivna proizvodnja, 3D printanje, funkcionalna hrana, jagoda, bioaktivni spojevi*

APPLICATION OF DIELECTRIC BEHAVIOUR ANALYSIS FOR MONITORING OF BIOMASS HYYDROLYIS AND CO-FERMENTATION PROCESS

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In the utilization technologies of secondary and tertiary biomass sources (lignocellulosic biomass-LCB, wastewater sludge etc.) pre-treatment, and fermentation can also be considered as crucial steps to achieve higher efficiency. There are needed to develop monitoring methods to detect the bioconversion rate, kinetics of fermentation, and biogas production yield of anaerobic digestion (AD). During pre-treatments and enzymatic hydrolysis of macromolecules, the chemical changes (disruption of chemical bonds, physicochemical changes) induce the altering of dielectric behavior of the system. Therefore, analysis of dielectric behavior can provide information related to the efficiency of fermentation process. Because of the short time need, ability for real-time, and on-line measurement, the non-destructive dielectric detection methods can be implemented in biomass utilization technologies.
In our research the dielectric constant and loss factor of lignocellulosic biowaste (corn-cob mix-CCB), and meat and dairy industry originated wastewater sludge was measured in the frequency range of 200 – 2400 MHz by a Speag DAK 3.5 dielectric probe. The efficiency of enzymatic hydrolysis of LCB and sugar/ethanol conversion was determined by spectrophotometric methods. Disintegration degree of the sludge and the feed for co-fermentation tests (CCB and sludge) was given based on chemical oxygen demand (COD). Biogas production was measured in lab-scale batch mesophilic AD tests.
Our results have verified that the dielectric constant of LCB suspension at the frequency range of 300-600 MHz show good linear correlation with the cellulose degradation degree. The dielectric constant in the frequency range of 300-900 MHz has been proved suitable to monitor the hydrolysis efficiency in LCB/sludge pre-treatment processes (microwave, alkaline). For estimation of sugar/ethanol bioconversion the dielectric loss factor at the frequency range of 300-400 MHz can be applied. The change of disintegration degree and biodegradation index occurred by pre-treatments and during the anaerobic co-fermentation process can be detected by the measurement of dielectric constant at 300-400 MHz and 2200-2400 MHz frequency ranges, as well.
***Key words**: biomass, dielectric behavior, biodegradation*

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CHECK OF DEVICE FOR GAS LEAK DETECTION

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Universal gas leak detection devices are often used to detect natural gas leaks. These are devices that have built-in different types of sensors such as infrared, semiconductor or electrochemical sensors. As a result, the devices can detect leaks of different types of gases such as: methane CH_4, oxygen O_2, carbon dioxide CO_2, carbon monoxide CO and hydrogen sulfide H_2S. To detect natural gas leaks, the device uses an infrared sensor that actually detects the presence of methane CH_4. The gas leak detector cannot determine the exact value of the gas concentration. The idea is to use a gas leak detector to locate the place where the gas leak occurs. According to the German regulation DVGW G 465-3 (Classification criteria for leaks in buried and not buried pipework in gas distribution systems), which is often applied in the Republic of Serbia, the place of a gas leak can be classified into one of four leak classes: AI, AII, B and C. According to the class of gas leakage, a decision is made on the measures that need to be implemented in order to eliminate the potential danger. The gas leak detector should be periodically checked at the check station. The subject of the paper is the procedures for checking gas leak detector. Several gas leak detectors of the model "GMS 4000" produced by "Schütz Messtechnik" GmbH were checked for the purposes of the research. The detectors were checked within the company "Novi Sad Gas" d.o.o. from Novi Sad at the check station model "PS403" manufactured by "Schütz Messtechnik" GmbH. Within the paper were presented and analyzed the results of the following checks: gas concentrations of 10 ppm, gas concentrations greater than 10 ppm and the vacuum pump that performs gas sampling in the device. The check was done at the check station using bottles with known concentrations of methane CH_4 in synthetic air. The conducted checks confirmed the importance of periodic checks of gas leak detectors.
***Key words**: gas leak, methane, natural gas*

PROVERA UREĐAJA ZA DETEKCIJU CURENJA GASA

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Za detekciju curenja prirodnog gasa često se koriste univerzalni uređaji za detekciju curenja gasova. Radi se o uređajima koji u sebi imaju ugrađene različite tipove senzora poput infracrvenog, poluprovodničkog ili elektrohemijskog senzora. Usled toga uređaji mogu da detektuju curenja različitih vrsta gasova poput: metana CH_4, kiseonika O_2, ugljen dioksida CO_2, ugljen monoksida CO i vodonik sulfida H_2S. Za detektovanje curenja prirodnog gasa uređaj koristi infracrveni senzor koji zapravo detektuje prisustvo metana CH_4. Uređaj za detekciju curenja gasa ne može da odredi tačnu vrednost koncetracije gasa. Ideja je da se uređajem za detekciju curenja gasa locira mesto na kome dolazi do curenja gasa. Prema nemačkom pravilniku DVGW G 465-3 (Procena mesta curenja gasa na podzemnim i nadzemnim gasnim vodovima u gasnim mrežama) koji se često primenjuje u Republici Srbiji, mesto curenja gasa može da se svrsta u jednu od četiri klase curenja: AI, AII, B i C. Prema klasi curenja gasa donosi se odluka o merama koje je potrebno sprovesti u cilju otklanjanja potencijalne opasnosti. Uređaj za detekciju curenja gasa je potrebno periodično proveriti na stanica za proveru uređaja. Predmet rada su procedure provere uređaja za detekciju gasova. Za potrebe rada urađena je provera nekoliko uređaja za detekciju curenja gasa modela “GMS 4000” proizvođača “Schütz Messtechnik” GmbH. Provera uređaja urađena je u okviru kompanije “Novi Sad Gas” d.o.o. iz Novog Sada na stanici za proveru model “PS403” proizvođača “Schütz Messtechnik” GmbH. U okviru rada prikazani su i analizirani rezultati sledećih sprovedenih provera: koncentracije gasa od 10 ppm, koncentracije gasa većih od 10 ppm i vakum pumpe koja u uređaju vrši uzorkovanje gasa. Provera je urađena na stanici za proveru uređaja pomoću boca sa poznatim koncentracijama metana CH_4 u sintetičkom vazduhu. Sprovedene provere potvrdile su važnost periodičnih provera uređaja za detekciju gasa.
***Ključne reči**: curenje gasa, metan, prirodni gas*

THE CIRCULAR ECONOMY BY EXAMPLE DEVELOPMENT OF AN INNOVATIVE SUGAR BEET PULP DRYING PROCESS USING FACTORY WASTE HEAT

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Currently, there are 17 sugar plants in Poland, which are part of 4 concerns. National Food Industry Group (KGS) is the largest state-owned food producer in Poland and the only one of strategic importance for the food safety in this country. The main business of KGS is sugar production.

Sugar production leads to deformation by-products: molasses and sugar beet pulp. Sugar beet pulp remaining after the process of extracting sugar from sugar beet cuttings. At KGS, in view of increasingly higher quality requirements for feed ingredients, efforts were made in 2015 to develop a new method of drying pulp using waste heat accompanying sugar production. The presented dryer located in Krasnystaw Sugar Factory takes into account the experience from the operation of the dryer in Werbkowice and is a continuation of research to develop a target drying technology, which will allow drying pulp enriched in biologically active substances. The developed technology will be able to be implemented in other KGS sugar plants, i.e. Kluczewo and Malbork.

The design of the new dryer includes the following benefits:

- the drying path will be lengthened and drying air temperatures will be lowered,
- an additional 4 fans will be added on the water/glycol line, the speed of which will be controlled by a frequency converter and adjusted to current needs. This will make the dryer more flexible in terms of modeling the temperature curve,
- the water/glycol mixture used to the maximum in the traditional air heaters will be directed to additional heaters mounted directly above the steam heaters. Their purpose is to preheat the air directed by the steam heaters to the last sections of the pulp dryer. Thanks to this solution, the consumption of the high-energy medium steam will be minimized and a higher temperature will be achieved with low energy consumption using waste heat,
- hot air used to dry the pulp in the last section of the dryer with the help of steam heaters, after passing through the layer of dried pulp, will be returned to the beginning of the dryer and reused as a drying agent. In this way, we will reuse the energy from the already-heated air.
- abandoning pulp and re-drying to 5% moisture content.

Pulp with this moisture content took up to 11% moisture from the environment during storage, indicating that the heat used to re-dry to 5% was unnecessarily wasted. Re-drying to 5% moisture was done in steam-fed sections. Reducing or completely eliminating this step will reduce or even eliminate the use of steam in the dryer, which will translate into lower drying costs. The proposed changes to the solutions used in the experimental dryer in Werbkowice will introduce a new quality in pulp drying and will be one of the first of its kind in the world. They will allow almost full utilization of waste heat waste heat, reducing its losses to a minimum, and almost completely abandoning steam re-drying.

***Key words**: Dryer, sugar beet pulp, waste heat, sugar industry*

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MODEL BIOGAS PRODUCTION PROCESS USING WOOL AND COTTON HYDROLYSATES FROM TEXTILE WASTE

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With population growth, increasing urbanization and globalization, and widespread consumerism, a worldwide industry is being driven. Every year more and more material goods are produced, and consequently more and more waste. It is estimated that by 2050, global solid waste production will increase by as much as about 70% to as much as 3.4 billion tons. One of the most intensively growing industries is the textile industry. In 2020, global fiber production was as high as 109 million tons. Textile production consumes huge amounts of water, energy and chemicals and generates tons of waste and wastewater. Global demand for textiles (apparel, decorative and utility fabrics, specialty fabrics, etc.) is growing steadily, and it looks like this trend will continue. In 2030, the value of the textile market is expected to be as high as approx. 1,420 billion dollars.

According to the Circular Economy, waste is considered as an alternative raw material that can continue to be used and processed into new products or product components. In this economic model, resources are kept in use for as long as possible, extracting the maximum value from them during use, and then reclaiming and remanufacturing products and materials at the end of a product's useful life.

Textile waste can be divided into two main groups:

- pre-consumption (post-production), that is, waste that is generated during production processes,
- post-consumption, i.e. waste that is generated as a result of use and disposal by consumers.

Currently, 63% of textiles are made from petrochemical raw materials, which cannot be processed by microorganisms. So unfortunately, only 37% of pre-consumer waste is natural fibers such as cotton, wool and linen. Due to the use of synthetic additives and chemical treatment of natural fibers, post-consumer waste is hardly biodegradable and is a significant group of waste. Currently, most textile waste ends up in landfills or is incinerated. Therefore, new solutions to the problem of textile waste treatment and disposal are being sought.

This paper presents a procedure for heat-assisted acid hydrolysis of cotton fibers with wool fibers, optimized to obtain the highest possible amounts of glucose and amino acids. The acid hydrolysis process used a 2% solution of phosphoric acid (V), and the reaction was carried out in batch stirred pressure reactors at 140°C for 2 hours. The effect of the proportion of wool hydrolysate in cotton hydrolysate was studied in terms of maximizing biogas production. The addition of wool hydrolysate at 5%, 10% and 15% by weight was used.

The resulting hydrolysates were used as fermentation media toward biogas production. Biogas production were performed using batch fermentation systems consisting of 1 dm^3 glass bottles, each with a working volume of 0.7 dm^3. The daily biogas production was measured by a water displacement method; for this purpose each bottle was connected to a 1 dm^3 gas collecting tank.

Key words*: textile waste, cotton, wool, biogas, enveierment*

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MORPHOLOGY AND CHEMICAL COMPOSITION OF THE BLACK POWDER COLLECTED AT THE GAS METERING AND REGULATING STATION "JARAK"

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Internal corrosion of steel gas pipelines occurs due to the presence of water in natural gas. Water is separated from natural gas and dehydration of natural gas is carried out in order to reduce the amount of water in natural gas. In the dehydration process, the amount of water vapor from natural gas is reduced. Due to high dew points, residual water vapor from natural gas can potentially condense on the inner surfaces of steel pipeline walls. Also, due to certain disturbances, water can penetrate into the gas pipeline. Carbon dioxide CO_2, hydrogen sulfide H_2S and oxygen O_2 in natural gas without the presence of water do not participate in corrosion processes. Water chemically reacts with carbon dioxide CO_2, hydrogen sulfide H_2S and oxygen O_2 creating unwanted internal corrosion products such as iron carbonate $FeCO_3$, iron sulfide FeS and iron oxide (Fe_3O_4, FeOOH). Internal corrosion products mixed with salt, sand, liquid hydrocarbons and metal residues form a black powder. Black powder can cause various problems: endangering human health and the environment; causing a fire; clogging of equipment and instrumentation; erosion of the internal surfaces of the steel pipeline; reducing pipeline capacity and soiling of measuring equipment. The particles of black powder are micro and nano in size, so they represent a problem for the clearances of valves, cylinders and pistons of compressors, filters, separators, etc. Black powder can be dry in the form of a fine powder or wet like tar. The following removal methods are used to manage and control the amount of black powder in the systems: mechanical cleaning; chemical cleaning; separators and filters. The morphology and composition of black powder particles depend on the pipeline system from which the powder was removed. The paper's focus is on the morphology and composition of the black powder that was removed from the filter of the gas metering and regulating station "Jarak", which is located on the gas distribution system of the public company "Srem-Gas" from Sremska Mitrovica. The morphology of the black powder was recorded using a scanning electron microscope, while the chemical characterization of the black powder was performed using an energy dispersive spectrometer. The analysis of the morphology and composition of black powder was done for the purposes of managing and controlling the amount of black powder in the distribution system.
Key words: *black powder, natural gas, gas pipeline*

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MORFOLOGIJA I HEMIJSKI SASTAV CRNOG PRAHA SAKUPLJENOG NA MERNO - REGULACIONOJ GASNOJ STANICI "JARAK"

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Usled prisustva vode u prirodnom gasu dolazi do pojave unutrašnje korozije čeličnih gasovoda. U cilju smanjenja količine vode u prirodnom gasu radi se izdvajanje vode iz prirodnog gasa i dehidratacija prirodnog gasa. U postupku dehidratacije smanjuje se količina vodene para iz prirodnog gasa. Usled visokih tačaka rose potencijalno može da se kondenzuje preostala količina vodene pare iz prirodnog gasa na unutrašnjim površinama zidova čeličnih gasovoda. Takođe usled određenih poremećaja voda može da prodre u gasovodni cevovod. Ugljen dioksid CO_2, vodonik sulfid H_2S i kiseonik O_2 u prirodnom gasu bez prisustva vode ne učestvuju u procesima korozije. Voda hemijski reaguje se ugljen dioksidom CO_2, vodonik sulfidom H_2S i kiseonikom O_2 stvarajući neželjene produkte unutrašnje korozije poput gvožđe karbonata $FeCO_3$, gvožđe sulfida FeS i gvožđe oksida (Fe_3O_4, FeOOH). Produkti unutrašnje korozije pomešani sa soli, peskom, tečnim ugljovodonicima i ostacima metala formiraju crni prah. Crni prah je abrazivan materijal tvrđi od tipičnog ugljeničnog čelika koji se obično koristi za izgradnju gasovodnih sistema. Crni prah može da prouzrokuje različite probleme: ugrožavanje zdravlja ljudi i životne sredine; izazvanje požara; začepljenje opreme i instrumentacije; eroziju unutrašnjih površina čeličnog cevovoda; smanjenje kapaciteta cevovoda i zaprljanje opreme za merenje. Čestice crnog praha su mikro i nano veličine pa predstavljaju problem za zazore ventila, cilindara i klipova kompresora, filtera, separatora itd. Crni prah može biti suv u formi finog praha ili vlažan poput katrana. Za upravljanje i kontrolisanje količine crnog praha u sistemima koriste se sledeće metode uklanjanja: mehaničko čišćenje; hemijsko čišćenje; separatori i filteri. Morfologija i sastav čestica crnog praha zavise od gasovodnog sistema iz koga je prah uklonjen. Predmet rada je morfologija i sastav crnog praha uklonjenog na filteru merno-regulacione gasne stanice "Jarak" koja se nalazi na distributivnom gasovodnom sistemu JP „Srem-Gas" iz Sremske Mitrovice. Morfologija crnog praha snimljena je primenom skenirajućeg elektronskog mikroskopa, dok je hemijska karakterizacija crnog praha urađena pomoću energetskog disperzivnog spektrometra. Analiza morfologije i sastava crnog praha urađena je za potrebe upravljanja i kontrolisanja količine crnog praha u distributivnom sistemu.

Ključne reči: *crni prah, prirodni gas, gasovod*

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CONTROL OF NATURAL GAS ODORIZATION USING GAS DETECTION TUBES

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Natural gas (NG) has no smell hence consumers cannot sense the presence of NG with their sense of smell. For safety reasons, NG in every part of the gas distribution system must have a warning odor level. In order to obtain the smell, the odorization procedure of NG is carried out. Odorization of NG is the procedure of injecting an odorous substance (odorant) into the flow of NG. Odorization of NG is conducted in NG odorizers. NG odorizers are located near or are part of gas metering and regulating stations. Ethyl mercaptan was previously used as an odorant, while today tetrahydrothiophene is most often used. In the Republic of Serbia, ethyl mercaptan can no longer be used as a NG odorant from the end of 2022. In order to consumers be able to feel the warning odor regular checks of the gas odor level are required. The required concentration of odorant in NG is the one that achieves a warning odor level in the most distant points of the gas distribution system. According to the regulations in the Republic of Serbia, NG delivered to households through gas distribution systems, as well as NG distributed through PE pipes, must be odorized. The required concentration of tetrahydrothiophene as an odorant in the farthest points of the gas distribution system is from 12 to 23 mg/m^3 under normal conditions. Control of gas odorization can be done by determining the concentration of odorants in the gas and/or olfactometric tests. The control of odorant concentration in NG can be continuous with the help of permanently installed measuring devices or discontinuous by using manual measuring devices. The subject of the paper is the control of gas odorization by determining the concentration of odorants in NG using gas detection tubes. It is a simple method that discontinuously and with sufficient accuracy determines the concentration of odorants in NG. The paper presents the procedure for determining the concentration of tetrahydrothiophene in NG at the end of the gas distribution system of JP "Srem-Gas" from Sremska Mitrovica using gas detection tubes. Control of gas odorization confirmed that the required concentration of odorant (warning odor level) in the NG was achieved at a measuring point at the end of the gas distribution system.

***Key words**: odorant, odorization, natural gas*

KONTROLA ODORIZACIJE PRIRODNOG GASA PRIMENOM CEVČICA ZA DETEKCIJU GASOVA

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Prirodni gas nema miris pa potrošači čulom mirisa ne mogu da osete njegovo prisustvo. Iz razloga bezbednosti prirodni gas u svakom delu distributivnog gasovodnog sistema mora da ima upozoravajući stepen mirisa. U cilju dobijanja mirisa sprovodi se postupak odorizacije prirodnog gasa. Odorizacija prirodnog gasa je postupak ubrizgavanja mirisne materije (odoranta, sredstva za odorizaciju) u struju prirodnog gasa. Odorizacija gasa sprovodi se u stanicama za odorizaciju gasa. Stanice za odorizaciju gasa nalaze se u blizini merno-regulacionih stanica ili su deo merno-regulacionih stanica. Ranije se kao odorant koristio etil merkaptan, dok se danas najčešće koristi tetrahidrotiofen. U Republici Srbiji zaključno sa krajem 2022. godine ne može više da se koristi etil merkaptan kao sredstvo za odorizaciju. Da bi potrošači mogli da osete upozoravajući stepen mirisa gasa potrebne su redovne kontrole nivoa odorisanosti gasa. Potrebna koncentracija odoranta u prirodnom gasu je ona koja u najudaljenijim tačkama distributivnog gasovodnog sistema ostvaruje upozoravajući stepen mirisa. Prema propisima u Republici Srbiji prirodni gas koji se distributivnim gasovodnim sistemima isporučuje domaćinstvima, kao i prirodni gas koji se distribuira PE cevima mora biti odorisan. Potrebna koncentracija odoranta tetrahidrotiofena u najudaljenijoj tački distributivnog gasovodnog sistema (THT) je 12-23 mg/m3 pri normalnim uslovima. Kontrola odorizacije gasa može da se radi određivanjem koncentracije odoranta u gasu i/ili olfaktometrijskim ispitivanjima. Kontrola koncentracije odoranta u prirodnom gasu može da bude kontinuirana uz pomoć trajno postavljenih mernih uređaja ili diskontinuirana pomoću ručnih mernih uređaja. Predmet rada je kontrola odorizacije gasa određivanjem koncentracije odoranta u prirodnom gasu pomoću jednokratnih cevčica. Radi se o jednostavnoj metodi kojom se diskontinuirano i sa dovoljnom tačnošću određuje koncentracija odoranta u prirodnom gasu. U radu je prikazan postupak određivanja koncentracije tetrahidrotiofena u prirodnom gasu na kraju distributivnog gasovodnog sistema JP „Srem-Gas" iz Sremske Mitrovice primenom jednokratnih cevčica. Kontrola odorizacije gasa pokazala je da je u mernoj tački na kraju distributivnog gasovodnog sistema ostvarena potrebna koncentracija odoranta u gasu, tj upozoravajući stepen mirisa gasa.
***Ključne reči**: odorant, odorizacija, prirodni gas*

AUTOMATION AND CONTROL SYSTEM FOR PRODUCTION OF EDIBLE OIL: EXAMPLE FROM OIL RAFINERY IN SOMBOR

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One of the important segments in the production of refined edible oil is the refining of crude vegetable oil. Sunflower, soybean and rapeseed crude oil from the pressing and extraction process with the quality of crude vegetable oil and a certain percentage of phosphatides, free fatty acids, waxes, and other accompanying impurities must undergo a refining process before being placed on the market as edible refined vegetable oil.
This paper presents the monitoring and control system designed for the oil refinery in Sombor. The main product is sunflower oil, which goes through the process of degumming with water, then bleaching and deodorizing. All these processes are directly managed at a lower level by a PLC (Programmable Logic Controller) in manual and automatic mode of operation. Operators have a visual display of the state of all machines and equipment from the plant on the monitors of modern SCADA (Supervisory Control and Data Acquisition) systems that enable data collection and control at a higher level. The SCADA system is implemented on 2 computers, each of which is equipped with 2 monitors located in the control room. In addition to this, operators are also able to control the process directly from the plant on site using three 12-inch Touch Panels. Touch screens are located right next to the machines.
The system was tested and put into operation in the facility of the refinery in the oil and vegetable fats factory Bimal Sunce in Sombor in 2022. The system managed to significantly increase the refining capacity, namely water degumming from 180 t/day to 250 t/day, bleaching from 110 t/day to 200 t/day and deodorization of neutral, dewaxed bleached oil from 120 t/day to 200 t/day. In addition, with this automation, the existing cooling system that used well water was replaced by a new cooling system with cooling towers.
Another important result of this automation is the convenience that operators get. Some of the most important features presented in this work are an innovative way of assigning interlocking blockages of all positions (defining mutual conditions for the work of actuators), intuitive monitoring of all measurement values with individual settings related to data acquisition, value filtering, display of graphics and great freedom of setting limits for alarm conditions and warnings with the possibility of individually setting audible alarms, etc. All of this greatly improved the production process and brought, first, great advantages in the organization of management, reduced stress for operators and therefore possible errors caused by human influence, and finally opened space for many future planned expansions.
Key words: *SCADA, PLC, automatic control*

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SISTEM AUTOMATSKOG UPRAVLJANJA U PROIZVODNJI JESTIVIH ULJA: PRIMER U RAFINERIJI ULJA U SOMBORU

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Jedan od važnih segmenata u proizvodnji rafinisanog jestivog ulja jeste rafinacija sirovog biljnog ulja. Suncokretovo, sojino i repičino sirovo ulje iz procesa presovanja i ekstrakcije sa kvalitetom sirovog biljnog ulja i određenim procentom fosfatida, slobodnih masnih kiselina, voskova i drugih pratećih nečistoća mora proći proces rafinacije pre plasiranja na tržište kao jestivo rafinisano biljno ulje.

U ovom radu je predstavljen sistem za nadzor i upravljanje koji je projektovan za rafineriju ulja u Somboru. Glavni proizvod je suncokretovo ulje koje prolazi kroz proces degumiranja vodom, zatim beljenja i deodorizacije. Svim ovim procesima direktno na nižem nivou upravlja PLC (engl. Programmable Logic Controller) u ručnom i u automatskom režimu rada. Operateri imaju vizuelni prikaz stanja svih mašina i opreme iz pogona na monitorima modernih nadzorno upravljačkih SCADA (engl. Supervisory Control and Data Acquisition) sistema koji omogućavaju prikupljanje podataka i upravljanje na višem nivou. SCADA sistem je realizovan na 2 računara od kojih je svaki opremljen sa po 2 monitora koji se nalaze u komandnoj sobi. Pored ovoga, upravljanje je operaterima omogućeno i direktno iz pogona sa lica mesta pomoću 3 ekrana na dodir veličine 12 inča. Ekrani na dodir se nalaze neposredno pored mašina.

Sistem je testiran i pušten u rad u objektu rafinerije u fabrici ulja i biljnih masti Bimal Sunce u Somboru 2022. godine. Sistem je uspeo da značajno poveća kapacitet rafinacije i to vodenog degumiranja sa 180 t/dan na 250 t/dan, beljenja sa 110 t/dan na 200 t/dan i deodorizacije neutralnog, odvoštanog izbeljenog ulja sa 120 t/dan na 200 t/dan. Osim toga ovom automatizacijom je i postojeći sistem za hlađenje koji je koristio bunarsku vodu zamenjen novim sistemom hlađenja sa rashladnim tornjevima.

Još jedan važan rezultat ove automatizacije je i komoditet koji dobijaju operateri. Neke od najvažnijih opcija prikazanih u ovom radu su: inovativan način zadavanja blokada svih pozicija (definisanje međusobnih uslova za rad izvršnih organa), intuitivno praćenje svih mernih vrednosti sa pojedinačnim podešavanjima vezanim za akviziciju podataka, filtriranje vrednosti, prikaz grafika i velika sloboda zadavanja granica za stanja alarma i upozorenja sa mogućnošću pojedinačnog podešavanja zvučnih alarma, itd. Sve ovo je u velikoj meri unapredilo proizvodni proces i donelo pre svega velike prednosti u organizaciji upravljanja, smanjilo stres operaterima pa samim tim i moguće greške nastale ljudskim uticajem, i na kraju otvorilo prostor za mnoga buduća planirana proširenja.

Ključne reči: *SCADA, PLC, automatsko upravljanje*

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THE EFFECT OF THYMUS ALGERIENSIS ESSENTIAL OIL ON THE MICROBIAL SHELF LIFE OF MARINATED PORK MEAT

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Thyme essential oil increases the shelf life of various foods (meat, meat products, fish) making it an important potential source of natural preservatives. Our previous results showed that the essential oil of *Thymus algeriensis* contains carvacrol as the main component followed by *p*-cymene. In this study, the shelf-life, quality, and safety of vacuum-packed pork loin meat in two marinades (extra vergine olive oil/red wine Sangiovese and extra vergine olive oil, beer O' Hara's and lemon) with and without the addition of thyme essential oil (*Thymus algeriensis*) were investigated. Tests were carried out on loin slices marinated in vacuum bags and thyme essential oilwas added during the preparation of the marinade. To assess the safety, a challenge test was performed in the presence of *Listeria monocytogenes*, *Salmonella enteritidis* and *Staphylococcus aureus.* Samples for shelf-life assesment and challenge test were stored at 4°C and analyzed for pH, colour, microbial counts and sensorial tests during 15 days of storage. Microbiological data indicated that the marinated samples showed a lower microbial load of the main spoiling microorganisms (*Pseudomonas* spp. and psycothrophic aerobic bacteria) compared to the control samples, regardless of the addition of essential oil. The results of the challenge tests showed a strong inhibitory effect of the marinade on the growth of *Listeria monocytogenes*, *Salmonella enteritidis* and *Staphylococcus aureus*. The addition of thyme essential oil of to the marinade solution accelerated the deactivation kinetics of *Listeria* and *Salmonella.* In addition, the marination process allowed to reduce meat pH increasing its water holding capacity. Sensory tests showed that marinated samples, in particular with the addition of thyme essential oil, were the most positively perceived by the panelists. The data obtained indicate that the proposed marinade solution added with thyme essential oil might represent an encouraging strategy to increase shelf-life and safety of meat products.

Key words*: essential oil; Thymus algeriensis; shelf-life; marinated meat*

UTICAJ ETARSKOG ULJA THYMUS ALGERIENSIS NA ROK TRAJANJA MARINIRANOG SVINJSKOG MESA

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Poznato je da etarsko ulje *Thymus* produžava rok trajanja namirnica različitog porekla (mesa, mesnih prerađevina, ribe) što ga čini važnim potencijalnim izvorom prirodnih konzervanasa. Prethodni rezultati su pokazali da etarsko ulje *Thymus algeriensis* sadrži karvakrol kao glavnu komponentu. U ovom radu ispitivani su rok trajanja, kvalitet i bezbednost vakumiranog svinjskog mesa u dve marinade (maslinovo ulje/crveno vino Sangiovese i maslinovo ulje/pivo O' Hara's i limun) sa i bez dodatka etarskog ulja *Thymus algeriensis*. Ispitivanja roka trajanja su obavljena na parčićima svinjskog filea mariniranih u vakuum kesama, a tokom pripreme marinade dodavano je etarsko ulje. Da bi se procenila bezbednost, urađen je test izazova sa *Listeria monocytogenes*, *Salmonella enteritidis* i *Staphylococcus aureus.* Uzorci za procenu roka trajanja su čuvani na 4°C i analizirani na pH, boju, mikrobni rast i senzorne analize tokom 15 dana skladištenja. Mikrobiološki podaci su pokazali da su marinirani uzorci imali manje mikrobno opterećenje mikroorganizama uzročnika kvarenja mesa (*Pseudomonas* spp. i psihotrofnih aerobnih bakterija) u poređenju sa kontrolnim uzorcima, bez obzira na dodatak etarskog ulja. Rezultati testa izazova pokazali su jak inhibitorni efekat marinade na rast *Listeria monocytogenes*, *Salmonella enteritidis* i *Staphylococcus aureus*. Dodavanje etarskog ulja u rastvor marinade ubrzalo je kinetiku deaktivacije *Listeria* i *Salmonella*. Pored toga, proces mariniranja je omogućio da se smanji pH mesa povećavajući njegov kapacitet zadržavanja vode. Senzorni testovi su pokazali da su marinirani uzorci, posebno sa dodatkom etarskog ulja, bili najpozitivnije ocenjeni od strane panelista. Dobijeni podaci ukazuju da bi predloženi rastvor marinade sa dodatkom analiziranog etarskog ulja mogao predstavljati obećavajuću strategiju u cilju produženja roka trajanja i bezbednosti mesnih proizvoda.

***Ključne reči**: etarsko ulje; Thymus algeriensis; rok trajanja; marinirano meso*

ACTIVE PACKAGING FILMS BASED ON PUMPKIN OIL CAKE AND β-CYCLODEXTRIN INCLUSION COMPLEX

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In addition to numerous good properties, such as biodegradability, environmental suitability, good barrier properties to gases, aromas, etc., very important and recently increasingly the most examined properties of biopolymer films are their use as active packaging materials. These active ingredients may come from a variety of synthetic and natural sources, but due to increasing consumer demand for natural food ingredients, research has focused on natural active compounds such as essential oils, or main components in essential oils known for their biological activity. A new approach in food preservation industry involves the use of different encapsulation agents in order to form micro and nanoparticles, which are intended to protect the active component and allow their gradual and slow release in food product. One of the commonly used encapsulation agent, especially for essential oil encapsulation, is β-cyclodextrin (β-CD). β-CDs have a special capability to entrap hydrophobic guests and to interact with non-polar active constituents of essential oils or their bioactive molecules. Moreover, the release rate of the guest molecules can be controlled or retarded by the β-CD making them very useful as a biological control for additives.
In this work, the influence of 1 % and 2 % β-CD inclusion complex with winter savory essential oil on pumpkin oil cake (PuOC)-based films properties, was analyzed. The impact on mechanical, physicochemical, barrier, structural and antioxidant activity of those active compounds has been examined.
Obtained results showed that addition of 1 % β-CD inclusion complex significantly increased the thicknesses of films for 89 %, and for more than 130 % with addition of 2 % inclusion complex. Addition of inclusion complex led to an increase of tensile strength of biopolymer films, meanwhile decreases of elongation at break for more than 95 %, was observed. When it comes to physicochemical properties (moisture content, total soluble matter and swelling degree) the highest influence of added active compounds was observed in swelling properties, where the reduction of swelling of PuOC-based films was up to 89 %. Barrier properties, water vapor transmission rate and light transmission rate were improved after addition of β-CD inclusion complex, as well as antioxidant activity, where significant increase in DPPH radical scavenging activity of PuOC-based film after addition of 2 % β-CD inclusion complex, was observed.

Key words*: biopolymers, pumpkin oil cake, β-cyclodextrin*

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AKTIVNI AMBALAŽNI MATERIJALI NA BAZI POGAČE ULJANE TIKVE GOLICE I β −CIKLODEKSTRIN INKLUZIONOG KOMPLEKSA

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Pored brojnih dobrih svojstava, kao što su biorazgradivost, ekološka pogodnost, dobra barijerna svojstva za gasove, arome itd., veoma važna i u poslednje vreme najistraženija svojstva biopolimernih filmova je njihova upotreba kao aktivnih ambalažnih materijala. Aktivni sastojci mogu voditi poreklo iz različitih sintetskih i prirodnih izvora, ali zbog sve veće potražnje potrošača za prirodnim sastojcima hrane, istraživanja su se fokusirala na prirodna aktivna jedinjenja kao što su etarska ulja, ili različite glavne komponente etarskih ulja poznatih po svojoj biološkoj aktivnosti. Novi pristup u industriji konzervisanja hrane podrazumeva upotrebu različitih agenasa za inkapsulaciju u cilju formiranja mikro i nanočestica, koje su namenjene zaštiti aktivne komponente i omogućavaju njihovo postepeno i sporo otpuštanje u prehrambenom proizvodu. Jedan od najčešće korišćenih agenasa za inkapsulaciju etarskih ulja, je β-ciklodekstrin (β-CD). β -CD imaju posebnu sposobnost da zarobe hidrofobne molekule i da stupe u interakciju sa nepolarnim aktivnim sastojcima etarskih ulja ili njihovim bioaktivnim molekulima. Štaviše , brzina oslobađanja molekula može se kontrolisati ili usporiti pomoću β-CD.
U ovom radu je analiziran uticaj inkluzivnog kompleksa 1% i 2% β-CD sa etarskim uljem rtanjskog čaja na svojstva filmova na bazi pogače uljane tikve golice (PuOC). Ispitan je uticaj na mehanička, fizičko-hemijska, barijerna, strukturna i antioksidativna svojstva filmova.
Dobijeni rezultati su pokazali da je dodatak 1 % inkluzivnog kompleksa β-CD značajno povećao debljinu filmova za 89 %, a za čak više od 130 % nakon dodatka 2 % inkluzivnog kompleksa. Dodavanje inkluzivnog kompleksa dovelo je do povećanja zatezne jačine biopolimernih filmova, dok je uočeno smanjenje istezanja pri kidanju za više od 95 %. Kada su u pitanju fizičko-hemijske osobine (sadržaj vlage, ukupna rastvorljivost materije i stepen bubrenja) najveći uticaj dodatih aktivnih jedinjenja zabeležen je u svojstvima bubrenja, gde je smanjenje bubrenja filmova na bazi PuOC iznosilo i do 89 %. Barijerna svojstva, brzina propuštanja vodene pare i brzina propuštanja svetlosti su poboljšane nakon dodavanja β-CD inkluzionog kompleksa, kao i antioksidativna aktivnost, gde je primećeno značajno povećanje sposobnosti uklanjanja DPPH radikala filmova na bazi PuOC nakon dodavanja 2% β-CD inkluzivnog kompleksa.
***Ključne reči**: biopolimeri,pogača uljane tikve golice, β-ciklodekstrin*

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COLD PLASMA TREATMENTS FOR MINIMALLY PROCESSED LEAFY VEGETABLES: DECONTAMINATION OF PROCESSING WASH WATER AND EFFECTS ON PRODUCT SAFETY AND QUALITY

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Washing fruit and vegetables is a key step in the fresh produce processing industry to assure microbial quality and safety of ready-to-eat vegetables as it helps removing spoilage and pathogenic bacteria such as *Escherichia coli*, *Listeria monocytogene*s and *Salmonella* and traces of pesticides from the product surface. Consequently, wash waters quickly accumulate high content of solids, organic matter, and microbial contaminants which make necessary an adequate sanitizing treatment prior to water disposal or its re-use. EU legislation stipulates that recycled water used in food processing should be of the same standard as drinking water. Traditionally decontamination of wash water is based on chemical or physical treatments, e.g. sodium hypochlorite, oxidizing agents, UV-C or ozone treatments. Among emerging technologies, Cold Atmospheric Plasma (CAP) and Plasma Activated Water (PAW) have recently drawn considerable attention as several studies have highlighted their activity against several food-borne pathogens and spoilage microorganisms in different food matrices. The aim of the study was to test the technology to assess its potentials in decontaminating washing waters. The efficacy of CAP treatments was compared with reference sanitization technology currently in the industry. Different operational conditions were tested and, for each of them, water quality (COD, BOD) and efficacy in reducing content of the main microbial spoilage populations were measured. The washing waters treated with plasma were also used to wash/re-wash fresh leafy vegetable. The reduction of natural spoilage microbiota and the effects on product quality (pH, colour parameters, total phenolic content) were evaluated immediately after treatments. Overall, the results showed that plasma technology is a promising solution for the food industry to assure safety and microbial quality of both the wash water and the product with the possibility to get water sanitation, water reuse and water saving.

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***Key words**: plasma technology, wash water decontamination, water saving*

BIOTECHNOLOGICAL VALORISATION OF BY-PRODUCTS FROM CLEMENTINE JUICE PRODUCTION INTO FUNCTIONAL INGREDIENTS

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Industrial processing of fruit and vegetables generates high amounts of wastes and by-products, whose management and disposal pose several issues from an economic and environmental point of view. On the other hand, such plant by-products are a source of valuable and bioactive compounds being rich in nutrients and dietary fibers, carbohydrates, essential oils, polyphenols. Besides recovering these valuable components, a promising approach for their valorisation can be based on biotechnological processes carried out by selected GRAS yeasts and lactic acid bacteria to produce a functional ingredient. In this work by-products from clementine juice production were preliminary characterized for their antioxidant (DPPH, ABTS assays), prebiotic activity and antimicrobial action against some food-relevant pathogenic and spoilage microorganisms. Thereafter, GRAS strains of yeasts and lactic acid bacteria, belonging to the Industrial Microbial Culture Collection of the University of Bologna, were screened for their ability to grow and ferment the clementine by-products by modulating their inoculum rate and the by-product characteristics (e.g. water content). Moreover, the production of volatile compounds (GC-MS/SPME) and metabolites with positive sensory impact, functional activities, e.g. the antioxidant and the antimicrobial ones, resulting from microbial activities of the inoculated strains were evaluated. Based on the results, the most promising strains were selected to optimise the process conditions and improve functionality, quality, sensory properties and microbial stability of the fermented substrate. Overall, the results highlight the potentiality of this tailored biotechnological strategy to obtain new ingredients which can be re-used as a food component to deliver new and/or enhanced functional, technological and sensory properties.

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***Key words**: clementine by-products, food ingredient, microbial fermentation*

REVITALIZING THE FOOD INDUSTRY: ADAPTING TO EMERGING TRENDS AND UPGRADING SKILLS

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The last decade has seen tremendous changes in the food industry, as it has been forced to address several major challenges related to sustainability, health, and the skills gap in the job market. One of the biggest changes has been the rapid pace of technological advancement, including the introduction of information technology, artificial intelligence, automation, and robotics, which has led to the disappearance of some jobs and created a need for new skills. This change has been particularly challenging for the food industry, which is facing pressure from consumers to supply more vegan alternatives due to concerns over sustainability, animal welfare, and diet.
The shift towards plant-based diets is driven by both vegan and flexitarian consumers. Vegan consumers are choosing to avoid meat and animal products completely, while flexitarian consumers are reducing their meat consumption but not avoiding it completely. Both groups represent a significant share of the population and are affecting the habits of those around them, including their friends and families. The booming in the offer of new vegan products is in its infancy and the revenue from these products is expected to increase and stabilize around 20 years from now.
To address the skills gap created by these trends, the EQVEGAN project proposes to tackle the challenge by reskilling and upskilling workers through training in soft skills, green skills, digital and automation skills, and new plant-based processing technologies. Additionally, the project aims to certify job profiles and provide work-based learning opportunities to help workers stay up to date with the latest developments in the industry. By addressing these challenges head-on, the EQVEGAN project hopes to help ensure that the food industry remains at the forefront of innovation and continues to meet the changing needs of consumers.
Key words*: vegan, automatization, skills*

THE EXPERIENCES OF THE REALIZATION OF PV POWER PLANTS AFTER IMPLEMENTATION OF THE PROSUMER STATUS

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The amendment of the Law on Energy and the adoption of the new Law on the Use of Renewable Energy Sourcesenabled a sudden increase in the installed capacity of photovoltaic (PV) power plants in the Republic of Serbia in 2022. Thanks to the new possibility of acquiring prosumers status, interest in the construction of PV power plants has increased, both with households and with commercials entities.

New law for the fist time defines energy production or self-consumption, called the prosumer status, where previously passive power consumers become an active member in the energy market with the possibility of energy management based on the available production and consumption. This particular incentive has made it possible to have massive installation of PV power plants in households, industry and agricultural subjects. Almost simultaneously, the Republic of Serbia has made it possible to have 50 % subsidy for the PV power plant of 6 kW for households.

Law on use of renewable energy sources defines the prosumer status as an end-buyer who has connected their own facility for generating electricity from renewable energy sources to the internal installations, where the generated electricity is used for own consumption, and the surplus generated electricity is delivered to the transmission system, distribution system or closed distribution system. When calculating the energy, net metering is defined to be applied to households and net calculation is applied to all other final consumers.

In order to achieve full effects of the prosumer status, the most important thing in the long term is the balance between consumption and the production of electrical energy. This is easily achieved for the households, where the available roof surface is sufficient for the installation of the PV system capable of covering the consumption. With industrial subjects, the consumption is usually much higher than the production of the PV system since the roof top surface is not sufficient for the necessary power plant capacity.

With all the things considered, since the prosumer status was introduced, by the end of February of 2023, in Republic of Serbia there were 6185,4 kW of PV power plants installed for the households, while non-households installed 5340,3 kW in total. Consequently, in little over a year the total installed capacity of PV power plants in prosumers status surpassed the capacity of privileged producer status power plants in the last ten years.

Key words: *photovoltaic power plants, prosumers status, agriculture*

ISKUSTVA REALIZACIJE FOTONAPONSKIH ELEKTRANA NAKON UVOĐENJA STATUSA KUPAC-PROIZVOĐAČ

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Izmena Zakona o energetici i donošenje novog Zakona o Obnovljivim izvorima energije omogućilo je nagli porast instalisanih kapaciteta fotonaponskih (FN) elektrana u Republici Srbiji u 2022. godini. Zahvaljujući novom modalitetu koji je nazvan kupac-proizvođač, pojačan je interes za gradnju FN elektrana, kako od strane domaćinstava, tako i od privrednih subjekata.

Novi zakon po prvi put definiše proizvodnju električne energije za sopstvenu potrošnju, takozvani status kupac-proizvođač energije (prosumer), gde pasivni kupci postaju aktivni učesnici na tržištu sa mogućnošću samostalnog upravljanja energijom na osnovu proizvodnje i potrošnje. Ovaj status omogućava masovnu izgradnju fotonaponskih elektrana kako u domaćinstvima, tako i među privrednim i poljoprivrednim subjektima. Paralelno sa promenom propisa, omogućeno je da lokalne samouprave u saradnji sa državom pokrivaju 50% troškova izgradnje fotonaponskih elektrana snage do 6kW za domaćinstva.

Zakon o korišćenju obnovljivih izvora energije definiše status kupca-proizvođača kao krajnjeg kupca koji je na unutrašnje instalacije priključio sopstveni objekat za proizvodnju električne energije iz OIE, pri čemu se proizvedena električna energija koristi za snabdevanje sopstvene potrošnje, a višak proizvedene električne energije isporučuje u distributivni sistem. Prilikom obračuna električne energije definisano je neto merenje, koje se primenjuje za domaćinstva i neto obračun koji se primenjuje za ostale krajnje kupce.

Da bi se postigao pun efekat prednosti statusa kupac-proizvođač dugoročno gledano bitna je izbalansiranost potrošnje i proizvodnje elektrane. Ovo se relativno lako postiže kod domaćinstva. Obično je raspoloživa površina krova za instalaciju fotonaponskih panela dovoljna za pokrivanje potrošnje. Kod privrednih subjekata po pravilu je potrošnja znatno veća od moguće proizvodnje elektrane. Razlog je taj da nema dovoljno krovnih površina za instalaciju fotonaponskih panela.

Od početka uvođenja statusa kupac-proizvođač do kraja februara 2023. godine u Srbiji su domaćinstava instalisali 6185,4 kW fotonaponskih elektrana, dok oni koji nisu domaćinstva imaju instalisanu snagu od 5340,3 kW. Dakle za nešto više od godinu dana je ukupno instalisano više kapaciteta fotonaponskih elektrana u statusu kupac-proizvođač nego za proteklih deset godina koji su u statusu povlašćenih proizvođača električne energije.

Ključne reči: *fotonaponske elektrane, status kupac-proizvođač, poljoprivreda*

COLD ATMOSFERIC PLASMA TREATMENT ON FRESH-CUT MELON: EFFECTS ON SAFETY AND QUALITY

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Non-thermal technologies as Cold Atmospheric Plasma (CAP) could be used to decontaminate and stabilize food products by removing spoilage microorganisms, moulds, and mycotoxins. Additionally, the consumption of ready-to-eat fruits has increased as the frequency of outbreaks and cases of foodborne disease linked to contaminated products. The aim of this work was to analyse the effects of CAP treatments on the native microbiota of fresh-cut melon. Also the effectiveness on products deliberately contaminated with pathogenic microorganisms, i.e. *Listeria monocytogenes* 56LY, *Salmonella* enteritidis 155 and *Escherichia coli* 555, was evaluated. Two alternative chemical regimes were used for the treatments, one with high levels of ozone (O3) and the other with high levels of nitrogen oxides, i.e. NO, NO_2, NO_3, N_2O_5 (NOx). Fresh-cut melon samples were exposed to the two gas regimes for different times: 2, 5, 10, 20, 30 minutes and the reduction of spoilage and pathogenic species were evaluated and compared with control sample. Several qualitative aspects such as pH, Brix°, colour and bioactive compounds were also evaluated. Results showed that plasma exposure allowed to achieve reductions of microbial loads up to about 1-1.5 Log CFU/g. Different sensitivities were detected for relevant microbial groups. In particular, lactobacilli and total mesophilic bacteria showed a significative decrease after 20 and 30 minutes of NOx treatment. Significant reductions of over 2 Log CFU/g were determined for the pathogens after 20 and 30 min NOx-treatments, and around 1.5 Log CFU/g for O3-treatment, regardless the pathogenic species and of their contamination levels (~ 4 and ~5 Log CFU/g). These results suggest that nitrogen oxides are more effective in microbial inactivation than ozone. As far as the effects of CAP treatment on physico-chemical characteristics, Brix° and colour did not show any difference. On the other hand, pH decreased by 1 unit with increasing treatment time for NOx-regime. In conclusion, 20 and 30 min treatments with NOx and 30 minutes with O3 had the strongest inactivation effect. These results allowed to understand and acquire more information in order to scale up this technology for its use in industrial processing.

The present work is part of the project “PRIN 2017 -PLASMAFOOD - Study and optimization of cold atmospheric plasma treatment for food safety and quality improvement” founded by MIUR - Ministero dell’Istruzione dell’Università e della Ricerca.

***Key words**: cold atmospheric plasma, spoilage and pathogenic microbiota, fresh cut fruit*

ULTRA-PROCESSING DEBATE: WHY PROCESSING LEVEL CANNOT BE RELATED TO THE FOOD HEALTHINESS

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Consumers are asking for healthy, palatable foods but able to meet needs related to the change of the social life in an always more complex relationship between work, different interests and activities and time at home. In this context the food industry has been able to look forward those needs with the offer of processed foods in order to give safe, palatable, nutritional foods with service characteristics and longer shelf-life, to be consumed out of home or at home with reduced preparation time. On the basis of the diffusion of such as types of different processed foods, from a scientific side, mainly a community of epidemiologists and nutritionists, a new food classification called NOVA has been proposed, based on the processing level, in principle. On the other hands an increase of obesity and other diet related problems such as diabetes and cardiovascular diseases is recorded in the so called “developed countries” where the industrial foods are more consumed and this has been related to the degree of processing, according to the NOVA classification authors. Thus, consumers started to consider processed food as less healthy and less natural than unprocessed foods. This was leading to a controversial understanding of the terms “Ultra processed foods” or “Highly processed foods”, starting a debate among different food science sectors, where the technological aspects (including processing technologies, unit operations and ingredients in formulation) have been considered not necessarily a reason to assess processed foods as unhealthy and unnatural. In fact, several authors started to provide data to understand the relationship between the degree of processing with naturalness and healthiness, using well recognized indices. Results showed that a number of highly processed products could be able to have good healthiness index (e.g. Nutri-Score) as a function of their formulation, despite of the degree of processing and / or a full list of ingredients. In conclusion, the simple NOVA classification seems to be unsuitable to correctly classify foods according to healthiness and naturalness for a good nutritional food habit. Thus, the classification on foods on the basis of the processing in term of processing level is not only wrong but misleading and could be a hurdle to the food industry to go forward to innovations.
Key words *Ultra-processed food, health problems, eating habits, ingredients, unit operations*

COLD PLASMA ASSISTED RESOURCE RECOVERY FROM CORN STALKS AS AGRI-FOOD INDUSTRY WASTES

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Biomass captures CO_2 from the atmosphere when growing. In the same time, approximately 1,4 Gt of available renewable biomass is annually wasted while cereal straw wastes contribute to that with 66%. Huge portion of residues is still burnt, while it is the source of bioactives, fermentable sugars and only natural aromatic polymer-lignin.

The main obstacle for valorization of biomass is the recalcitrant nature of dominantly present lignocellulose and variability in biomass composition which decreases already modest efficiency of acid/alkaline thermal treatment conventionally used in biorefineries. Conventional treatments have low selectivity, generate inhibitory compounds for enzymes or microorganisms used in biorefineries and have high environmental footprint.

Cold plasma treatment (CPT) can induce modifications of cellulosic and hemicellulosic fraction as well as oxidation and depolymerisation of lignin, but CPT lacks selectivity in complex substrates such as agri-food wastes. We combined CPT with Fenton reagent or hydrogen peroxide for treatment of corn stalks as significant lignocellulose agri-industrial waste in Serbia. Chemical properties of treated samples were analysed by FTIR, while carbohydrate fraction was subjected to enzymatic hydrolysis followed by spectrophotometric analysis. We showed that delignification with CPT can be efficiently combined with other oxidative treatments, including hydrogen peroxide and Fenton reagent, while preserving or even improving the enzymatic hydrolysis of carbohydrate fractions. Different chemical modifications were obtained depending on Fe/hydrogen peroxide ratio or hydrogen peroxide concentration, however, low energy CPT combined with other oxidative treatments significantly improves delignification and carbohydrate accessibility while decreasing overall processing time and energy consumption.

Further studies have to evaluate oxidative treatments and CPT sources with different parameters for recovery of all fractions present in lignocellulose. This is essential for sustainable biorefineries on lignocellulose. CPT here shows some additional benefits related to its sterilization and microbial decontamination effect. CPT is already used for surface “etching” and sterilization of grafts in medicine and slowly enters food industry in the similar application field. It has a prospect to improve biomass decomposition under carefully selected conditions as shown here, but it can also help in control of undesired microbiota in open fermentation processes. This could be very valuable for the number of biorefinery processes and contribute significantly to the bioeconomy.

Key words: *cold plasma, non-thermal processing, lignocellulose, sustainability, waste*

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HLADNA PLAZMA U TRETMANU KUKURUZNIH STABLJIKA – MOGUĆNOSTI ZA EFIKASNIJE ISKORIŠĆENJE RESURSA

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Biljna biomasa vezuje CO_2 iz atmosphere kada raste. U isto vreme, otprilike 1,4 Gt dostupne obnovljive biomase se godišnje baca, dok slama žitarica koja se smatra otpadom učestvuje sa oko 66% u toj količini. Veliki deo agroindustrijskog otpada se i dalje spaljuje, dok je istovremeno izvor bioaktivnih jedinjenja, fermentativnih šećera i jedinog prirodnog aromatičnog polimera –lignina.
Osnovno ograničenje u valorizaciji biomase predstavlja rezistentnost lignoceluloze, dominantne frakcije u većini sporednih sirovina agroindustrijskog porekla, kao i varijabilnost sastava. Time se dodatno smanjuje i onako ograničena efikasnost kiselinskih/baznih termalnih tretmana koji se konvencionalno koriste u biorafinerijskim postupcima. Konvencionalni tretmani imaju malu selektivnost, u njima nastaju inhibitorni proizvodi za enzime i mikroorganizme koje se koriste u biorafinerijskim postupcima i imaju značajan uticaj na životnu sredinu.
Tretman hladnom plazmom (THP) može izazvati modifikacije na celuloznoj i hemiceluloznoj frakciji, kao i oksidaciju i depolimerizaciju lignin, ali THP nedostaje selektivnost u kompleksnim supstratima kao što je agro-industrijski otpad. Mi smo kombinovali THP sa Fentonovim reagensom ili vodonik peroksidom u tretmanu kukuruznih stabljika kao značajnog izvora lignoceluloze agroindustrijskog porekla u Srbiji. Hemijska svojstva tretiranih uzoraka su analizirana FTIR-om, dok je ugljenohidratna frakcija bila podvrgnuta enzimskoj hidrolizi i analizirana spektrofotometrijskim metodama. Pokazali smo da delignifikacija THP može da se efikasno kombinuje sa vodonik peroksidom i Fentonovim reagensom tako da se očuva ugljenohidratna frakcija pogodna za enzimsku hidrolizu. Dobijene su razlike u hemijskim modifikacijama u zavisnosti od primenjenog odnosa Fe/vodonik peroksid ili koncentracije vodonik peroksida. Utvrđeno je da THP može biti kombinovan sa drugim naprednim oksidativnim procesima i značajno unaprediti delignifikaciju i dostupnost ugljenih hidrata, uz smanjenje ukupnog vremena tretmana i potrošnje energije.
Buduće studije će imati za cilj da utvrde uticaj parametara tremana hladnom plazmom na iskorišćenje svih frakcija lignoceluloze. Ovo je esencijalno za održivost biorafinerijskih postupaka zasnovanih na lignoceluloznoj biomasi. THP pokazuje neke dodatne benefite povezane sa sterilizacijom i inaktivacijom mikroorganizama što je značajan efekat za biotehnološke procese. THP je već korišćen za sterilizaciju površina graftova u medicini i pronalazi svoje mesto i u prehrambenoj industriji u sličnim oblastima primene. THP ima potencijal da unapredi razgradnju biomase pod pažljivo odabranim uslovima kao što je pokazano u ovom radu, ali takođe može obezbediti kontrolu neželjenih mikroorganizama u otvorenim fermentacijama. Ovo može biti veoma značajno za brojne biorafinerijske postupke i unapređenje bioekonomije generalno.
Ključne reči: hladna plazma, netermalni tretmani, lignoceluloza, održivost, otpad

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SAFFLOWER AS AN ALTERNATIVE OIL CROP - POTENTIAL IN THE PET NUTRITION

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Safflower (*Carthamus tinctorius L.*) is an annual plant from the *Composite family*. The resistance to climatic conditions, lack of water, and increased soil salinity makes a valuable alternative oil crop that has gained importance in recent years. Safflower is a significantly cheaper variant of the related culture of saffron, which use can be higher in human and animal nutrition, the textile and dye industry, biodiesel production, etc. Safflower can be said to be a "climate-smart" crop that can adapt to changing environmental conditions thanks to its rich genetic diversity. Effective implementation of support policies in technology, appropriate incentives, and marketing, especially in countries facing water deficits and changing soil quality, has significant potential for improving food security and the income and livelihoods of people engaged in agriculture. Safflower contains 90% of total unsaturated fatty acids, of which 14% are monounsaturated (MUFA) and 76% are polyunsaturated (PUFA). Among the n-6 fatty acids, the main ingredient is linoleic acid, which accounts for 74% of the total fat content. The use of safflower in animal nutrition dates back to the 1980s of the last century. The results of feeding animals with safflower show that it is a palatable and acceptable source of protein and fiber, with yields similar to or even better than oats or alfalfa. Safflower pastures have also shown that feeding ruminants with this plant contribute to better growth and higher fertility of animals. However, there are very few investigations of the evaluation of safflower oil and cake in the nutrition of animals, especially pets. The use of safflower seeds in the diet of ornamental birds (parrots, canaries, etc.) is widely known as an ingredient that improves the quality and shine of feathers. In this regard, it could be assumed that have the same effect on the skin and hair of pets, which has been confirmed in research related to the use of safflower oil in human nutrition. Also, numerous data from experts in the field of pet nutrition showed the positive effects of this oil as an ingredient in the diet of dogs and cats, not only in the domain of skin and hair health but also for the structure of the cell membrane, cell function, as well as for healthy reproduction, growth, a strong heart, and immunity.
Key words*: pet food, safflower oil, safflower cake*

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ŠAFRANIKA KAO ALTERNATIVNA ULJANA KULTURA – POTENCIJAL U ISHRANI KUĆNIH LJUBIMACA

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Šafranika (Carthamus tinctorius L.) je jednogodišnja biljka iz porodice Composite, otporna na klimatske uslove, nedostatak vode i povišen salinitet zemljišta. Upravo to je svrstava u vrednu alternativnu uljanu kulturu koja dobija na značaju poslednjih godina imajući u vidu njenu otpornost na pomenute faktore. Šafranika predstavlja znatno jeftiniju varijantu srodne kulture šafrana i njena upotreba može biti značajno veća u ishrani ljudi, životinja, u tekstilnoj industriji i industriji boja, proizvodnji biodizela i sl. Za šafraniku se može reći da predstavlja "klimatski pametan" usev koji se može prilagoditi promenljivim uslovima životne sredine zahvaljujući svojoj bogatoj genetskoj raznovrsnosti. Efikasna primena politika podrške u tehnologiji, odgovarajućim podsticajima i marketingu od strane države naročito u zemljama koje se suočavaju sa deficitom vode i promenom kvaliteta zemljišta, ima značajan potencijal za poboljšanje bezbednosti hrane i poboljšanje prihoda i sredstava za život ljudi koji se bave ratarstvom. Šafranika sadrži 90% ukupnih nezasićenih masnih kiselina od čega je 14% mononezasićenih (MUFA) i 76% polinezasićenih (PUFA). Među n-6 masnim kiselinama, glavni sastojak je linolna kiselina koja čini 74% od ukupnog sadržaja masti. Upotreba šafranike u ishrani životinja datira još od 80-tih godina prošlog veka. Rezultati ishrane životinja sa šafranikom pokazuju da ona predstavlja ukusan i prihvatljiv izvor proteina i vlakana, sa prinosima koji su slični pa čak i bolji od ovsa ili lucerke. Pašnjaci šafranike su takođe pokazali da ishrana preživara ovom biljkom doprinosi boljem prirastu kao i plodnosti životinja. Međutim, postoji veoma mali broj radova o upotrebi ulja i pogače šafranike u ishrani životinja, naročito kućnih ljubimaca. Opšte poznata je upotreba semena šafranike u ishrani ukrasnih ptica (papagaja, kanarinaca is l), kao sastojka koji poboljšava kvalitet i sjaj perja. S tim u vezi, pretpostavlja se da isti efekat može imati i na kožu dlaku kućnih ljubimaca što je i potvrđeno u istraživanjima vezanim za upotrebu ulja od šafranike u ishrani ljudi. Takođe, brojni saveti stručnjaka u oblasti ishrane kućnih ljubimaca ukazuju na pozitivne efekte ovog ulja, kao izuzetno vrednog sastojka u ishrani pasa i mačaka, ne samo u domenu zdravlja kože i dlake već i za strukturu ćelijske membrane, funkciju ćelije, kao za zdravu reprodukciju, rast, snažno srce i imunitet.
***Key words**: pet food, šafranika, ulje, pogača*

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THE EFFECT OF SUCCESSIVE ULTRASOUND-ASSISTED EXTRACTION ON PHENOLIC CONTENT OF CAROB POD, MASTIC LEAVES AND MYRTLE LEAVES AND FRUIT

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Recently, there has been a significant increase in consumer awareness of the importance of natural, plant-based ingredients with beneficial effects on human health. Among these, polyphenols are highly regarded for their antioxidant and anti-inflammatory effects. Mediterranean medicinal plants are a rich but still underutilized source of valuable phenols. To take advantage of their benefits, the first and most important step is their isolation. Nowadays, novel, "green" and energy-saving techniques such as ultrasound-assisted extraction have taken the lead over traditional reflux and heat-assisted methods. Therefore, the aim of this study was to evaluate the effects of successive ultrasound-assisted extraction with three different solvents, ethyl acetate, 80% acetone, and ethanol, on the content of total phenols (TP) and total flavonoids (TF) in carob pods, mastic leaves, and myrtle leaves and fruits. Extractions were carried out in an ultrasonic bath at 65 °C for 30 min for each fraction, followed by spectrophotometric determination of TP and TF. The results showed that all plant species were rich sources of flavonoids and total phenolics, with the highest content found in mastic leaves followed by myrtle leaves and fruits, while carob pods had the lowest content of both TP and TF. The highest extraction yield of TP and TF was found in all plant species in the second fraction, i.e., with 80% acetone, except in carob pods, where the first fraction, ethyl acetate, showed the highest yield of TF. For all other plant species, the ethyl acetate fraction was characterized as the one with lowest content of both TP and TF. The differences in solvent suitability among observed plant species can surely be attributed to the structural and chemical differences among individual compounds contributing to their TP content. In conclusion, the results of this study indicate the suitability of the acetone fraction for the isolation of total phenols and flavonoids from selected Mediterranean plant species and confirm that they are a rich source of polyphenols and therefore suitable for further use in value-added foods and nutraceuticals.
***Key words**: carob, mastic, myrtle, extraction solvent, phenols*

UTJECAJ SUKCESIVNE ULTRAZVUČNE EKSTRAKCIJE NA SADRŽAJ FENOLNIH SPOJEVA ROGAČA, LISTA TRŠLJE TE LISTA I BOBICA MIRTE

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Posljednjih godina je uvelike porasla svjesnost potrošača o važnosti prirodnih sastojaka biljnog podrijetla koji pokazuju povoljan utjecaj na ljudsko zdravlje. Važnu skupinu među njima čine fenolni spojevi, upravo zahvaljujući svojim antioksidacijskim i protuupalnim svojstvima. Bogat izvor fenolnih spojeva ali još nedovoljno iskorišten je mediteransko bilje. Prvi korak u iskorištavanju njegovog potencijala je izolacija vrijednih fenolnih spojeva. Danas se prednost za izolaciju bioaktivnih spojeva daje novim, "zelenim" tehnologijama, poput ultrazvučne ekstrakcije, koje sve više zamjenjuju tradicionalne ekstrakcijske metode temeljena na zagrijavanju otapala s uzorkom. Stoga je cilj ovog rada bio utvrditi utjecaj sukcesivne ultrazvučne ekstrakcije primjenom tri različita otapala, etil acetata, 80% acetona i etanola, na sadržaj ukupnih fenola (UF) i ukupnih flavonoida (FL) u mahunama rogača, lišću tršlje i lišću i bobicama mirte. Ekstrakcije su sukcesivno provedene u ultrazvučnoj kupelji primjenom triju otapala pri 65 °C u trajanju od 30 min, nakon čega je sadržaj UF i FL određen spektrofotometrijski. Rezultati su pokazali kako su sve ispitivane biljne vrste bogat izvor fenola i flavonoida pri čemu je najviši sadržaj određen u lišću tršlje te zatim u padajućem nizu u lišću i bobicama mirte, dok je rogač imao najniži sadržaj i UF i FL. Najveći ekstrakcijski prinos UF i FL je kod svih biljnih vrsta određen u drugoj ekstrakcijskoj frakciji s 80 %-tnim acetonom, s iznimkom mahune rogača kod koje je prva etil-acetatna frakcija bila najučinkovitija za izolaciju FL. Za sve druge ispitivane biljne materijale etil-acetatna frakcija je ostvarila najniži prinos i u slučaju UF i u slučaju FL. Uočene razlike u učinkovitosti ekstrakcijskih otapala proizlaze iz strukturnih i kemijskih razlika pojedinačnih spojeva u sastavu fenolnog profila. Zaključno, rezultati ovog istraživanja su ukazali na prikladnost acetonske frakcije za izolaciju ukupnih fenola i flavonoida iz odabranih vrsta mediteranskog bilja kao bogatog izvor bioaktivnih spojeva s visokim potencijalom primjene u proizvodima s dodanom vrijednošću i nutraceuticima.
***Ključne riječi**: rogač, tršlja, mirta, ekstrakcijsko otapalo, fenolni spojevi*

MULTICRITERIA DECISION MAKING IN FOOD SCIENCES USING THE SUM OF RANKING DIFFERENCES METHOD

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Multicriteria optimization has been always a part of food scientists' life. Due to the complex nature of food science, multiple variables coming from different sources are measured and used to assess or characterize a set of samples. Additionally, it is common to compare or test different product alternatives, technologies, or models. The evergreen problem arises when we need to choose one winner from the many alternatives, varieties, prototypes, models, etc. These issues are solved by multicriteria optimization approaches (or multicriteria decision-making (MCDM) tools) that take several input variables from different sources and rank multiple objects according to them. There is no single subfield of food science where the researchers cannot face problems requiring multicriteria optimization. One of the most straightforward and robust multicriteria optimization tools is the sum of ranking difference (SRD) method, a nonparametric tool that results in a clear rank of the objects to be compared. Although there are other MCDM tools available, SRD has been proven to provide the consensus of several MCDM tools. The short history, principles, rationale, and earlier applications of the sum of ranking differences method will be introduced along with its multiple available validation techniques. Due to its flexibility and ease of use, SRD has been used in different fields of science such as testing classification models predicting food choices from eye movements, selecting columns for chromatographic applications, variable selection for near-infrared spectra data processing, comparing the nutritional characteristics of edible insects to conventional protein sources and even to assess NFL draft performance of teams. A further strength of the method is that it is available on several platforms. The original version uses MC Excel VBA, which offers a user-friendly application for anyone. For more experienced users, MATLAB and Python versions are also available with slightly restricted functionality. As a recent development, SRD is now available on CRAN, meaning that R-project users can also include SRD in their scripts. The next step of the development includes an online version based on the R Shiny platform. The advantages of the method will be presented in an example that compares different classification models based on multiple performance indicators.

***Key words**: multicriteria decision making, MCDM, R-package, rSRD, ranking, validation*

PHYSICO-CHEMICAL, SENSORY AND RHEOLOGICAL STABILITY OF CORN OILS ENRICHED ITH TANNIN-RICH EXTRACTS

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In recent years, people are increasingly interested in consuming natural and healthier products that are rich in bioactive compounds with beneficial effects on human health. As a response, food industries are working to develop new functional and innovative products, focusing their research on various bioactive compounds, including tannins. Studies demonstrated as these compounds exert an appreciable antioxidant activity, mainly performed through the scavenging of free radicals, the suppression and inactivation of oxidants such as transition metals (iron), the regulation of the antioxidant defense system and the boosting and activating endogenous antioxidant enzymes. Tannins also show effective antimicrobial activity by behaving as bacteriostatic agents, especially against Gram-positive bacteria. However, they are usually referred to possess unpleasant organoleptic properties such astringency, bitterness, and dryness and, for all these reasons, tannins are nowadays exploited in limited food sectors, namely beverage, oenological and brewing sectors. On these bases, the aim of this research was to perform preliminary analysis to evaluate the physic-chemical, also in terms of oxidative performances and rheological stability of corn oil enriched with different tannin-rich extracts, using different methodologies. Moreover, sensory analysis was also carried out on these products. Four plant extracts, obtained by different sources and characterized by a distinctive phytocomplex profile, were tested at different concentration levels in corn oil by applying three different approaches: i) powder; ii) dispersed in ethanol; iii) dispersed in water. The oxidative and rheological stability, microstructural parameters and sensory pleasantness, compared to a control oil were investigated. Results have shown that samples obtained by dissolving the powder extracts in water presented both the highest oxidative and rheological stability, compared to the others, as also confirmed by microstructural analysis. Moreover, the stability is directly related to the concentration and chemical characteristics of the extract applied to the oil. Sensory analysis underlined, the presence of very defined and peculiar aroma profiles that varying in relation to botanical origin of the extracts and their concentration, that affect the acceptance of consumers in strong way. Obtained results represent a starting point in order to evaluate and select the more suitable tannin-rich extract in order to design functionalized foods.

***Key words**: Tannins-rich extracts, physico-chemical stability, functionalized foods*

INTEGRATION OF ROOFTOP PHOTOVOLTAICS AND COGENERATION FOR DECARBONISING THE MARGARINE PRODUCTION PROCESS

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Although the food industry is moderately energy-intensive, it belongs to industries with significant CO_2 emissions due to its scope, potential growth, and energy use. Therefore, it has been identified as one of the crucial factors in the industrial sectors' overall decarbonisation process. The margarine industry and processing of vegetable oils and fats are a fast-growing segment of this industrial sector, characterized by energy-intensive processes, such as cooling, water vapour preparation, and pasteurization. Energy supply (electricity and heat) is one of the essential parts of the technological process that can significantly contribute to the decarbonisation of the entire production process by applying energy-efficient technologies and renewable energy sources. The decarbonisation program can assist the margarine and vegetable oils and fats processing industries in becoming more competitive in the market while reducing their carbon footprint. Along with efforts to reduce CO_2 emissions, energy consumption costs are also decreasing. Furthermore, decarbonisation will result in lower future CO_2 expenses.

First of all, the global paradigm of industrial decarbonisation implies the electrification of processes, which assumes that facilities will be supplied with more renewable electricity. However, the ability to use renewable electricity is primarily determined by the characteristics of the power system to which the facility is connected. Cogeneration, on the other hand, is one of the most efficient technologies for generating electricity and heat. As a result, the paper proposes a methodology for determining the optimal solution for cogeneration (CHP) and rooftop photovoltaics (PV) for minimising CO_2 emissions. The methodology is based on material and energy flow analysis in the manufacturing process and electricity and heat consumption/load profiles. Based on the created consumption/load profiles, technical limitations, and legal regulations, the possibility of installing rooftop PV panels and implementing suitable CHP technology is considered. The proposed methodology is applied and tested on a margarine production facility. The integrated use of CHP and rooftop PV panels could reduce CO_2 emissions by up to 71% if the PV panels were installed on the fully accessible roof surface and up to 55.7% if 150 kW were installed in accordance with the new national regulation.

Key words: *food industry, photovoltaic (PV), cogeneration (CHP)*

INTEGRACIJA KROVNIH FOTONAPONSKIH PANELA I KOGENERACIJE ZA DEKARBONIZACIJU PROIZVODNOG PROCESA MARGARINA

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Iako prehrambena industrija spada u umereno energetski intenzivne, zbog obima, potencijalnog rasta i načina korišćenja energenata, spada u grupu industrijskih grana sa značajnom emisijom CO_2. Stoga je identifikovana kao jedna od ključnih u procesu dekarbonizacije celokupnog industrijskog sektora. Industrija margarina i prerade biljnih ulja i masti je brzorastući segment ovog industrijskog sektora koji uključuje korišćenje energetski intenzivnih procesa, kao što su hlađenje, priprema vodene pare i pasterizacija. Snabdevanje energijom (električnom i toplotnom) je jedan od najvažnijih delova tehnološkog procesa koji može u velikoj meri doprineti dekarbonizaciji celog proizvodnog procesa i to primenom energetski efikasnih tehnologija i obnovljivih izvora energije. Kompanijama za proizvodnju margarina i preradu biljnih ulja i masti program dekarbonizacije može pomoći da postanu konkurentniji na tržištu dok istovremeno smanje svoj ugljenični otisak jer se uz preduzimanje mera za smanjenje emisije CO_2 smanjuju i troškovi potrošnje energije. Pored toga, dekarbonizacija će dovesti do smanjenja dodatnih budućih troškova CO_2.
Globalna paradigma industrijske dekarbonizacije podrazumeva, pre svega, elektrifikaciju procesa koja pretpostavlja snabdevanje postrojenja većim količinama električne energije dobijene iz obnovljivih izvora. Međutim, mogućnost korišćenja na ovaj način generisane električne energije zavisi od, pre svega, karakteristika elektro-energetskog sistema na koju je preduzeće povezano. Sa druge strane kogeneracija spada u najjefikasnije tehnologije za generisanje električne energije i toplote. Shodno tome, u radu je predložena metodologija za definisanje optimalnog rešenja integrisane primene kogeneracije i krovnih fotonaponskih panela, sa ciljem minimizacije emisije CO_2. Metodologija se zasniva na analizi tokova energije i materijala u proizvodnom procesu i kreiranju profila potrošnje električne energije i toplote. Na osnovu kreiranih profila potrošnje, tehničkih ograničenja i zakonske regulative razmatra se mogućnost za postavljanje krovnih fotonaposnkih panela na odgovarajućoj lokaciji i implementacija odgovarajućih kogeneracionih tehnologija. Predložena metodologija je primenjena i testirana na proizvodnom procesu za proizvodnju. Integrisanom primenom kogeneracije i krovnih PV panela, smanjenje emisije CO2 bi iznosilo do 71 % ukoliko bi PV paneli bili instalirani na kompletno dostupnoj površini krova, odnosno do 55,7% ukoliko bi bilo insalirano 150 kW u skladu sa novom nacionalnom regulativom.

Key words: *prehrambena industrija, fotonaponski paneli, kogeneracija*

FLAVORING AND ANTIOXIDANT COMPOUNDS OBTAINED THROUGH FERMENTATION OF FLATHEAD GREY MULLET WASTE BY YARROWIA LIPOLYTICA OR BACILLUS SPP.

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In the last decades fish processing industry has experienced significant expansion due to the growth of the global population and the subsequent rapid increase in urbanization and industrialization. This had an impact on the overall production of fish waste and by-products. Valorization of these marine materials through biotechnological processes can represent a valuable strategy for a sustainable bioeconomy generating added-value compounds, such as bioactive and functional peptides, lipids, chitosan, enzymes, flavoring agents that have a great potential in several sectors such as the agrifood and medical ones. The main aim of the present study, performed in the framework of the European Project "NewTechAqua", was to use microbial fermentation as a safe, ecological, and profitable technique to obtain a wide variety of these compounds. Based on a preliminary screening that allowed to define the best proteolytic and lipolytic microorganisms, two strains of *Bacillus* spp. (B5M and B5C) and 2 strains of *Yarrowia lipolytica* (YL2 and YL4) were incubated up to 9 days with flathead grey mullet (*Mugil cephalus*) waste supplemented with 3% glucose. The growth of the different microbial strains was followed over time by plate counting *Y. lipolytica* in YPD agar and *Bacillus* spp. in BHI agar upon serial dilution in saline solution (NaCl, 9 g/L). After 4 and 9 days of fermentation, the samples were collected and analyzed for their peptide content using the OPA assay, and antioxidant activity (DPPH and ABTS assay). The production of volatile compounds was evaluated by SPME/GC-MS technique while fat content and composition, upon extraction with the Folch method, were determined with GC-MS.
All the microorganisms were able to develop in the substrate. The peptide content reached 89 mg/ml with *Bacillus* B5M and 72 mg/ml with the two yeast strains after 4 days of fermentation, while it increased up to 102 mg/ml after 9 days with all the microorganisms. Strain B5M and YL2 showed the highest antioxidant activity (around 53-60%) after 4 days of fermentation while it improved up to 83% only in samples with *Bacillus* spp. after 9 days. Hydrolysates obtained with YL2 and YL4 after 4 day-incubation were rich in volatile molecules, such as 3-methyl-butanal (9-17%), 3-methyl-1-butanol (11-19%) phenylethyl alcohol (3.9-4.8%) and 1-penten-3-ol (2.2-2.4%), while those fermented with B5M and B5C were characterized by acetoin (29-31%) and 1-octen-3-ol (6.5-6.7%). A longer incubation determined a lower abundance of volatile compounds. Eventually, the use of oleaginous yeasts, such as *Y. lipolytica*, reduced the final fat content of the samples and determined a modification in the final fat composition. Overall, microbial fermentation of fish by-products and waste represents a promising tool to produce functional peptides, enzymes, and flavoring agents to be applied as ingredients in the food sector.
***Key words**: fish waste, Yarrowia lipolytica, antioxidant activity, volatile molecules; fat content*

NATURAL PRODUCTS IN STORED PRODUCT PEST CONTROL: CHALLENGES AND OPPORTUNITIES

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Postharvest losses of stored grains are recognized as a major constraint in food security. The losses caused by stored product pests (insects, microorganisms and rodents) amount from 20 to 80%, depending on the region, thus their reduction can increase available food supplies. The control of pests in storage and processing industry is mainly relying on the use of chemically synthesized pesticides and toxic fumigants. However, the inadequate and frequent use of these compounds has led to a development of pest resistance (to residual insecticides, fumigants and some fungicides), residues in food and feed, environmental and health hazards and other adverse impacts. The mentioned has resulted in a ban or restriction of a number of pesticide compounds in recent years, particularly insecticides, enabling the expansion of natural products (NPs) use in stored product pest management. Although NPs have long been used as pesticides and have served as an inspiration for numerous commercial synthetic products, at some point in history they were neglected. NPs originate from natural sources, and are i) mineral-derived (inert dusts: diatomaceous earth, kaolin clay, boric acid, zeolite, silver nanoparticles etc.) or ii) plant-derived compounds (terpenes, phenolics, steroids, alkaloids etc.).
A search for alternatives to chemical pesticides and fumigants resulted in an attempt to involve inert dusts (IDs) in stored product protection. IDs are mainly used as insecticides because they cause desiccation in insects by destroying the wax layer in the cuticle, causing the 60% loss of body water i.e. 30% loss of total body weight. The majority of IDs applied include natural silica (DE and zeolite) or clays, however the efficacy depend on the origin and physio-chemical characteristics. Compatibility of IDs with other control techniques, such as conventional insecticides, botanicals, aeration and heat treatment can increase their practical utilization, and this field of research is still wide open. The second most important group of NPs represents plant-derived compounds, also called botanicals. Many plant species contain secondary metabolites with biological activity against different storage pest groups (insects, mites, pathogenic fungi or bacteria). However, even after a long history of application and confirmed efficacy, at the moment botanicals, and other NPs are a small contributor to the global plant protection product market. Nonetheless, in the era of "green chemistry" as well in the light of more severe pesticide restriction, it is estimated that these products will take a higher market share in the future, if not as sole products, than as models for development of new synthetic pesticides.
This work presents the NPs with the highest applicative potential against stored product pests, and gives an insight into their mode of action, biological activity, spectra, health implications, obstacles to commercialization and scaling-up potential.
***Key words**: inert dusts, botanicals, storage pests*

PRIRODNI PROIZVODI U SUZBIJANJU ŠTETOČINA USKLADIŠTENIH PROIZVODA: IZAZOVI I MOGUĆNOSTI

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Posležetveni gubici uskladištenih zrnastih proizvoda prepoznati su kao glavno ograničenje u raspoloživosti hrane. Gubici koje uzrokuju štetočine uskladištenih proizvoda (insekti, mikroorganizmi i glodari) iznose od 20 do 80%, u zavisnosti od regiona, te smanjenje istih može doprineti povećanju zaliha hrane. Suzbijanje štetočina u skladišnim objektima i prehrambenoj industriji, uglavnom se zasniva na upotrebi hemijski sintetisanih pesticida i toksičnih fumiganata. Međutim, neadekvatna i česta upotreba ovih jedinjenja dovela je do razvoja rezistentnosti štetnih organizama prema rezidualnim insekticidima, fumigantima i nekim fungicidima, do pojave ostataka u hrani za ljudsku ishranu i životinje, opasnosti po životnu sredinu i zdravlje i drugih negativnih posledica. Navedeno je rezultiralo zabranom ili restrikcijom primene brojnih pesticidnih jedinjenja, posebno insekticida, usled čega se intenzivirala razvoj i upotreba prirodnih proizvoda (PP) u zaštiti od skladišnih štetočina. Iako su PP dugo korišćeni kao pesticidi i služili su kao model jedinjenja za brojne komercijalne sintetičke proizvode, u nekom trenutku u prošlosti, su zanemareni. PP potiču iz prirodnih izvora i mogu biti i) mineralnog (dijatomejska zemlja, kaolin glina, borna kiselina, zeolit, nanočestice srebra itd.) ili ii) biljnog porekla (terpeni, fenoli, steroidi, alkaloidi itd.).
Inertna prašiva (IP) su uključena u zaštitu uskladištenih proizvoda kao alternativa pesticidima i fumigantima. IP se uglavnom koriste kao insekticidi, jer uzrokuju desikaciju insekata uništavanjem voštanog sloja epidermisa, uzrokujući gubitak vode iz tela od 60%, odnosno 30% gubitak ukupne telesne težine. IP se prvenstveno primenjuju kao insekticidi i većina su u osnovi prirodni silicijum dioksid (DE i zeolit), međutim efikasnost zavisi od porekla i fizičko-hemijskih osobina. Kompatibilnost IP sa drugim tehnikama suzbijanja štetnih organizama, kao što su konvencionalni insekticidi, botanički preparati, aeracija i toplotni tretmani mogu povećati njihovu praktičnu primenu u skladištima i ovo polje je ostalo neistraženo. Druga najvažnija grupa PPa predstavljaju botanički pesticidi, jedinjenja biljnog porekla. Poznato je da brojne biljne vrste sadrže sekundarne metabolite sa biološkom aktivnošću protiv različitih grupa skladišnih štetočina (insekti, grinje, patogene gljive ili bakterije). Međutim, i pored duge istorije primene, i potvrđene efikasnosti, botanički preparati, ali i PP uopšte, trenutno čine mali udeo u globalnom tržištu sredstava za zaštitu bilja. No, u eri „zelene hemije“, kao i u svetlu predstojećeg ograničenja primene raspoloživih pesticida, procenjuje se da će PP zauzeti veći tržišni udeo u budućnost, ako ne kao komercijalizovani proizvodi, onda kao model molekuli u razvoju novih sintetičkih pesticida.
Rad ima za cilj da prikaže prirodna jedinjenja sa najvećim aplikativnim potencijalom u suzbijanju štetočina uskladištenih proizvoda, dajući uvid u njihov način i spektar delovanja, bioloku aktivnost, tehniku aplikacije, zdravstvene aspekte primene, prepreke u komercijalizaciji i potencijal za širu primenu.
***Key words**: inertna prašiva, botanički preparati, skladišne štetočine*

RHEOLOGICAL PROPERTIES OF ANCIENT WHEAT VARITIES AND SOURDOUGH PROCESSING USED AS A TOOL FOR IMPROVING ANTIOXIDATIVE PROPERTIES OF BREAD

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Wheat (*Triticum aestivum*) is one of the most grown cereal crop in the world, beside rice and corn. Modern wheat varieties have been created to fulfill various requirements such as high yield and different quality parameters. During recent years consumers are getting more interested in consumption of bakery product based on ancient wheat varieties. The reason for such growing interest is related to the fact that ancient cereals such as spelt, emmer, khorasan, etc. are considered as "healthier" among general population. According to some findings ancient wheats are characterized by higher protein, soluble fiber, vitamins, minerals, lipids and different bioactive compound content. Among bioactive substances, polyphenols are mostly in the focus of nutritionists since these compounds have numerous health beneficial effects such as anti-inflammatory, antioxidant, anticarcinogenic and antimutagenic, as well as preserving properties against food deterioration, etc. Although considered nutritionally improved, ancient cereals are generally characterized by low yield, the necessity of dehulling technology application and lower technological quality compared to modern wheat varieties. Recently, sourdough fermentation was proposed as a tool for increasing phenolic compound content as well as for overcoming the shortcomings related to ancient wheat flours dough processing.

In order to determine technological quality of three different ancient wheat varieties (emmer, spelt, khorasan) various rheological test were performed. Common wheat served as a control sample. Mixolab measurements (Chopin France) using Chopin+ protocol were conducted to reveal mechanical changes in tested dough samples upon mixing and heating. Moreover, wet gluten content and gluten index parameter which is also related to dough mechanical properties were determined. Spontaneous sourdough fermentation was performed in order to evaluate the impact of the sourdough fermentation on total phenolic content (TPC) bioaccessibility as well as DPPH antioxidant capacity during breadmaking. Bread samples prepared with common wheat flour using yeast as well as spontaneous sourdough fermentation served as control samples.

The obtained results revealed that spelt flour exhibited high wet gluten content and consequently formed strong gluten network which was characterized by the highest water absorption among all tested samples. However, khorasan flour showed the lowest wet gluten content but the highest dough stability during mixing which could be related to high gluten index values. Moreover, although all samples were characterized by similar starch content, khorasan flour showed the highest starch gelatinization and retrogradation rate during thermal treatment. The results of sourdough fermentation revealed that, after fermentation, antioxidant activity and TPC increased which was followed by minor decrease or it stayed unchanged upon baking. The obtained results also showed that emmer and spelt sourdough were characterized by higher bound phenolics release rate due to the higher acidity of these sourdoughs.

According to obtained results, it can be concluded that rheological properties were dependent on wet gluten content and gluten index values, i.e. gluten quantity and quality. Moreover, it was also determined that sourdough fermentation favored the release of bound phenolics which can be potentially utilized to increase the bread shelf life while avoiding antioxidant addition as food additives in different bakery products.

***Key words**: rheology, sourdough, antioxidative properties*

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REOLOŠKE OSOBINE DREVNIH ŽITARICA I UTICAJ FERMENTACIJE KISELIH TESTA NA POBOLJŠANJE ANTIOKSIDATIVNIH OSOBINA HLEBA

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Pšenica (Triticum aestivum), pored pirinča i kukuruza, predstavlja jednu od najčešće gajenih žitarica na svetu. Savremene sorte pšenice su kreirane da ispune različite zahteve kao što su visok prinos i različiti parametri kvaliteta. Poslednjih godina potrošači su sve više zainteresovani za konzumiranje pekarskih proizvoda na bazi starih sorti pšenice. Razlog za ovaj porast interesovanja je vezan za činjenicu da se drevne žitarice kao što su spelta, dikokum, kamut, itd. smatraju „zdravijim“ među opštom populacijom. Prema nekim istraživanjima, drevne sorte pšenice karakteriše veći sadržaj proteina, rastvorljivih vlakana, vitamina, minerala, lipida i različitih bioaktivnih jedinjenja. Polifenoli, kao bioaktivne supstance, su generalno sve više u fokusu nutricionista jer je utvrđeno da ova jedinjenja imaju brojne blagotvorne efekte po zdravlje kao što su antiinflamatorni, antioksidativni, antikancerogeni i antimutageni efekti, kao i da imaju svojstva sprečavanja kvarenja hrane, itd. Međutim, za ove žitarice je generalno karakteristično i da imaju nizak prinos, neophodan je proces ljuštenja i niži je tehnološki kvalitet u odnosu na savremene sorte pšenice. Fermentacija kiselih testa je nedavno predložena kao sredstvo za povećanje sadržaja fenolnih jedinjenja, kao i za prevazilaženje nedostataka vezanih za preradu testa na bazi brašna od drevnih pšenica.

Kako bi se utvrdio tehnološki kvalitet tri različite drevne sorte pšenice (dikokum, spelta, kamut) izvršena su različita reološka ispitivanja. Obična pšenica je služila kao kontrolni uzorak. Miksolab merenja (Chopin, Francuska) su sprovedena korišćenjem Chopin+ protokola da bi se utvrdile mehaničke promene ispitivanog uzorka testa pri mešanju i zagrevanju. Pored toga, ispitivan je sadržaj vlažnog glutena i vrednost gluten indeksa koji takođe utiču na mehanička svojstva testa. Takođe je izvršena i spontana fermentacija kiselih testa kako bi se procenio uticaj fermentacije kiselih testa na bioraspoloživost sadržaja ukupnih fenola (TPC) kao i antioksidativni kapacitet (DPPH) tokom pečenja hleba. Kao kontrolni uzorci poslužili su uzorci hleba pripremljeni od običnog pšeničnog brašna koristeći pekarski kvasac, kao i spontanu fermentaciju kiselog testa na bazi pšeničnog brašna.

Dobijeni rezultati su pokazali da brašno od spelte ima visok sadržaj vlažnog glutena i samim tim formira jaku glutensku mrežu koju karakteriše najveća moć upijanja vode među svim ispitivanim uzorcima. Međutim, brašno od kamuta je imalo najmanji sadržaj vlažnog glutena, ali najveću stabilnost testa tokom mešanja, što se može dovesti u vezu sa visokim vrednostima gluten indeksa. Pored toga, iako su svi uzorci bili okarakterisani sličnim sadržajem skroba, brašno od kamuta je pokazalo najveću brzinu želatinizacije i retrogradacije skroba tokom termičke obrade. Rezultati fermentacije kiselih testa su otkrili da se nakon fermentacije povećava antioksidativna aktivnost i TPC, koji se neznatno smanjuju ili ostaju nepromenjeni nakon pečenja hleba. Takođe se pokazalo da se kiselo testo od dikokuma i spelte odlikuje većom brzinom oslobađanja vezanih fenola usled većeg stepena kiselosti ovih testa.

Na osnovu dobijenih rezultata može se zaključiti da su reološka svojstva zavisila od sadržaja vlažnog glutena i vrednosti gluten indeksa, odnosno količine i kvaliteta glutena. Pored navedenog, utvrđeno je da fermentacija kiselih testa favorizuje oslobađanje vezanih fenola koji se potencijalno mogu iskoristiti za produženje roka trajanja i za izbegavanje dodavanja antioksidanasa kao prehrambenih aditiva u hrani u različitim pekarskim proizvodima.

***Ključne reči**: reologija, kisela testa, antioksidativne osobine*

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BIOLOGICAL ROUTE OF ISOBUTANOL PRODUCTION

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Isobutanol is a new generation of biofuel, it has a higher energy content and should be more amenable to pipeline distribution. Isobutanol can be blended with diesel and biodiesel in high ratios, Compared to diesel fuel, CO and NOx emissions decrease with the use of the blends of isobutanol and diesel. Isobutanol as a sustainable aviation fuel was approved by the International Civil Aviation Organization

Klebsiella spp. are good candidates as chassis for cell factories, and various chemicals have been produced by them. K. pneumoniae ΔbudA, the α-acetolactate decarboxylase inactivated strain, produced 2-ketoisovalerate and isobutanol at neutral pH conditions. The 2-ketoisovalerate and isobutanol synthesis pathway, the 2,3-butanediol synthesis pathway, and the branched-chain amino acid synthesis pathway share some common steps in which pyruvate, a principal metabolite of the cell, is their main precursor compound.

Dihydroxy acid dehydratase, encoded by the ilvD gene, catalyzes the reaction of 2-ketoisovalerate formation from 2,3-dihydroxyisovalerate. An ilvD disrupted strain was constructed which resulted in the inability to synthesize 2-ketoisovalerate, yet accumulate 2,3-dihydroxyisovalerate in its culture broth. A 2,3-dihydroxyisovalerate producing Enterobacter cloacae strain was constructed following a similar strategy.

2-ketoisovalerate decarboxylation was a bottleneck of this isobutanol synthesis pathway. To improve isobutanol production, ipdC was overexpressed on a plasmid. However, high level expression of ipdC resulted in a decrease of isobutanol production. It was found that, IpdC accepts a broad variety of substrates, and pyruvate is a substrate of IpdC. Pyruvate conversion by IpdC is a disadvantage for isobutanol production. A high level of IpdC leads to more pyruvate being decarboxylated to aldehyde and reduces the available pyruvate for isobutanol synthesis. To address this, we have engineered Kp-IpdC to reduce pyruvate decarboxylase activity. The mutant T290L that showed only 22.1% of catalytic efficiency on pyruvate compared to wild-type, was then expressed in K. pneumoniae for in vivo testing. Isobutanol production by K. pneumoniae T290L was 25% higher than that of the control strain.

Keywords: *Biofuel, Isobutanol, Cell factory, Klebsiella*

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BIOLOŠKI PUT PROIZVODNJE IZOBUTANOLA

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Izobutanol je gorivo nove generacije, ima viši sadržaj energije i pogodnije je za distribuciju. Izobutanol se može mešati sa dizelom i biodizelom u visokim odnosima. Emisija CO i NOx opada sa korišćenjem izobutanola u mešavinama sa dizelom. Izobutanol je održivije gorivo za upotrebu u avioindustriji i odobrenom je od Internacionalne organizacije za civilini vazdušni saobraćaj.

Klebsiella spp. su dobri kandidati kao "šasije" za ćelijske fabrike, i brojna jedinjenja se proizvode pomoću ovih sistema. *K. pneumoniae* Δ*budA*, α-acetolaktat dekarboksilaza inaktiviran soj, proizvodi 2-ketoizovalerat i izobutanol pri neutralnom pH. 2-ketoizovalerate i izobutanol sintetski put, 2,3-butanediol sintetski put, i sintetski put razgranatih aminokiselina imaju zajedničke korake, kao što je piruvat, osnovni ćelijski metabolit, koji je glavni prekursor ovih metaboličkih puteva.

Dihidroksi kisela dehidrataza, kodirana ilvD genom, katalizuje reakciju izgradnje 2-ketoizovalerate iz 2,3-dihidroksiizovalerata. Soj bez ilvD je konstruisan, što je dovelo do nemogućnosti sinteze 2-ketoizovalerata i akumulacije 2,3-dihidroksiizovalerata u podlozi. Primenom slične strategije, konstruisan je soj *Enterobacter cloacae* za proizvodnju 2,3-dihidroksiizovalerata.

Korak 2-ketoizovalerat dekarboksilacije predstavlja kritičn fazu sintetskom putu izobutanola. Kako bi se unapredila proizvodnja izobutanola, ipdC je višestruko eksprimiran na plazmidu. Ipak, visok nivo ekspresije je smanjio proizvodnju izobutanola. Utvrđeno je da IpdC prihvata različite tipove supstrata, uključujući piruvat. Konverzija piruvata pomoću IpdC je nepovoljna za proizvodnju izobutanola. Visok nivo IpdC dovodi do značanije dekarboksilacije piruvata do aldehida i smanjuje dostupnost piruvata za sintezu izobutanola. Kako bi ispitalo ovo, inženjerizovali smo Kp-IpdC kako bi smanjili aktivnost piruvat dekarboksilaze. Mutant T290L je pokazao samo 22.1% katalitičke efikanosti na piruvatu u poređenju sa divljim tipom i eksprimiran je u *K. pneumoniae* za *in vivo* testiranje. Proizvodnja izobutanola pomoću inženjerizovanog soja *K. pneumoniae* T290L je bila 25% viša u odnosu na kontrolni soj.

Ključne reči: biogorivo, izobutanol, ćelijske fabrike, *Klebsiella*
Zahvalnica: Alliance of International Science Organizations (ANSO) - project SparkGREEN (ANSO-CR-PP-2022-08)

THE POSSIBILITY OF USING EXPERIMENTAL EQUATIONS TO CALCULATE THE DEGREE OF DEACETYLATION OF CHITOSAN

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Hitozan i njegov potencijal za široku industrijsku primenu intenzivnije su proučavani poslednjih godina. Stepen deacetilovanosti (DD) je hemijska karakteristika od značaja za fizičke i biološke osobine hitozana od kojih u velikoj meri zavise performanse ključne za njegovu primenu.
Za određivanje stepena deacetilovanosti razvijene su brojne metode: linearna potenciometrijska titracija, infracrvena spektrofotometrija, spektroskopija nuklearne magnetne rezonance, spektrometrija pirolize-mase, UV spektrofotometrija, titrimetrija. Odabir adekvatne metode za određivanje stepena deacetilovanosti predstavlja izazov za istraživače. Neke od metoda su preduge, previše skupe za rutinsku analizu (primer spektroskopija nuklearne magnetne rezonance), a neke mogu dovesti i do destrukcije uzorka. Zbog svoje jednostavnosti i ekonomičnosti najčešće se za određivnje stepena deacetilovanosti hitozana koristi metoda infracrvene spektroskopije.
U ovom radu korišćena su tri uzorka hitozana različitog viskoziteta i poznatog stepena deacetilovanosti (između 80 i 90%) kako bi se ispitala mogućnost primene eksperimentalnih jednačina prijavljenih u literaturi za određivanje stepena deacetilovanosti hitozana u laboratorijskim uslovima. Korišćene su tri različite metode: potenciometrijska titracija, kiselo-bazna titracija i infracrvena spektrofotometrija za izračunavanje stepena deacetilovanosti hitozana. Prednost primene kiselo-bazne i potenciometrijske titracije je jednostavnost zahtevane opreme za metodu, ali su metode (posebno potenciometrijska titracija) dugotrajnije. Sa druge strane, infracrvena spektrofotometrija je zahtevnija u instrumentalnom smislu, ali je za samo izvođenje ispitivanja potrebna minimalna količina uzorka i analiza je brza.
Rezultati su pokazali da je metode infracrvenu spektrofotometriju i kiselinko-baznu titraciju, uz primenu gotovih eksperimentalnih jednačina moguće koristiti za procenu stepena deacetilovanosti hitozana, dok za potenciometrijsku titraciju nije potvrđena mogućnost uspešne primene za navedenu namenu.
Ključne reči: *hitozan, stepen deacetilovanosti, eksperimentalne jednačine*

MOGUĆNOST UPOTREBE EKSPERIMENTALNIH JEDNAČINA ZA IZRAČUNAVANJE STEPENA DEACETILOVANOSTI HITOZANA

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Chitosan and its potential for wide industrial applications have been intensively studied in recent years. The degree of deacetylation (DD) is a chemical characteristic of importance for the physical and biological properties of chitosan, on which the performance crucial for its application largely depends.
Numerous methods have been developed to determine the degree of deacetylation: linear potentiometric titration, infrared spectrophotometry, nuclear magnetic resonance spectroscopy, pyrolysis-mass spectrometry, UV spectrophotometry, titrimetry. Choosing an adequate method for determining the degree of deacetylation is a challenge for researchers. Some of the methods are time-consuming, too expensive for routine analysis (for example, nuclear magnetic resonance spectroscopy), and some can lead to the destruction of the sample. Due to its simplicity and economy, the method of infrared spectroscopy is most often used to determine the degree of deacetylation of chitosan.
In this work, three samples of chitosan with different viscosity and a known degree of deacetylation (between 80 and 90%) were used in order to examine the possibility of applying the experimental equations reported in the literature to determine the degree of deacetylation of chitosan in laboratory conditions. Three different methods were used: potentiometric titration, acid-base titration and infrared spectrophotometry to calculate the degree of deacetylation of chitosan. The advantage of applying acid-base and potentiometric titration is the simplicity of the equipment required for the method, but the methods (especially potentiometric titration) are more time-consuming. On the other hand, infrared spectrophotometry is more demanding in terms of instrumentation, but only a minimal amount of sample is required to perform the test and the analysis is fast.
The results showed that the methods of infrared spectrophotometry and acid-base titration, with the application of reported experimental equations, can be used to assess the degree of chitosan deacetylation, while potentiometric titration has not confirmed the possibility of successful application for the stated purpose.
Key words: *chitosan, deacetylation degree, experimental equations*

PROXIMATE COMPOSITION OF SJENIČKI SUDŽUK AS AFFECTED BY ALTERNATIVE RIPENING CONDITIONS

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This investigation was conducted on dry-fermented sausage *Sjenički sudžuk* in order to determine the effect of alternative ripening (ambient) conditions during summer production season, in small/micro processing plant, on its proximate composition. In traditional practice *Sjenički sudžuk* is manufactured during winter, in a part of the Pešter plateau (altitude of about 1.000 m), a nearby area of the small town of Sjenica (southwestern Serbia), when air temperatures are around 0°C or lower, and relative humidity is high. It is produced according to original procedure, using just beef, sea salt and spices, without food additives and microbial starters. However, as a result of the high consumer demand sudžuk is often produced outside of the standard production season, when climate conditions are less proper for this type of processing. Therefore, the properties of the obtained "summer" sausages (S) are different compared to "winter" ones (W), and so is the proximate composition of the products. Higher air temperature in traditional smoking/drying room have caused more intensive drying process during the summer, resulting in significantly lower ($P < 0.05$) moisture content in S sausages compared to W samples (29.6% and 36.5%, respectively). Consequently, due to increase in dry matter content, a significantly higher ($P < 0.05$) concentration of fat (27.4% vs. 22.6%) and total protein (31.8% vs. 30.5%) was found in S sausages, while the difference in share of collagen in total protein was not found to be significant ($P > 0.05$) between the observed samples (14.2% vs. 13.7%). Surprisingly, the concentration of ash and NaCl was significantly lower in S compared to W sausages, being 7.82% vs. 7.91%, and 5.33% vs. 5.42%, respectively. This finding could be the consequence of non-standardized (empirical) procedure of meat salting at the very beginning of sudžuk processing, before the pre-ripening phase. According to the obtained results, it can be concluded that the production of traditional *Sjenički sudžuk* outside the usual processing season is possible only with the appropriate air conditioning in smoking/drying room, aiming to imitate the ambient conditions that prevail during winter production season in traditional practice.

***Keywords**: fermented sausage, composition, production season*

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EFEKAT ALTERNATIVNIH USLOVA SUŠENJA I ZRENJA NA SASTAV SJENIČKOG SUDŽUKA

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Ovo istraživanje je sprovedeno na fermentisanoj suvoj kobasici *Sjenički sudžuk* kako bi se utvrdio uticaj različitih uslova sušenja i zrenja (ambijentalni uslovi) tokom letnje proizvodne sezone, u malom objektu za preradu mesa, na njegov osnovni hemijski sastav. U tradicionalnoj praksi, *Sjenički sudžuk* se proizvodi tokom zime, u delu Pešterske visoravni (nadmorska visina cca. 1000m) oko gradskog naselja Sjenica (jugozapadna Srbija), kada su temperature vazduha oko 0°C ili niže, a relativna vlažnost vazduha je visoka. Ova kobasica se izrađuje prema originalnoj proceduri, uz upotrebu goveđeg mesa, morske soli i začina, a bez dodatka prehrambenih aditiva i starter kultura. Međutim, kao rezultat velike potražnje, sudžuk se često proizvodi i van uobičajene sezone, kada klimatski uslovi nisu povoljni za ovu vrstu prerade. Otuda, karakteristike proizvedenih „letnjih“ kobasica (L) su drugačije od „zimskih“ (Z), pa je drugačiji i hemijski sastav proizvoda. Viša temperatura vazduha u tradicionalnoj prostoriji za dimljenje/sušenje je izazvala intenzivniji proces sušenja kobasica tokom leta. Ovo je rezultovalo značajno manjim ($P < 0,05$) sadržajem vlage u L kobasicama u poređenju sa uzorcima Z (29,6% i 36,5%, redom). Posledično, usled povećanja sadržaja suve materije, kod L kobasica je utvrđena značajno veća ($P < 0,05$) koncentracija masti (27,4% naspram 22,6%) i ukupnih proteina (31,8% naspram 30,5%), dok utvrđena razlika u udelu kolagena u ukupnim proteinima nije bila značajna ($P > 0,05$) između posmatranih uzoraka (14,2% naspram 13,7%). Neočekivano, koncentracija pepela i NaCl je bila značajno niža ($P < 0,05$) u L kobasicama u poređenju sa Z, iznoseći 7,82% naspram 7,91%, te 5,33% naspram 5,42%, redom. Ovaj nalaz bi mogao biti posledica nestandarnog (empirijskog) postupka soljenja mesa na samom početku proizvodnje sudžuka, odnosno neposredno pre faze predzrenja. Na osnovu dobijenih rezultata može se zaključiti da je proizvodnja tradicionalnog *Sjeničkog sudžuka* van uobičajene sezone prerade moguća samo uz odgovarajuću klimatizaciju u prostoriji za dimljenje/sušenje, sa ciljem postizanja ambijentalnih uslova sličnih onima koji vladaju tokom zimske proizvode sezone u tradicionalnoj praksi.

***Ključne reči**: fermentisana kobasica, sastav, proizvodna sezona*

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ENHANCING THE ANAEROBIC DIGESTION OF SLUDGE BY COMBINED PRE-TREATMENT METHODS

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The anaerobic digestion (AD) of wastewater sludge is a promising and efficient method in wastewater and sludge treatment, as it can lower the organic content of sludge while producing a renewable source of energy – biogas - at the same time. However, using native, non-treated industry-originated wastewater sludge as a substrate for AD may present difficulties, hence we focused our research primarily on the applicability of different pre-treatment methods to enhance the yield and/or gas composition of the produced biogas. For the experiments, 100 cm^3 of meat industry-originated wastewater sludge was being used, and the anaerobic fermentation took place in mesophilic conditions (38±0.2 °C). The nascent absolute pressure inside the fermenters were recorded with automatic manometric measuring devices (Oxi-Top IDS/B, WTW). The biogas composition was measured by an Agilent 6890 N gas chromatograph unit. For the pre-treatment processes, standalone microwave irradiation (MW) and magnetite nanoparticles in different concentrations (MNP) coupled with MW treatment were being used. Microwave treatments were carried out in a Labotron 500 laboratory microwave unit with an operating frequency of 2450 MHz. To gain information about the digestion process itself as well, we also measured the dielectric behavior of the fermentation media during the AD, and we were looking for correlations between certain dielectric properties, and the biogas yield or composition. Dielectric measurements were taken with a SPEAG DAK 3.5 open-ended coaxial dielectric probe connected to a Rhode&Schwarz ZVL-3 vector network analyzer in the frequency range of 200-2400 MHz.
Our experimental results revealed that each of the applied pre-treatment methods could enhance the biogas yield compared to the control samples by 20-138%, and the best result was gained when using 10 m/m% of MNPs with P=250W, t=360s microwave irradiation. The standalone MW treatment did not affect the biogas composition significantly, however when combining it by adding MNPs into the system, the methane content increased from 62% to 75-81%, depending on the concentration of the nanoparticles. The best methane yield was achieved when using 10-15% m/m% of MNPs, coupled with 250W, 360s microwave irradiation treatment. Based on the dielectric parameters of the fermentation media during the AD we found strong correlation between the changes in the dielectric constant and dielectric loss factor and the kinetics of the biogas production, regardless of the applied pre-treatment methods. Therefore, it can be stated that dielectric measurements can be used as a promising alternative examining technique to monitor the anaerobic fermentation of wastewater sludge, especially because it is fast, accurate, and doesn't require any preparatory operation or chemical compounds.
Key words*: wastewater sludge, pre-treatment, biogas production*

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HONEY FROM THE REGION OF RTANJ MOUNTAIN

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The Republic of Serbia is characterized by a long tradition in beekeeping with a large annual honey production of about 7000 t and a high average annual export growth rate. These facts point to the necessity of continuous quality control of honey produced in Serbia with the focus on special honey types with protected botanical and geographical origin (linden honey from Fruška gora, honey from Homolje, Đerdap honey, and Kačar honey).
Honey from the region of Rtanj Mountain (Rtanj honey) became the product with geographical indication certificate obtained at the national level in 2022.
The geographical area where Rtanj honey is produced is located in eastern Serbia and includes the area of two municipalities, Sokobanja and Boljevac. From the aspect of beekeeping and honey production, it is important to emphasize the meadow phytocenoses of great floristic diversity, with the presence of endemic and relict species, which represent one of the most characteristic centers of diversity in Eastern Serbia.
Several studies have proposed different chemical markers to determine the region of honey origin. Pollen types, chemical composition, mineral content, polyphenol profile and sensory characteristics of honey are strongly influenced by its geographical origin.
Therefore, physicochemical parameters, minerals and sensory profile of honey samples (76) were used to characterize Rtanj honey with the focus on establishing the geographical origin of this honey type. Among physicochemical parameters moisture content, electrical conductivity, pH, free acidity and HMF were determined.
Although moisture content of Rtanj honey samples was in the wide range of 13.6 ± 0.23–19.2 ± 0.07% all of them were below the limit (max 20%) recommended by Codex Alimentarius Commission.
Free acidity of Rtanj honey values ranged from 23.2 ± 0.14 to 65.6 ± 0.38 meq/kg with only one sample being above the limit (50 meq/kg). The pH values in examined Rtanj honey samples varied from 3.42 ± 0.10 to 5.54 ± 0.22.
Electrical conductivity of honey samples ranged from 114 to 1251 μS/cm indicating that some honey samples contained honeydew.
The contents of in all samples of Rtanj honey HMF indicated that honey was fresh (HMF < 10 mg/kg).
Rtanj honey dominantly contained K (> 3000 mg/kg), but also Mg (cca 150 mg/kg), Ca (> 100 mg/kg), Na (15 mg/kg), Mn (8 mg/kg), Fe (> 1,50 mg/kg) and other minerals.
Rtanj honey colour varied from light yellow ochre to light amber (12–65 mm, rated on Pfund's colour scale). Taste of Rtanj honey developed from moderately sour to moderately sweet, with the appearance of a slightly bitter aftertaste. Depending on the dominant honey plants, Rtanj honey aroma represented a harmonious combination of herbal, fruity and floral notes. Rtanj honey odour was reminiscent of dried herbs, fermented fruit, interspersed with light floral scents. Rtanj honey aroma had a weak persistence with noticeable notes of caramel and fried sugar, as well as those of fresh and fermented fruit and fresh flowers during consumption. Rtanj honey was of moderate to high viscosity, and upon crystallization it crystallized in the form of moderately coarse to coarse crystals.
Key words: *honey, Rtanj Mountain, geographical origin*

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MED IZ REGIONA PLANINE RTANJ

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Republiku Srbiju odlikuje duga tradicija u pčelarstvu sa velikom godišnjom proizvodnjom meda od oko 7000 t i visokom prosečnom godišnjom stopom rasta izvoza. Ove činjenice ukazuju na neophodnost kontinuirane kontrole kvaliteta meda proizvedenog u Srbiji sa fokusom na posebne vrste meda sa zaštićenim botaničkim i geografskim poreklom (fruškogorski lipov med, homoljski, đerdapski i kačarski med).
Med sa područja planine Rtanj (rtanjski med) postao je proizvod sa sertifikatom zaštićenog geografskog porekla dobijenim na nacionalnom nivou 2022. godine.
Geografsko područje na kome se proizvodi rtanjski med nalazi se u istočnoj Srbiji i obuhvata područje dve opštine, Sokobanje i Boljevca. Sa aspekta pčelarstva i proizvodnje meda, važno je istaći livadske fitocenoze velikog florističkog diverziteta, sa prisustvom endemskih i reliktnih vrsta, koje predstavljaju jedan od najkarakterističnijih centara diverziteta u istočnoj Srbiji.
Nekoliko studija je predložilo različite hemijske markere za određivanje/definisanje geografskog porekla meda. Vrste polena, hemijski sastav, sadržaj minerala, profil polifenola i senzorne karakteristike meda su u tesnoj sprezi sa njegovim geografskim poreklom.
Stoga su fizičko-hemijski parametri, minerali i senzorni profil uzoraka meda (76) korišćeni za karakterizaciju rtanjskog meda sa fokusom na utvrđivanje geografskog porekla ove vrste meda. Fizičko-hemijski parametri određivani u rtanjskom medu su sadržaj vlage, električna provodljivost, pH vrednost, slobodna kiselost i sadržaj HMF.
Iako je sadržaj vlage u uzorcima rtanjskog meda bio u širokom rasponu od 13,6 ± 0,23–19,2 ± 0,07% svi uzorci su bili ispod granice (max 20%) koju je definisala Codex Alimentarius Commission.
Vrednosti slobodne kiselosti rtanjskog meda kretale su se od 23,2 ± 0,14 do 65,6 ± 0,38 meq/kg pri čemu je samo jedan uzorak bio iznad granične vrednosti (50 meq/kg). pH vrednosti u ispitivanim uzorcima rtanjskog meda varirale su od 3,42 ± 0,10 do 5,54 ± 0,22.
Električna provodljivost uzoraka meda kretala se od 114 do 1251 μS/cm, što ukazuje da su neki uzorci meda sadržali medljiku.
Sadržaj HMF u svim uzorcima rtanjskog meda ukazao je da je med bio svež (HMF < 10 mg/kg).
Rtanjski med je dominantno sadržao K (> 3000 mg/kg), ali i Mg (> 150 mg/kg), Ca (> 100 mg/kg), Na (15 mg/kg), Mn (8 mg/kg), Fe (1,50 mg/kg) i druge minerale.
Boja rtanjskog meda je varirala od svetlo okeržute do svetlo ćilibarne (12–65 mm, ocenjeno na Pfund-ovoj skali boja). Ukus rtanjskog meda se razvijao od umereno kiselog preko umereno do intenzivno slatkog, sa pojavom blago gorkog naknadnog ukusa. U zavisnosti od dominantnog medonosnog bilja, miris i aroma rtanjskog meda predstavljale su harmoničnu kombinaciju biljnih, voćnih i cvetnih nota. Miris rtanjskog meda podsećao je na osušeno bilje, fermentisano voće, protkan laganim cvetnim mirisima. Aroma rtanjskog meda je bila slabe postojanosti, a tokom konzumiranja su se uočavale note karamela i prženog šećera, kao i one na sveže i fermentisano voće i sveže cveće. Rtanjski med je bio od umerene do izrazite viskoznosti, a pri kristalizaciji kristalisao je u obliku umereno grubih do grubih kristala.
Ključne reči: *med, planina Rtanj, geografsko poreklo*

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MAIZE KERNEL BREAKAGE - CAUSES, INFLUENCES AND CONSEQUENCES – A REVIEW

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The scientific literature indicates that maize kernel breakage and damage has increased along with maize grain yields as innovative agriculture practices have been adopted. This included genetic enhancement for increased grain yield, increased mechanization for harvesting and handling grain, increased artificial grain drying, and new processing and storage methods for maize grain. These changes increased grain yield and operator time efficiency with variable effects on grain quality and grain losses. One negative effect was to increase maize grain kernel damage, especially grain breakage, due to increased grain susceptibility to breakage and increased mechanical impact on kernels. This has led to broken kernels being included as grain quality factor for sale of maize grain and, thereby, increasing scientific research on factors influencing maize grain breakage. Research had documented climatic and production factors that pre-condition maize grain for breakage such as genetics, climate factors such as air temperature, relative humidity, precipitation, and hail; and production practices such as planting date, plant density, fertilizer application, irrigation, and plant protection practices. These indirect factors influenced the severity of direct effects on damage of maize grain exposed to impacts, friction, kneading, trampling, falling from different heights during harvesting and handling, and hot air with which it is dried, cold air with which it is cooled after drying and in which it is stored. Further, this enhances grain damage from grain storage insects, development of moisture and temperature gradients in stored grain, grain mold micro-organisms development with associated losses, and rodent damage during storage. Grain breakage leads to increased dust generation that besides increasing losses, also creates increased occurrence of fires and explosions, and health problems for confinement livestock animals and humans working with confinement livestock and in storage warehouses. Increased maize grain breakage has negative consequences on quality for all maize grain end-uses, but especially for dry milling which is used widely used around the world in human food processing. This review attempts to highlight the major direct and indirect factors that influence grain breakage throughout the growing season; and during harvest, handling, drying and storage.

Key words: *maize, kernel, breakage, dust, end-use quality*

LOM ZRNA KUKURUZA – UZROCI, UTJECAJI I POSLJEDICE

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Određene inovacije u poljoprivredi uzrokovale su oštećenja i lom zrna kukuruza. Veličina i kapacitet strojeva i opreme koja se koristi u žetvi te, tijekom prijema i umjetnog sušenja, ali i uvođenje i primjena novih tehnologija u doradi i skladištenju zrna, najviše su utjecali na oštećenja i lom zrna kukuruza. Povećanje uroda, kao posljedica primjene suvremenog sortimenta kukuruza i suvremene gnojidbe, dovodi i do povećanja osjetljivosti zrna na lom. To u kombinaciji s povećanim mehaničkim djelovanjem na zrno dovodi do ukupnog povećanja loma zrna. Kako je poznato, udjel polomljenih zrna jedan je od glavnih čimbenika prosudbenih kriterija kvalitete u trgovini kukuruznim zrnom. Stoga, posve je razumljivo da se povećava i opseg znanstvenih istraživanja o čimbenicima koji utječu na lomljenje zrna kukuruza. Iz provedenih istraživanja može se utvrditi koji čimbenici posredno (indirektno) utječu na lom zrna. To su: izbor hibrida, klimatski čimbenici (temperatura i relativna vlažnost zraka, oborine, tuča) i primijenjena agrotehnika (datum sjetve, gustoća sjetve odnosno broj biljaka po jedinici površine, primjena mineralnih gnojiva, navodnjavanje i postupci u zaštiti bilja). Navedeni čimbenici, iako posredno djeluju na veličinu loma zrna, mogu utjecati na povećanje oštećenja zrna kukuruza kada je zrno izloženo udarcima, trenju, gnječenju, gaženju, padu s različitih visina tijekom žetve i rukovanja, te vrućem zraku kojim se suši, hladnom zraku kojim se hladi nakon sušenja i pri kojem se skladišti. Nadalje, zrno koje je prošlo kroz sve prije navedeno, drugačije prima i otpušta vlagu nego ono koje nije oštećeno i polomljeno, podložnije je napadu štetnih insekata i glodavaca i na njemu se lakše razvijaju mikroorganizmi. Prilikom oštećivanja i lomljenja zrna stvara se prašina koja osim što je gubitak, može uzrokovati pojavu požara i eksplozije, te zdravstvene probleme životinja koje se drže u zatvorenom prostoru i ljudi koji rade s životinjama u zatvorenom prostoru i u skladištima. Povećani udjel oštećenog i polomljenog zrna kukuruza u masi zrna, negativno utječe na kvalitetu raznih postupaka prerade ali posebno utječe na kvalitetu suhog mljevenja koje se puno koristi diljem svijeta u proizvodnji hrane. Ovaj pregledni rad pokušava istaknuti glavne čimbenike koji direktno ili indirektno utječu na pojavu loma zrna kukuruza, a koji se pojavljuju tijekom vegetacijske sezone te tijekom žetve, umjetnog sušenja, dorade i skladištenja.

Ključne riječi: *kukuruz, zrno, lom, prašina, kvaliteta zrna za određenu namjenu*

THE ROLE OF SUSTAINABLE BIOGAS PRODUCTION IN THE NET ZERO ECONOMY

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The increase in the production and consumption of biofuels has so far been mainly encouraged by policies that initially greatly promoted the use of biofuels regardless of the raw material from which they were produced. However, today, the RED II (2018/2001/EC) encourages the production of those biofuels that are classified as sustainable. A sustainable biofuel is a biofuel that is produced from a sustainably produced raw material in a sustainable circular production process, with no or a minimal quantity of the remaining by-products. Moreover, due to the impending energy crisis, the European Commission has published the communication REPowerEU (COM (2022) 108) in May 2022, which aims to an increased production of biogas and biomethane by 20 % in the EU member states until 2030, with the aim of increasing their energy independence. Biogas and biomethane are renewable gases, produced during the anaerobic digestion of organic material, which help abate emissions across the whole value chain. Their further use is essential if we are to accelerate the reduction of GHG emissions in multiple sectors, including buildings, industry, transport and agriculture. On the other hand, the sustainability criteria will have to be met in order to achieve a sustainable biogas production in the following period. Hence, sustainable biomass will play a significant role in meeting the goal of reducing GHG emissions by 2030, included in the EU Green Deal (EC, 2019). The production and use of biomass in the production of biofuels and/or bioproducts can be significant from the point of view of GHG emissions trading (e.g. EU ETS, ESR). The proposed revision of the Directive 2003/87/EC on the greenhouse gas trading system for the first time includes the biomass sustainability criteria, including the production and use of biofuels. The aim of this research is to present the current GHG trading systems, the main sources of the biogenic CO_2, its utilization as well as its market possibilities. While most of the focus on CO_2 is on its contribution to climate change, it can also be a commercial input to a range of products and services (IEA, 2019). The biogas and biomethane production sector can provide flows of the biogenic CO_2 that can be used in other sectors of industry (for production of fuels, chemicals and building materials), or for permanent mitigation of negative GHG emissions.

***Key words**: biogas production, sustainability, net zero emissions*

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ULOGA ODRŽIVE PROIZVODNJE BIOPLINA U NETO NULTOM GOSPODARSTVU

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Povećanje proizvodnje i potrošnje biogoriva dosad je uglavnom bilo poticano od strane politika koje su u početku uvelike promovirale uporabu biogoriva neovisno o sirovini iz koje se ono proizvodi. Međutim, danas se Direktivom o obnovljivoj energiji RED II (2018/2001/EC) potiče proizvodnja samo onih biogoriva koja su klasificirana kao održiva. Održivo biogorivo je ono biogorivo koje se proizvodi iz održivo proizvedene sirovine u održivom kružnom proizvodnom procesu, uz nikakvu ili minimalnu količinu nusproizvoda koji ostaju. Nadalje, uslijed prijeteće energetske krize, Europska komisija je u svibnju 2022. god. objavila dokument REPowerEU (COM (2022) 108), u kojem se potiče povećana proizvodnja bioplina i biometana od 20 % u državama članicama EU do 2030. godine, s ciljem povećanja njihove energetske neovisnosti. Bioplin i biometan obnovljivi su plinovi, proizvedeni procesom anaerobne digestije organskog materijala, koji pomažu u smanjenju emisija u cijelom lancu vrijednosti. Njihova je daljnja uporaba ključna ukoliko želimo ubrzati smanjenje emisija stakleničkih plinova u više sektora, uključujući zgradarstvo, industriju, promet i poljoprivredu. S druge strane, morat će se zadovoljiti kriteriji održivosti procesa anaerobne digestije kako bi se u narednom razdoblju postigla održiva proizvodnja bioplina. Stoga će održiva biomasa, kao sirovinska baza, igrati značajnu ulogu u ispunjenju cilja smanjenja emisija stakleničkih plinova do 2030. god., što je obuhvaćeno u EU Zelenom planu (EK, 2019.). Proizvodnja i korištenje biomase u proizvodnji biogoriva i/ili bioproizvoda može biti značajno sa stajališta trgovanja emisijama stakleničkih plinova (npr. EU ETS, ESR). Predložena revizija Direktive 2003/87/EC o sustavu trgovanja stakleničkim plinovima po prvi put uključuje kriterije održivosti biomase, uključujući proizvodnju i korištenje biogoriva. Cilj ovog istraživanja je prikazati postojeće sustave trgovanja stakleničkim plinovima, glavne izvore biogenog CO_2, njegovu iskoristivost kao i tržišni potencijal. Do danas je u fokusu bio utjecaj CO_2 na klimatske promjene, međutim CO_2 može predstavljati komercijalni input u cijelom nizu proizvoda i usluga (IEA, 2019). Sektor proizvodnje bioplina i biometana može osigurati protok biogenog CO_2 koji se može koristiti u drugim sektorima industrije ili za trajno smanjenje negativnih emisija stakleničkih plinova.

***Ključne riječi**: proizvodnja bioplina, održivost, neto nulte emisije*

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ANTIMICROBIAL EFFECT OF IMMORTELLE ESSENTIAL OIL AND LACTOBACILLUS RHAMNOSUS CELL-FREE SUPERNATANT ON BACILLUS CEREUS

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The presence of pathogenic and toxigenic microorganisms in food is still a problem of modern food production. On the other hand, research points to the high efficiency of natural antimicrobial agents, such as essential oils (EO) of plants and metabolites of Lactic Acid Bacteria (LAC), such as lactic acid and bacteriocin, against pathogenic microorganisms - food contaminants. In addition, the application of these compounds favorably affects oxidative and sensory properties of food. Thus, much attention is currently being paid to the biopreservation of food with natural antimicrobial compounds. For this reason, the aim of this research was to determine individual and synergistic effect of EO immortelle (*Helichrysum arenarium* L.) and *Lactobacillus rhamnosus* cell-free supernatant on *Bacillus cereus, in vitro*.
To test antimicrobial activity of cell-free supernatant of BMK, the species *L. rhamnosus* ATCC 7469 was selected, and the test microorganism was *B. cereus* ATCC 11778. The antimicrobial activity of immortelle EO and *L. rhamnosus* cell-free supernatant against *B. cereus* was tested by disc diffusion (determination of zones inhibition) and by microdilution method (determination of minimum inhibitory, MIC, and minimum bactericidal concentration, MBC) individually and in a mixture (in ratio 1:1). After determining the MIC and MBC of oil, *L. rhamnosus* cell-free supernatant, and mixture of oil and *L. rhamnosus* cell-free supernatant, Fractional Inhibitory Concentration Index (FIC_{index}) was determined for the mixture. GC-MS analysis revealed that the main component of immortelle EO is α-pinene (20.33%). The results of the disc-diffusion method show that EO immortelle showed the best antimicrobial effects when it was applied in an amount of 20 µL (inhibition zone 21 mm). The MIC for EO immortelle was 14.20 µL/mL and MBC was 28.41 µL/mL. The cell-free supernatant of *L. rhamonosus* showed a weaker antimicrobial effect against *B. cereus*, compared to EO immortelle, with MIC of 113.64 µL/mL and MBC of 227.27 µL/mL. The tested mixture of EO immortelle and *L. rhamnosus* cell-free supernatant (in ratio 1:1) showed a synergistic effect against *B. cereus* with FIC_{index} of 0.56.
The obtained research indicates a significant antimicrobial potential of EO immortelle and *L. rhamnosus* cell-free supernatant, as well as their mixture, and represents a contribution to the development of a new concept of alternative methods in protecting food from microbiological contamination.
Key words: *antimicrobial potential, immortelle, L. rhamnonosus cell-free supernatant*

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ANTIMIKROBNI UTICAJ ETARSKOG ULJA SMILJA I BEZĆELIJSKOG SUPERNATANTA LACTOBACILLUS RHAMNOSUS NA BACILLUS CEREUS

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Prisustvo patogenih i toksigenih mikroorganizama u hrani predstavlja i danas problem savremene proizvodnje hrane. S druge strane istraživanja ukazuju na visoku efikasnost prirodnih antimikrobnih agenasa, kao što su etarska ulja (EU) biljaka i metabolita bakterija mlečne kiseline (BMK), poput mlečne kiseline i bakteriocina, protiv patogenih mikroorganizama – kontaminenata hrane. Pored toga, primena ovih jedinjenja povoljno utiče na oksidativna i senzorska svojstva hrane. Tako, da se velika pažnja u današnje vreme posvećuje biokonzervisanju hrane prirodnim antimikrobnim jedinjenjima. Iz tog razloga, cilj ovog istraživanja bio je određivanje pojedinačnog i sinergističkog uticaja EU smilja (*Helichrysum arenarium* L.) i bezćelijskog supernatanta *Lactobacillus rhamnosus* na *Bacillus cereus* u *in vitro* uslovima. Za ispitivanje antimikrobne aktivnosti bezćelijskog supernatanta BMK, odabrana je vrsta *L. rhamnonosus* ATCC 7469, a kao test mikroorganizam ispitivan je *B. cereus* ATCC 11778. Antimikrobna aktinost EO smilja i bezćelijskog supernatanta *L. rhamnosus* prema *B. cereus* ispitna je disk-difuzionom (određivanje zone inhibicije) i mikrodilucionom metodom (određivanje minimalne inhibitorne, MIC i minimalne baktericidne koncentracije, MBC) pojedinačno i u smeši (u odnosu 1:1). Nakon određivanja MIC i MBC ulja, supernatanta *L. rhamonosus* i smeše ulja i supernatanta *L. rhamnosus*, određen je Frakcijski inhibicijski koncentracijski indeks (FICindex) za smešu. GC-MS analizom određen je hemijski sastav EU smilja i kao glavna komponenta utvrđena je α-pinen (20,33%). Rezultati disk-difuzione metode pokazuju da je EU smilja pokazalo najbolje antimikrobne efekte kada je primenjeno u količini od 20µl (zona inhibicije 21mm). MIC za EU smilja bila je 14,20 µl/ml, a MBC 28,41 µl/ml. Bezćelijski supernatant *L. rhamonosus* je pokazao slabiji antimikrobni efekat prema *B. cereus*, u odnosu na EU smilja, sa MIC od 113,64 i MBC od 227,27 µl/ml. Ispitivana smeša EU smilja i bezćelijskog supernatanta *L. rhamnosus* (u odnosu 1:1) pokazala je sinergistički efekat prema *B. cereus* sa FIC_{index} od 0,56.
Dobijena istraživanja ukazuju na značajan antimikrobni potencijal EU smilja i bezćelijskog supernatanta *L. rhamnosus,* kao i njihove smeše, i predstavljaju doprinos razvoju novog koncepta alternativnih metoda u zaštiti hrane od mikrobiološke kontaminacije.
***Ključne reči**: antimikrobni potencijal, smilje, supernatant L. rhamnonosus*

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DETERMINATION OF PIGMENTS AND ANTIOXIDANT CAPACITY IN EXTRACTS FROM SELECTED MEDICINAL AND AROMATIC PLANTS OBTAINED BY ULTRASOUND-ASSISTED EXTRACTION

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Mediterranean herbs such as carob (*Ceratonia siliqua*), myrtle (*Myrtus communis*) and mastic tree (*Pistacia lentiscus*) are a rich source of various bioactive compounds (BAC), of which above different phenolic compounds and pigments occupy the main place. For the isolation of these compounds from the plant matrix, various extraction methods have been anciently used. With the technology progress, new extraction techniques have been developed, such as ultrasound-assisted extraction, which has the advantages in comparison with classical extraction techniques such as less environment harms due to reduced consumption of chemicals, shorter extraction time, increased extraction efficiency and greater energy savings.

The aim of this research was to determine the influence of ultrasound-assisted extraction on the yields of pigments (chlorophyll a and b as well as carotenoids) and antioxidant capacity (AC) in extracts obtained from dry carob pods, myrtle leaves and fruits, and mastic tree leaves. Successive extraction was carried out using solvents of increasing polarity (ethyl acetate, 80% acetone and 96% ethanol; v/v) at temperature of 65 °C during 30 min. The content of chlorophyll a, chlorophyll b and carotenoids in the extracts was analyzed by the spectrophotometric method, and the AC by the ORAC method.

The results of the conducted analyses showed that the highest mass fraction of chlorophyll a was determined in the ethyl acetate extracts of the mastic tree leaves (20.31 mg/100 g d.m.), followed by acetone extracts obtained from the mastic leaves (16.09 mg/100 g d.m.), myrtle leaves (8.03 mg/100 g d.m.) and myrtle berries (4.58 mg/100 g d.m.), and the lowest one was found in carob pod extracts. Chlorophyll b (14.95 mg/100 g d.m.) and carotenoids (10.45 mg/100 g d.m.) were the most abundant in acetone extracts from myrtle berries, while their lowest mass fraction was found in all carob pod extracts. The highest AC was determined in acetone extracts obtained from myrtle leaves and berries as well as mastic tree leaves, while in carob pods the higher AC was determined in ethanol extracts. In general, 80% acetone proved to be a better choice for the extraction of pigments with ultrasound-assisted extraction from different plant species and also provided extracts with the highest AC determined by the ORAC method.

***Key words**: medicinal and aromatic plants, pigments, antioxidant capacity, ultrasound-assisted extraction, extraction solvents*

ODREĐIVANJE PIGMENATA I ANTIOKSIDACIJSKOG KAPACITETA U EKSTRAKTIMA DOBIVENIH EKSTRAKCIJOM POTPOMOGNOM ULTRAZVUKOM IZ ODABRANIH LJEKOVITIH I AROMATSKIH BILJNIH VRSTA

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Mediteransko bilje poput rogača (*Ceratonia siliqua*), mirte (*Myrtus communis*) i tršlja (*Pistacia lentiscus*), bogat su izvor različitih bioaktivnih spojeva (BAS) od kojih glavno mjesto zauzimaju različiti fenolni spojevi te pigmenti. Za izolaciju ovih spojeva iz biljnog matriksa, od davnina pa sve do danas se koriste različite metode ekstrakcije. S napretkom tehnologije, razvile su se i nove tehnike ekstrakcije kao što je to ekstrakcija primjenom ultrazvuka (UAE) čija je prednosti prema klasičnim tehnikama ekstrakcije manja štetnost za okoliš zbog smanjene potrošnje kemikalija, skraćeno vrijeme ekstrakcije, povećana je efikasnost ekstrakcije i veće su uštede energije.
Cilj ovog istraživanja bio je odrediti utjecaj ultrazvukom potpomognute ekstrakcije na prinose pigmenata (klorofila a i b te karotenoida) i antioksidativni kapacitet (AC) u ekstraktima dobivenim iz osušenih i usitnjenih plodova rogača, listova i plodova mirte te listova tršlje. Provedena je sukcesivna ekstrakcija primjenom otapala rastuće polarnosti (etil-acetat, 80% aceton te 96% etanol (v/v)) pri temperaturi od 65 °C i vremenu trajanja od 30 minuta. U ekstraktima su određivani sadržaj klorofila a, klorofila b i karotenoida spektrofotometrijskom metodom, a antioksidativni kapacitet ORAC metodom.
Rezultati provedenih analiza su pokazali da je najveći maseni udio klorofila a utvrđen u etil acetatnim ekstraktima listova tršlje (20,31 mg/100 g s.tv.), te u acetonskim ekstraktima dobivenim iz listova tršlje (16,09 mg/100 g s.tv.), listova mirte (8,03 mg/100 g s.tv.) i bobica mirte (4,58 mg/100 g s.tv.), a najmanje u svim ekstraktima dobivenim iz plodova rogača. Klorofila b (14,95 mg/100 g s.tv.) i karotenoida (10,45 mg/100 g s.tv.) najviše je određeno u acetonskim ekstraktima bobica mirte, dok je najmanji maseni udio određen u svim ekstraktima plodova rogača. Najviši AC utvrđen je u acetonskim ekstraktima dobivenim iz lišća i bobica mirte te lišća tršlje, dok je u mahunama rogača viši AC utvrđen u etanolnim ekstraktima. Općenito, 80% aceton se pokazao boljim izborom za ekstrakciju pigmenata uz ekstrakcijom potpomognutom ultrazvukom iz različitih biljnih vrsta i njihovih dijelova u kojima je određen i najveći antioksidativni kapacitet ORAC metodom.
***Ključne riječi**: ljekovito i aromatsko bilje, pigmenti, antioksidacijski kapacitet, ekstrakcija potpomognuta ultrazvukom, ekstrakcijska otapala*

EXPLORING USE OF THE METSCHNIKOWIA PULCHERRIMA YEAST TO IMPROVE PROPERTIES OF APPLE WINES

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Metschnikowia pulcherrima is a ubiquitous yeast frequently presents in spontaneous fermentations. The current interest in this yeast is supported by the secretion of many extracellular metabolities - various aromatic compounds. The low fermentative power of *M. pulcherrima* makes necessary the sequential or mixed use with winery strains of *Saccharomyces cerevisiae* to completely ferment grape musts. *M. pulcherrima* has a respiratory metabolism that conducts to lower ethanol production. In addition, this non-conventional yeast shows good compatibility with conventional winery yeasts in producing a low volatile acidity and a reduced level of H_2S. It is worth noting that the sequestration of iron gives *M. pulcherrima* many advantages in biocontrol of fermentation processes.
In this study, we evaluate the chemical properties of Polish apple wines obtained by yeast monocultures or co-cultures of conventional and non-conventional yeasts. We used controlled mixed fermentations of apple musts with the *Metschnikowia pulcherrima*, *Saccharomyces cerevisiae* Tokay, and non-conventional wild yeasts: *Wickerhamomyces anomalus* and *Dekkera bruxellensis*. The assimilation profiles, enzyme fingerprinting, and metabolic profiles of yeast species (chromatography HPLC, GC), both individually and in mixed systems, were investigated.
In young apple wines obtained with monocultures, the percentage of sugar consumption was 74.22% for *S. cerevisiae*. In the case of the mixed cultures, the percentage of sugar consumption was significantly lower. It is worth noting that the mixed cultures of the Tokay strain with other non-*Saccharomyces* yeasts resulted in a lower concentration of ethanol compared to fermentation with *S. cerevisiae* Tokay as a monoculture. The use of mixed yeast cultures for apple juice fermentation slightly affected the formation of other metabolities compared to the monocultures. The acetic acid content (0.03 g/L) and the glycerol content (0.23 g/L) were the lowest for the *M. pulcherrima* strain, while the highest glycerol concentration was detected for *S. cerevisiae* Tokay (4.7 g/L). However, for co-cultures of Tokay and *M. pulcherrima* this value was only slightly lower. In the apple wine, the highest concentrations of the main volatile was of 3-methylbutan-1-ol (164.58 mg/L), produced by a co-culture Tokay + *M. pulcherrima* + *W. anomalus* + *D. bruxellensis*. This aliphatic higher alcohol contributes desirable complexity to wine aroma in moderate concentrations below 300 mg/L. Higher concentrations of ethyl acetate (88.94 mg/L) formed in the wine fermented with a monoculture of *W. anomalus*, and acetaldehyde (46.33 mg/L) was produced by the monoculture of *M. pulcherrima*. These compounds are also the components of wine volatilomes. Thus, mixed populations strongly altered the aromatic profiles of the fruit wines compared to the corresponding monocultures.
In summary, the chemical complexity of apple wines was improved using the *M. pulcherrima* spp. as co-starter. *M. pulcherrima* with *S. cerevisiae* produced apple wine with a lower ethanol content, similar glycerol level, and a higher level of volatilome in comparison to wines obtained by the monoculture of *S. cerevisiae* Tokay. Therefore, the use of *M. pulcherrima* as a starter in mixed fermentations with *S. cerevisiae* could be of great interest in modern fruit enology. However, large-scale research using industrial-quality fruits harvested from different climate regions is particularly necessary.
Key words*: apple wine; Metschnikowia pulcherrima; metabolic profiles*

POSSIBILITY OF USING SOLAR ENERGY IN SERBIA ANALYZED THROUGH THE PROSUMER CONCEPT

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Energy stability and independence are fundamental goals in the long-term policies of all countries. To this end, the development of energy exploitation from renewable sources is encouraged. In addition to energy, developing renewable energy sources has a remarkable ecological and socioeconomic effect.
Solar energy, just like hydropower, has been used since ancient times primarily for heating buildings. Today, the conversion of solar energy into electricity is topical, and the field of photovoltaic power plants is highly dynamic. That assertion supports the fact that in the period from 2017 to 2022, the total global installed power of photo voltaic systems increased three times, from 400 GW to over 1200 GW.
Until recently, the biggest problem with the development of photovoltaic systems was the high cost of the panels and the economic non-competitiveness with other sources of electricity. However, the rapid progress of technology is rapidly reducing the price of kW of installed power of photovoltaic panels, so it is expected that the electricity produced by photovoltaic power plants (PVP) will soon be cheaper than the energy produced by gas plants.
The basic idea of the prosumer (PC) concept is that he produces electricity for his own needs and hands over any surpluses to the electricity distribution system (DSEE). The role of PC is not to constantly deliver energy to DSEE and thereby make a profit.
PC can transfer excess energy to the system and acquire "credit." Then, later, he can take over that amount of deposited energy for his own needs, but he cannot charge the excess from the electricity supplier. Another important fact that affects the PC's work, and the choice of the power of its PVP is the accounting period. Namely, at the end of the twelve-month accounting period, all excess energy currently in the system delivered by PC is deleted.
Also, the critical fact is that the difference between delivered and received energy is calculated according to tariffs. That means that energy can be taken from the system only in the tariff in which the injection was made. In this way, the PC can come to a situation where he injected more energy than he took in a higher tariff and he will have a surplus that he cannot bill. But, conversely, if he took more energy than he injected in a lower tariff, he will have to pay for the difference.
The paper analyzes the cases of electricity calculation for a consumer without PVP and for PC with different powers of installed PVP and different amounts of injected energy in DSEE. For a successful comparison, consumers with the same approved power, connected to low voltage and the same monthly consumption were observed. The results show the optimal PV power for individual consumers, as well as the investment return period depending on the price of electricity on the market.
Key words*: renewable energy sources, solar energy, prosumer*

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MOGUĆNOST UPOTREBE SOLARNE ENERGIJE U SRBIJI ANALIZIRANA KROZ KONCEPT KUPAC - PROIZVOĐAČ

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Energetska stabilnost i nezavisnost su važni ciljevi u dugoročnim politikama svih zemalja u Svetu. U tom cilju se podstiče razvoj eksploatacije energije iz obnovljivih izvora. Pored energetskog, razvoj obnovljivih izvora energije ima izuzetan ekološki i socioekonomski efekat. S obzirom da su obnovljivi izvori energije lokalno dostupni, njihov razvoj ostvaruje izuzetan povoljan efekat na otvaranje novih radnih mesta i olakšan pristup energiji, pre svega električnoj.
Solarna energija se, isto kao i hidroenergija, koristi još od davnina pre svega za zagrevanje objekata. Danas je aktuelno pretvaranje sunčeve energije u električnu i oblast fotonaponskih elektrane je u veoma dinamičnoj ekspanziji. U prilog tome govori i podatak da je u periodu od 2017. do 2022. ukupna globalna instalisana snaga fotopanela porasla tri puta, sa 400 GW na preko 1200 GW.
Do nedavno je najveći problem razvoja fotonaponskih sistema bila visoka cena panela i ekonomska nekonkurentnost ostalim izvorima električne energije. Brz napredak tehnologije veoma rapidno obara cenu kW instalisane snage fotonaponskih panela pa se očekuje da će u skorijoj budućnosti električna energija proizvedena u fotonaponskim elektranama (PVE) biti jeftinija od energije proizvedene u gasnim.
Osnovna ideja koncepta kupac – proizvođač (KP) jeste da on proizvodi električnu energiju za svoje potrebe i eventulane viškove predaje u distributivni sistem električne energije (DSEE). Uloga KP nije da konstantno isporučuje energiju u DSEE i na taj način ostvaruje dobit, čak je to i nemoguće.
KP može višak energije da preda u sistem i da stekne „kredit“. Kasnije tu količinu deponovane energije može da preuzme za svoje potrebe ali taj višak ne može da naplati od snabdevača električnom energijom. Još jedna bitna činjenica koja utiče na rad KP i izbor snage njegove PVE jeste obračunski period. Naime, na kraju dvanaestomesečnog obračunskog perioda sav višak energije koji trenutno postoji u sistemu a predat je od strane KP se briše.
Druga bitna činjenica jeste da se obračun razlike između predate i preuzete energije vrši po tarifama. To znači da se energija iz sistema može preuzeti samo u onoj tarifi u kojoj je izvršeno injektovanje. Na taj način kupac - proizvođač može doći situaciju da je više energije injektovao nego preuzeo u višoj tarifi i tu će imati viša, a da je više preuzeo nego injektovao u nižoj tarifi i tu će razliku morati da plati.
U radu su analizirani slučajevi obračuna za električnu energiju za potrošača bez PVE i za KP sa različitim snagama instalisanih PVE i različitim količinama injektovane energije u DSEE. Radi uspešnog poređenja posmatrani su potrošači sa istom odobrenom snagom, priključeni na niski napona i istom mesečnom potrošnjom. Rezultati prikazuju koja je optimalna snaga PVE za pojedine potrošače, kao i period povrata investicije u zavisnosti cene električne energije na tržištu.

***Ključne reči**: obnovljivi izvori energije, solarna energija, kupac - proizvođač*

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BIOGAS PRODUCTION IN SERBIA – A CASE STUDY

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According to the origin of fuel, biogas power plants are renewable energy sources (RES). Their owners are privileged electricity producers, and the state subsidizes their production. Therefore, eligible producers have the opportunity to sell electricity to the "Electric Power Industry of Serbia" for a more extended time under economically favorable and guaranteed subsidized conditions.
As part of the global initiative to reduce emissions and the greenhouse effect, as well as to preserve a healthy environment, the Government of the Republic of Serbia in 2009 adopted a set of regulations governing the production of energy from renewable sources and set a feed-in tariff for electricity from renewable sources. Adopted regulation enables privileged producers to sell electricity to the "Electric Power Industry of Serbia" under favorable and guaranteed subsidized conditions for 12 years.
The 2014 Law on Energy passed a series of measures and regulations that regulate the area of renewable energy sources, including the biogas sector. A particular advantage was the possibility of acquiring the temporary status of a privileged electricity producer. This measure was a strong incentive for investors because it enabled them to obtain a privileged status before serious investments in technology and plant.
This issue is deleted in the Law on Energy from 2021 (Official Gazette of RS 40/2021). Instead, it becomes the subject of a special Law on the Use of Renewable Energy Sources (LURES) (Official Gazette of RS 40/2021). The Law on the Use of Renewable Energy Sources (Official Gazette of RS 40/2021) abolishes feed-in tariffs and introduces a system of auctions for energy from RES. A temporary privileged electricity producer still exists and is defined in Article 23 of the LURES.
This paper presents a historical overview of changes in the electricity market in the Republic of Serbia related to renewable energy sources in the period from 2009 to 2021. An analysis of the previous period and the current situation on the electricity market was performed. Based on that, certain conclusions were drawn about the current profitability of investing in specific technologies to produce electricity from renewable sources such as biogas and solar energy.
Keywords: *biogas, electricity, market.*

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PROIZVODNJA BIOGASA U REPUBLICI SRBIJI – STUDIJA SLUČAJA

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Biogasne elektrane su prema poreklu goriva, obnovljivi izvore energije. Njihovi vlasnici spadaju u povlaštene proizvođače električne energije i njihova proizvodnja je subvencionisana od strane države. Povlašteni proizvođači imaju mogućnost da pod ekonomski povoljnim i garantovanim subvencionisanim uslovima prodaju električnu energiju „Elektroprivredi Srbije“ u dužem vremenskom periodu.
U okviru globalne inicijative za smanjenje emisije štetnih gasova i efekta staklene bašte, kao i radi očuvanja zdrave životne sredine, Vlada Republike Srbije je tokom 2009. godine usvojila čitav set propisa kojima se uređuje proizvodnja energije iz obnovljivih izvora i utvrdila feed-in tarifu koja proizvođačima električne energije iz obnovljivih izvora omogućava da pod povoljnim i garantovanim subvencionisanim uslovima prodaju električnu energiju „Elektroprivredi Srbije“, u periodu od 12 godina.
Zakon o energetici iz 2014. godine doneo čitav niz mera i propisa koji detaljno regulišu oblast obnovljivih izvora energije, uključujući i sektor biogasa. Posebna pogodnost bila je mogućnost sticanja privremenog statusa povlašćenog proizvođača električne energije. Ova mera je bila snažan podsticaj za investitore, jer je omogućila dobijanje povlašćenog statusa pre ozbiljnih investicija u tehnologiju i postrojenje.
U Zakonu o energetici iz 2021 (Sl. glasnik RS 40/2021) ova problematike se briše i postaje predmet posebnog Zakona o korišćenju obnovljivih izvora energije (ZOIE) (Sl. glasnik RS 40/2021). Zakon o korišćenju obnovljivih izvora energije (Sl. glasnik RS 40/2021) ukida feed-in tarife i uvodi sistem aukcija za energiju iz OIE. Status privremenog povlaštenog proizvođača električne energije i dalje postoji i definisan je članom 23. ZOIE.
U ovom radu je izložen istorijski pregled promena na tržištu električne energije u Republici Srbiji vezanih za obnovljive izvore električne energije u periodu od 2009. do 2021. godine. Izvršena je analiza prethodnog perioda kao i trenutnog stanja na tržištu električne energije. Na osnovu toga su izvedeni određeni zaključci o trenutnoj isplativosti investiranja u određene tehnologije za proizvodnju električne energije iz obnovljivih izvora kao što su biogas i solarna energija.
***Ključne reči**: biogas, električna energija, tržište.*

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DRYING OF SUNFLOWERS 2022. HARVEST IN THE COMPANY DON DON - ZRENJANIN

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The paper presents the results of drying sunflowers of the 2022 harvest on the "Schmidt Seeger" dryer. In a broader sense, the paper deals with the reception, cleaning and storage of sunflowers in a silo designed for wheat storage. Due to the constructive differences between silos intended for wheat and silos intended for sunflower, problems appear that significantly complicate the planning of the concept as well as the realization of business plans when it comes to sunflower. The silo in Zrenjanin has the role of storing wheat for the needs of the mill, while sunflower is stored as a service to be delivered after a certain time. The dryer has the ability to work in direct and indirect mode and uses natural gas as an energy source. Only the indirect mode of operation is used for drying sunflowers. Sorting of the incoming sunflower is done by determining the reception cells of the silo depending on the incoming humidity and storing the cleaned sunflower in them. Cleaning is done on a Schmidt Seeger purifier with a large capacity (>40 t/h of sunflower) with a satisfactory cleaning effect. The drying mode is determined according to the selected cell, that is, the humidity of the input grain. The temperature of the working fluid is low and ranged up to max. 45°C. By raising the temperature, it was possible to increase the drying capacity, but the obstacles (limitations) are the characteristics of the transport devices, the dimensions and angles of the gravity pipelines. The weighted input humidity was 9.4%. Sunflower drying is carried out within a narrow range of specified output humidity (6.8 - 7 %), which significantly complicates the operation of the dryer in the given circumstances. The specific consumption of thermal energy is 4,513 kJ/kg water produced, but it is necessary to take into account that, due to high outside temperatures, a certain amount of sunflower was dried without the use of a burner, as well as that adequate continuity of operation of the dryer was not achieved because it was stopped during the night and restarted the next day.
The storage period was 6 months and there were no complaints about the quality of delivered sunflowers.
Key words: *Sunflower, drying, specific energy consumption*

SUŠENJE SUNCOKRETA ROD 2022. U KOMPANIJI DON DON - ZRENJANIN

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U radu su prikazani rezultati sušenja suncokreta rod 2022. na sušari "Schmidt Seeger". U širem smislu u radu je obrađen prijem, čisćenje i skladištenje suncokreta na silosu koji je projektovan za skladištenje pšenice. Usled konstruktivnih razlika između silosa namenjenih za pšenicu i silosa namenjenih za suncokret, pojavljuju se problemi koji značajno otežavaju planiranje koncepta kao i realizaciju poslovnih planova kada je suncokret u pitanju. Silos u Zrenjaninu ima ulogu skladištenja pšenice za potrebe mlina, dok se suncokret skladišti uslužno da bi nakon određenog vremena bio isporučen. Sušara ima mogućnost rada u direktnom i indirektnom režimu i kao energent koristi prirodni gas. Za sušenje suncokreta koristi se isključivo indirektni režim rada.
Razvrstavanje ulaznog suncokreta se vrši tako što se odrede prijemne ćelije silosa u zavisnosti od ulazne vlažnosti i u njih se skladišti očišćen suncokret. Čišćenje se vrši na Schmidt Seeger prečistaču velikog kapaciteta (>40 t/h suncokreta) sa zadovoljavajućim efektom čišćenja. Režim sušenja se određuje u skladu sa odabranom ćelijom odnosno vlažnosti ulaznog zrna. Temperatura radnog fluida je niska i kretala se do max. 45°C. Povišenjem temperature bilo je moguće povećanje kapaciteta sušenja, ali su prepreka (ograničenja) karakteristike transportih uređaja, dimenzije i uglovi gravitacionih cevovoda. Ponderisana ulazna vlažnost iznosila je 9,4 %. Sušenje suncokreta se vrši u uskom opsegu zadatih izlaznih vlažnosti (6,8 – 7 %) što značajno otežava rad sušare u datim okolnostima. Specifična potrošna toplotne energije iznosi 4.513 kJ/kg izd.vode, ali potrebno je uzeti u obzir da je, zbog visokih spoljnih temperatura, određena količina suncokreta sušena bez upotrebe gorionika kao i to da adekvatan kontinuitet rada sušare nije postignut jer je zaustavljana tokom noći i ponovo pokretana narednog dana.
Period skladištenja iznosio je 6 meseci i nije bilo reklamacija na kvalitet isporučenog suncokreta.
Ključne reči: *Suncokret, sušenje, specifična potrošnja energije*

THE EFFECT OF COMPOSITION OF PLANT-BASED FISH ANALOGUES ON CHOSEN PHISCIAL PROPERTIES

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Nowadays we can observe a growing global need for plant-based animal product analogues. This growing need is caused by environmental concerns of sustainability, human health, and animal welfare. The rising global population leads to increased consumption of animal-based food and a decrease in natural resources. Additionally, an unbalanced diet focused on red meat and animal welfare caused a rising need for plant-based products. The food and Agriculture Organization of the United Nations (FAO) and The World Health Organization (WHO) recommended the consumption of fish meat, but increasing marine farming may cause negative effects. It creates a need for seafood analogues in order to minimalize the negative effects of marine farming as well as the problems connected to the overfishing of the seas.
In this study, the effect of the composition of plant-based fish analogues on the physical properties were evaluated. The fish analogue samples were prepared on the basis of different sources of proteins as pea, rice or wheat. Additionally, in the recipe there were also added such products as starch, fiber, natural flavors (sea algae nigiri, composition of spices, etc.), foods rich in omega 3 and 6 fatty acids (yeast flakes, nuts, linseed, oil, etc.), natural colorings, etc. Samples were together mixed and the formation of the vegan fish was done. The obtained samples were measured before and after thermal processing. The physical properties of the fish analogue samples were evaluated on the basis of: dry matter content, water activity, color, and texture measurements. The color was measured with the CIE L*a*b space as well as the total color changes (ΔE) before and after thermal treatment were evaluated. Similarly, the texture was done before and after product thermal preparation.
The results showed that the selected raw materials allowed to obtain vegan analogues of fish. The dry matter content was the highest in samples with high content of pea, rice, and wheat proteins with the addition of wheat starch. The value of the dry matter was in the range of 21% to 60%. All of the products were showing high water activity before and after thermal processing. The lowest water activity was observed for samples with pea and rice protein (0.86). However, this not allows the product to be stored for a longer period of time and requires additional protection against the development of microorganisms. The color of the samples was dependent on the used composition as well as the preparation process. Similarly, the texture of the samples was mainly affected by the amount of protein.
Key words*: plant-based fish analogues, fish analogues composition, physical properties*

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EFFECTS OF ANCIENT WHEAT SOURDOUGH ADDITION ON BREAD RHEOLOGICAL AND TEXTURAL PROPERTIES

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Ancient varieties of wheat were neglected for some time, due to the advantages of modern varieties such as high yield with improved technological characteristics. The term modern wheat refers to wheat varieties which has been subjected to numerous changes in order to achieve previously mentioned characteristics. However, consumer's awareness of the importance of nutritional quality ingredients in food, as well as potential health benefits, has contributed to the revival of the use of ancient varieties. Furthermore, implementation of processes such as sourdough fermentation can improve dough and products characteristics. Sourdough fermentation is one of the most common processes used by artisan bakeries. The use of sourdough contributes to the rheological properties, influences the texture (hardness, adhesiveness, cohesiveness, chewiness, gumminess), shape, specific volume, colour, and moisture retention of products. Furthermore, there are some studies focusing on the improvement of microbiological, nutritional and functional characteristics of sourdough bread obtained with the flour of some ancient wheat species. Since the textural properties of food are closely related to its rheological properties, achieving good properties and improving dough rheological properties are important for obtaining good quality product which is reflected especially at sensory characteristics of products.

The sourdough was obtained from spontaneously fermented emmer, khorasan, spelt and wheat flour. After achieving mature sourdough, the bread was prepared for further investigation. Rheological measurements of dough samples were monitored for 6 hours fermentation, while textural properties (textural profile analysis – TPA) and specific volume were investigated on obtained bread samples.

The samples exhibited different trends in rheological parameters. Dough extensibility has increased during fermentation in samples with ancient wheat varieties, except in khorasan where during first few hours dough extensibility has been increasing and after 4 hours the extensibility has been decreased. However, the dough extensibility of modern wheat has decreased during first hours and after 4 hours has significantly increased. The specific volume of wheat sourdough sample has been significantly lower compared to other three ancient wheat samples. According to TPA tests, ancient wheat varieties had lower hardness and chewiness values, compared to modern wheat-based sourdough.

Due to different characteristics of flour and presence of different microbiota, rheological behaviour of samples showed different trends. However, after examination of textural and volume characteristics of bread samples it can be concluded that ancient wheats had higher potential for creating products with better quality. Further research should be conducted, in terms of nutritional and functional properties, in order to improve and additionally confirm above-mentioned statement.

Key words*: sourdough, rheology, ancient wheat*

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UTICAJ DODATKA KISELOG TESTA DREVNIH ŽITA NA REOLOŠKE I TEKSTURNE OSOBINE HLEBA

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Drevne sorte pšenice su neko vreme bile zanemarene, prvenstveno zbog prednosti savremenih sorti kao što su visok prinos sa poboljšanim tehnološkim karakteristikama. Pod pojmom moderna pšenica podrazumevaju se sorte pšenice koje su podvrgnute brojnim promenama u cilju postizanja prethodno navedenih karakteristika. Međutim, svest potrošača o značaju nutritivnog kvaliteta sastojaka u hrani, kao i potencijalnim zdravstvenim prednostima, doprinelo je oživljavanju upotrebe drevnih sorti pšenice. Pored toga, primena procesa kao što je fermentacija kiselih testa može poboljšati karakteristike testa i proizvoda. Fermentacija kiselih testa je jedan od najčešćih procesa koji koriste zanatske pekare. Upotreba kiselog testa doprinosi reološkim svojstvima, utiče na teksturu (tvrdoću, lepljivost, kohezivnost, žvakanje, gustoću), oblik, specifičnu zapreminu, boju i zadržavanje vlage proizvoda. Naime, postoje studije koje se fokusiraju na poboljšanje mikrobioloških, nutritivnih i funkcionalnih karakteristika hleba od kiselog testa dobijenog od brašna drevnih vrsta pšenice. Budući da su teksturna svojstva hrane usko povezana sa njenim reološkim svojstvima, postizanje dobrih svojstava i poboljšanje reoloških svojstava testa su važni za dobijanje proizvoda dobrog kvaliteta, što se posebno odražava na senzorne karakteristike proizvoda.
Kiselo testo je dobijeno spontanom fermentacijom brašna dikokuma, kamuta, spelte i pšenice. Nakon postizanja stadijuma zrelog kiselog testa, hleb je pripremljen i naknadno ispitivan. Reološka merenja testa su praćena tokom 6 sati fermentacije, dok su na dobijenim uzorcima hleba ispitivana teksturna svojstva (analiza teksturnog profila – TPA) i specifična zapremina.
Uzorci su pokazali različite trendove u reološkim parametrima. Rastegljivost testa se povećavala tokom fermentacije u uzorcima od drevnih sorti pšenice, osim kod kamuta gde je u prvih nekoliko sati rastegljivost testa bila povećana, a nakon 4 sata se smanjivala. Za razliku od njih, testo od moderne sorte pšenice je pokazalo smanjenje rastegljivosti u prvim satima, a posle 4 sata se značajno povećalo. Specifična zapremina uzorka kiselog testa na bazi pšeničnog brašna je značajno niža u poređenju sa ostala tri uzorka drevnih sorti pšenice. Prema TPA testovima, stare sorte pšenice imaju niže vrednosti tvrdoće i žvakljivosti u poređenju sa hlebom dobijenim od kiselog testa na bazi moderne sorte pšenice.
Zbog različitih karakteristika brašna i prisustva različite mikrobiote, reološko ponašanje uzoraka je pokazalo različite trendove. Međutim, nakon ispitivanja teksturnih i zapreminskih karakteristika uzoraka hleba može se zaključiti da drevne sorte pšenice imaju velik potencijal za kreiranje proizvoda boljeg kvaliteta. Potrebno je sprovesti dalja istraživanja u pogledu nutritivnih i funkcionalnih svojstava, kako bi se unapredile i dodatno potvrdile gore navedene konstatacije.
Ključne reči: *kiselo testo, reologija, drevne sorte pšenice*

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EXTRACTION OF HYDROXYMETHYLFURFURAL FROM HONEY USING AQUEOUS TWO-PHASE SYSTEMS

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Honey is a natural product that contains about 200 different compounds. It consists of carbohydrates, water, and other components, such as proteins (enzymes), organic acids, vitamins (especially vitamin B6, thiamin, niacin, riboflavin, and pantothenic acid), minerals, pigments, phenolic compounds, various volatile compounds, Maillard reaction products and caramelization products. 5-Hydroxymethylfurfural (HMF) is formed as an intermediate in the Maillard reaction and directly by dehydration of sugars in acidic conditions (caramelization) during thermal treatments of honey. In acidic conditions, HMF can be formed even at low temperatures, although its content increases dramatically with increasing temperature. Apart from the temperature, the amount of HMF formed also depends on the pH value, water activity, as well as concentration of divalent cations in the medium. *In vitro* toxicological studies have shown that HMF in high concentrations is cytotoxic, causing irritation of the eyes, upper respiratory tract, skin, and mucous membranes. *In vitro* experiments on animals have shown that exposure to high concentrations of HMF can cause skin cancer, kidney tumors, and increase the frequency of hepatocellular adenomas. In the middle 1950s, Albertsson proposed the use of aqueous two-phase systems as an alternative to traditional liquid-liquid extraction techniques, which usually require the use of volatile and toxic organic solvents. The aqueous two-phase system consists of two immiscible aqueous phases and is based on the combination of polymer-polymer, polymer-salt, and salt-salt. Although both substances are soluble in water, they separate into two coexisting phases above a certain concentration – with one phase rich in one and the other phase rich in the other component. Among them, the most studied class is ionic liquid-salt systems due to the high ability of salt ions to induce saltation of the ionic liquid and consequently create two aqueous phases.
The aim of this work was to develop and implement extraction procedures for HMF isolation from honey in order to ensure its safety status and to enable the further application of isolated HMF in various industry sectors. Bio-ionic liquids are seen as an ideal extractant for both purposes, and additionally, they can be reused lowering the costs of the analysis/process, as well as environmental pollution. By applying all tested aqueous two-phase systems based on choline ionic liquids (choline chloride ([Ch][Cl]), choline nicotinate ([Ch][Nic]), choline propionate ([Ch][Prop]) and choline butyrate ([Ch][But]) and inorganic salt K_3PO_4 for the extraction of HMF from honey, the extraction efficiency of more than 85% was achieved. Complete extraction (EE_{HMF} = 100%) was achieved using the extraction system with [Ch][But], while the weakest ability to extract HMF exhibited the system with [Ch][Cl].
***Key words**: honey, HMF, aqueous two-phase systems*

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EKSTRAKCIJA HIDROKSIMETILFURFURALA IZ MEDA PRIMENOM DVOFAZNIH VODENIH SISTEMA

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Med je prirodni proizvod koji sadrži oko 200 različitih jedinjenja. Sastoji se od ugljenih hidrata, vode i drugih komponenata, kao što su proteini (enzimi), organske kiseline, vitamini (posebno vitamin B6, tiamin, niacin, riboflavin i pantotenska kiselina), minerali, pigmenti, fenolna jedinjenja, najrazličitija isparljiva jedinjenja i proizvodi Maillard-ove reakcije i procesa karamelizacije. 5-Hidroksimetilfurfural (HMF) se formira kao intermedijer u Maillard-ovoj reakciji i direktno, dehidratacijom šećera u kiseloj sredini (karamelizacija) tokom termičkih tretmana meda. U kiselim uslovima, HMF se može formirati i pri niskim temperaturama, iako se njegov sadržaj drastično povećava sa temperaturom. Osim temperature, količina formiranog HMF zavisi i od pH vrednosti, aktivnosti vode, kao i od koncentracije dvovalentnih katjona u medijumu. *In vitro* toksikološke studije pokazale su da je HMF u velikim koncentracijama citotoksičan, izaziva iritaciju očiju, gornjeg respiratornog trakta, kože i sluzokože. *In vitro* eksperimenti na životinjama pokazali su da izloženost većim koncentracijama HMF može prouzrokovati karcinom kože, tumore na bubrezima, kao i da povećava učestalost hepatocelularnih adenoma. Sredinom pedesetih godina XX veka, Albertsson je predložio upotrebu dvofaznih vodenih sistema kao alternativu tradicionalnim tehnikama tečno-tečne ekstrakcije, koje uobičajeno iziskuju korišćenje isparljivih i toksičnih organskih rastvarača. Dvofazni vodeni sistem se sastoji od dve vodene faze koje se ne mešaju i zasnovane su na kombinaciji polimer-polimer, polimer-so i so-so. Iako su obe supstance rastvorljive u vodi, one se razdvajaju u dve koegzistirajuće faze iznad određene koncentracije – pri čemu je jedna faza bogata jednom, a druga faza drugom komponenton. Među njima, najproučavanija klasa su sistemi jonska tečnost-so zbog visoke sposobnosti jona soli da indukuju isoljavanje jonske tečnosti i konsekventno stvore dve vodene faze.
Cilj ovog rada je bio razvoj i implementacija ekstrakcionih postupaka za izolovanje HMF iz meda, kako bi se obezbedila njegova zdravstvena bezbednost i omogućila dalja primena izolovanog HMF u različitim granama industrije. Bio-jonske tečnosti se sagledavaju kao idealan ekstragens u svrhu obe namene, a dodatno, mogu se ponovo upotrebljavati (reciklirati), što snižava cenu analize/procesa, kao i zagađenje životne sredine. Primenom svih ispitanih dvofaznih vodenih sistema na bazi holinskih jonskih tečnosti (holin hlorid ([Ch][Cl]), holin nikotinat ([Ch][Nic]), holin propionat ([Ch][Prop]) i holin butirat ([Ch][But]) i neorganske soli K_3PO_4 za ekstrakciju HMF iz meda postignuta je efikasnost ekstrakcije veća od 85%. Potpuna ekstrakcija (EE_{HMF} = 100%) postignuta je primenom ekstrakcionog sistema sa [Ch][But], dok je najslabiju sposobnost da ekstrahuje HMF ispoljio sistem sa [Ch][Cl].
***Ključne reči**: med, HMF, dvofazni vodeni sistemi*

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THE INFLUENCE OF PYROLYSIS ON THE ENERGY PROPERTIES OF AGRICULTURAL BIOMASS

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At the beginning and during the development of civilization, natural sources were the only available source of energy. With the development of society and industry, they were replaced by the intensive use of fossil fuels. The non-renewability, price and negative impact on the environment questioned the rationality of using such sources. More recently, the massive use of fossil fuels has been burdened by the politics of energy independence, the consequences for the environment, and the reserves themselves. Therefore, natural energy sources are becoming more and more important, especially biomass, which is becoming an important energy source due to its environmental advantages. One important biomass source is agricultural biomass, whose advantage is cumulative CO2 neutrality, high availability, and relatively low price in line with bioeconomy goals. There are numerous ways to convert agricultural biomass into various forms of biofuels, namely thermochemical, biochemical, and mechanical extraction through esterification. Biochemical conversions include anaerobic digestion and alcoholic fermentation, while thermochemical conversions include combustion, pyrolysis, gasification, and liquefaction. Pyrolysis is a process of decomposition of organic matter, during which very valuable products in the form of biochar and bio-oil are obtained under the influence of a high temperature of 400 to 600 °C without the presence of oxygen. Biochar is a stable product used as a fertilizer and/or soil amendment, while bio-oil is used as a liquid biofuel.
For this study, agricultural biomass of major agricultural crops (corn, wheat, barley, oats, soybeans, and sunflower) collected in 2021 was used. Non-combustibles (moisture, ash, coke, solid carbon) and combustibles (combustibles, volatiles, and upper heating value) were determined before and after the pyrolysis process. The results show that the pyrolysis process of biomass from major agricultural crops improves the energetic properties and that agricultural biomass is a biomass that is well suited as a feedstock for direct combustion. Moreover, the mentioned crops are characterized by significant potential for pyrolytic conversion, i.e., for the production of bio-oil as an energy source and biochar as a value-added product, which is best evidenced by the increase in calorific value of all studied crops after the pyrolysis process.
Key words: *agricultural biomass, pyrolysis, calorific value*

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UTJECAJ PIROLIZE NA ENERGETSKA SVOJSTVA POLJOPRIVREDNE BIOMASE

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Početkom i tokom razvoja civilizacije prirodni izvori bili su jedini dostupan izvor energije. Razvojem društva i industrije zamjenjeni su intenzivnom primjenom fosilnih izvora. Neobnovljivost, cijena i negativan utjecaj na okoliš doveli su u pitanje racionalnost korištenja takvih izvora. Masovna upotreba fosilnih goriva u novije vrijeme je opterećena politikom energetske neovisnosti, ekološkim posljedicama te samim rezervama. Stoga, važnost sve više ponovno dobivaju prirodni izvori energije, ponajviše biomasa koja postaje značajan energent zbog svojih ekoloških prednosti. Važan izvor bomase je poljoprivredna biomasa, a prednost korištenja iste je njena kumulativna CO_2 neutralnost te visoka dostupnost i relativno niska cijena u skladu s ciljevima bioekonomije. Postoje brojne mogućnosti konverzije poljoprivredne biomase u različite oblike biogoriva i to termokemijska, biokemijska i mehanička ekstrakcija esterifikacijom. Biokemijske pretvorbe uključuju anaerobnu digestiju i alkoholnu fermentaciju, dok termokemijske uključuju izgaranje, pirolizu, uplinjavanje te likvefakciju. Piroliza je proces razgradnje organske tvari u kojem se pod utjecajem visoke temperature od 400 do 600°C bez pristunosti kisika dobivaju visoko vrijedni produkti u obliku biougljena i bioulja. Biougljen je stabilni produkt koji se upotrebljava kao gnojivo i/ili poboljšivač tla, dok se bioulje koristi kao tekuće biogorivo.
U ovome istraživanju korištena je poljoprivredna biomasa važnijih ratarskih kultura (kukuruz, pšenica, ječam, zob, soja i suncokret) prikupljena tijekom 2021. godine. Određene su negorive tvari (vlaga, pepeo, koks, fiksirani ugljik) i gorive tvari (gorive tvari, hlapljive tvari te gornja ogrijevna vrijednost) prije te nakon procesa pirolize. Dobiveni rezultati utvrdili su da se postupkom pirolize biomasa važnijih ratarskih kultura poboljšavaju energetska svojstva te da poljoprivredna biomasa predstavlja biomasu s visokom mogućnošću korištenja kao sirovine za izravno izgaranje. Također, navedene kulture karakterizira značajan potencijal kod pirolitičke pretvorbe, odnosno kod proizvodnje bioulja kao energenta te biougljena kao proizvoda dodane vrijednosti, što je nabolje dokazano porastom ogrijevne vrijednosti svih istraživanih kultura nakon procesa pirolize.
Ključne riječi: poljoprivredna biomasa, piroliza, ogrijevna vrijednost

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CURRENT AND FUTURE CHALLENGES IN PET FOOD INDUSTRY

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The pet food market has been very attractive and grown dramatically in the last decades offering a huge number of products that differ in physical form, composition of nutrients and physiological and pathological conditions. Approximately 30% of all pet food and pet care sales worldwide are made in Europe, which is regarded as one of the leaders in the sector. In Serbia as well, it is slowly starting to develop and gain importance. More and more families are acquiring pets causing the pet food industry to grow quickly. A recent research revealed that 99 percent of owners considered their pets to be "part" of the family. Over the years, dramatic changes in pet food industry making the basic pet foods more sophisticated that provide not only the right nutrients in optimal quantities but also much more than we call optimal.

The main trend influencing the pet food market is the humanization of pets. Many pet owners seek pet food that is representative of their personal preferences. Due to the rise in "natural", "raw" and "organic" food, there is now a greater selection of premium products available to owners. Specialist products such as those focusing on a specific health benefits have been very popular and shown strong growth. As owners appear to be more concerned with their pet's diet, premium, luxurious, healthy, and functional foods are entering the mainstream.

Pet foods can be in different forms as complete or complementary; wet, dry, snacks and treats or raw. A pet food manufacturer's skill bases on the selection and blending of various meat, fish, vegetables, cereals, minerals, and vitamins to create nutritious foods that pets enjoy. Owners have various options including fully prepared raw meals, a combination of wet and dry foods, and specially formulated pet treats.

Trends in pet food are beginning to resemble those in human food. In the future, new formulated products based on insects can be expected on the market, as well as many others that have unique functional and sensory properties with authentic ingredients.

Key words: *pet food, trends, future*

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SADAŠNJI I BUDUĆI IZAZOVI U INDUSTRIJI HRANE ZA KUĆNE LJUBIMCE

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Tržište hrane za kućne ljubimce je veoma atraktivno i ostvaruje dramatičan porast poslednjih decenija nudeći veliki broj proizvoda koji se razlikuju po fizičkom obliku, sastavu hranljivih materija kao i fiziološkom i patološkom stanju. Oko 30% ukupne prodaje hrane za kućne ljubimce i nege za kućne ljubimce širom sveta ostvaruje se u Evropi, koja se smatra jednim od lidera u ovom sektoru. U Srbiji se polako počinje razvijati ova grana industrije koja dobija sve veći značaj. Povećava se broj porodica koje nabavljaju kućne ljubimce zbog čega se industrija hrane za kućne ljubimce brzo razvija. Nedavno istraživanje je pokazalo da 99% vlasnika svoje ljubimce smatra „članom“ porodice. Poslednjih godina, dramatične promene u industriji hrane za kućne ljubimce se zasnivaju na činjenici da ovi proizvodi postaju sve više sofisticirani što znači da obezbeđuju ne samo neophodne hranljive materije u optimalnim količinama već i mnogo više od onoga što mi nazivamo optimalnim.

Glavni trend koji utiče na tržište hrane za kućne ljubimce je humanizacija kućnih ljubimaca. Mnogi vlasnici kućnih ljubimaca traže hranu za svoje ljubimce koja odgovara njihovim ličnim preferencijama. Zbog porasta „prirodne“, „sirove“ i „organske“ hrane, vlasnicima je sada na raspolaganju veći izbor vrhunskih proizvoda. Specijalizovani proizvodi koji se fokusiraju na određene zdravstvene benefite su veoma popularni i ostvarili su nagli porast u proizvodnji. Izgleda da su vlasnici više posvećeni i zabrinuti za ishranu svojih ljubimaca, s obzirom da vrhunska, luksuzna, zdrava i funkcionalna hrana ulazi u „mainstream“.

Hrana za kućne ljubimce može biti u različitim oblicima kao potpuna ili dopunska; mokra i suva; grickalice i poslastice, kao i sirova. Veština proizvođača hrane za kućne ljubimce zasniva se na odabiru i mešanju različitog mesa, ribe, povrća, žitarica, minerala i vitamina kako bi se napravio hranljivi proizvod u kome kućni ljubimci uživaju. Danas vlasnici imaju različite opcije u smislu izbora hrane za njihove ljubimce uključujući potpuno pripremljene sirove obroke, kombinaciju mokre i suve hrane i specijalno formulisane poslastice.

Trendovi u hrani za kućne ljubimce počinju da liče na one u ljudskoj hrani. U budućnosti se na tržištu mogu očekivati novi formulisani proizvodi na bazi insekata, kao i mnogi drugi koji imaju jedinstvena funkcionalna i senzorna svojstva sa autentičnim sastojcima.

Ključne reči: *hrana za kućne ljubimce, trendovi, budućnost*

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ASSESSMENT OF FARM ECONOMIC VIABILITY IN THE REPUBLIC OF SERBIA USING FADN DATA

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The main aim is to evaluate economic viability of farms by including opportunity costs of production factors in calculation. In general, farms are profitable if they generate income larger than expenses, but in order to assess farm economic viability, farms are viable if their accounting profit is high enough to cover opportunity costs of production factors (labour, capital and land). In this regard, short and long term economic viability is distinguished. A farm is short-term viable if accounting profit is larger than or equal to the opportunity costs of labour. The opportunity costs of labour (unpaid labour, family work) represents average wage in economy. A farm is long-term viable when accounting profit minus opportunity costs of non-land capital and opportunity costs of land is larger than or equal to opportunity costs of labour. The opportunity costs of non-land capital are measured according to 5 per cent rate of return, and the opportunity costs of land by average land rent. Farm economic viability is evaluated by using the data from the Serbian FADN (Farm Accountancy Data Network) for 2021. In order to evaluate short-term viability, 73.6% of farms are viable. The highest proportion of economic viable farms was found in farms included in field crops production (88.0%), followed by horticulture (80.8%) and vineyards and fruits (77.5%), while the lowest percentage of viable farms in short term was recorded in grazing livestock (58.8%) and dairy production (55.9%). On the other hand, share of long-term viable farms is 65.1%, and field crops are also dominant with 80.1% of economically viable farms in long term. Farms specializing in dairy production and grazing livestock have the lowest share of economically viable farms in long term (48.6% and 46.3%, respectively). From the size point of view, larger farms have better chance to achieve economic viability. Namely large farms, i.e. farms with standard output value more than 100,000 euros, have the highest proportion of viable farms in long term (95.0%), while small farms, i.e. farms with standard output value less than 8,000 euros, have the lowest share (18.9%). The results indicate that smaller and more extensive farms have lower potential of being economically viable.
Key words: *economic viability, opportunity costs, production factors.*

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OCENA EKONOMSKE ODRŽIVOSTI POLJOPRIVREDNIH GAZDINSTAVA REPUBLIKE SRBIJE NA OSNOVU FADN PODATAKA

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Cilj istraživanja je da se oceni ekonomska održivost poljoprivrednih gazdinstava (PG) na osnovu oportunitetnih troškova faktora proizvodnje. PG su profitabilna ukoliko u svom poslovanju ostvaruju prihode veće od rashoda, međutim u cilju ocene ekonomske održivosti gazdinstava navedena računovodstvena dobit se poredi sa oportunitetnim troškovima faktora proizvodnje (rad, kapital i zemljište). S tim u vezi, razlikuje se kratkoročna i dugoročna ekonomska održivost PG. Gazdinstvo je kratkoročno ekonomski održivo u slučaju kada ostvaruje dobit veću ili jednaku oportunitetnim troškovima rada (neplaćena radna snaga, članovi porodice). Oportunitetni troškovi rada se vrednuju po prosečnoj bruto zaradi u privrednom sektoru. Sa druge strane, gazdinstvo je dugoročno ekonomski održivo ukoliko beleži dobit umanjenu za oportunitetne troškove sopstvenog kapitala (bez zemljišta) i oportunitetne troškove zemljišta veću ili jednaku oportunitetnim troškovima rada. Oportunitetni troškovi sopstvenog kapitala (bez zemljišta) se vrednuju po referentnoj godišnjoj stopi prinosa na kapital od 5%, a oportunitetni troškovi zemljišta po prosečnoj godišnjoj renti za zemljište. Ekonomska održivost gazdinstva je ocenjena na osnovu FADN (engl. Farm Accountancy Data Network) podataka iz 2021. godine za Republiku Srbiju. Ako posmatramo kratkoročnu ekonomsku održivost, od ukupnog broja gazdinstava 73,6% je ekonomski održivo. Najveći procenat održivih gazdinstava je među onima koji se bave ratarstvom (88,0%), sledi hortikultura (80,8%), i voćarstvo i vinogradarstvo (77,5%), dok je najmanje održivih u ukupnom broju gazdinstava zabeleženo u stočarskoj proizvodnji – različita stoka koja se napasa (58,8%) i mlečnom govedarstvu (55,9%). Sa druge strane, udeo dugoročno održivih gazdinstava u ukupnom broju PG je nešto manji (65,1%). Ovde takođe prednjači ratarstvo sa 80,1% ekonomski održivih gazdinstava, dok mlečno govedarstvo sa 48,6% održivih gazdinstava i stočarska proizvodnja – različita stoka koja se napasa sa 46,3% imaju najmawi procenat održivih farmi. Kada posmatramo gazdinstva sa aspekta ekonomske veličine, jasno je da veća gazdinstva imaju veću šansu za dostizanje ekonomske održivosti. Najveći udeo dugoročno ekonomski održivih gazdinstava je kod PG preko 100.000 evra standardne vrednosti proizvodnje (95,0%), dok je kod PG ekonomske veličine do 8.000 evra svega 18,9% ekonomski održivih gazdinstava. Rezultati pokazuju da gazdinstva nižih klasa ekonomske veličine i ekstenzivnija gazdinstva imaju manji potencijal za dostizanje ekonomske održivosti.

Ključne reči: *ekonomska održivost, oportunintetni troškovi, faktori proizvodnje.*

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STATISTICAL INDICATORS FOR ACCIDENTS AT WORK IN AGRICULTURE ACTIVITY

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The agricultural activity employs an estimated 1.3 billion workers worldwide, that is half of the world's labour force. People working in agriculture (crop and animal production, hunting and related service activities) accounted for about 4.2 % of total employment in the EU in 2020, corresponding to an estimated 8.7 million persons. The structure of employes in agriculture activity are: (i) employed in agriculture activity, (ii) regular agricultural labour force, (iii) volume of agricultural work carried out and (iv) the farm managers. In terms of fatalities, injuries and work-related ill-health, it is one of the four most hazardous sectors of activity (along with construction, transportation and storage and manufacturing). According to ILO estimates, at least 170000 agricultural workers are dead each year. Agriculture is one of the most risk activities in terms of accidents at work. The workers in agriculture are exposed to a number of accidents at work, especially serious and fatal injuries, which is a sufficient cause for concern for the tripartite stakeholders of the International Labor Organization (ILO). Despite the existence of law of safety at work, accidents at work in this activity are increasing every year. In this paper the statistical indicators concerning non-fatal and fatal accidents at work in agriculture sector and an incidence rates in the European Union (EU-28) and in the Republic of North Macedonia in period from 2016 to 2020 were presented. For the values of the number of accidents at work (non-fatal or fatal) in the EU-28, the database were on Eurostat used, while for the Republic of North Macedonia the data from relevant institutions were used. For calculation of the values of the incidence rate the methodology of the European Statistics on Accidents at Work (ESAW) was used. The performed statistical analysis shows that the number of non-fatal and fatal accidents at work in agriculture sector in EU-28, in 2020 was decreased in comparison with 2016. In the Republic of North Macedonia in 2021 there was an increase in the number of non-fatal and was decrease in the number of fatal accidents at work in agriculture sector in comparison to the number of accidents at work in 2017. Nevertheless, in the Republic North of Macedonia the value of incidence rate for fatal accidents at work in agriculture sector in 2021 is much higher compared to the average value in EU-28.

Key words: *agricultural sector, non-fatal and fatal accidents at work, incidence rate.*

STATISTIČKI POKAZATELJI ZA NEZGODE NA RADU U POLJOPRIVREDNOM SEKTORU

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Poljoprivredni delatnost zapošljava oko 1.3 milijarde radnika širom sveta, sto je polovina svetske radne snage. Ljudi koji rade u poljoprivredi (proizvodnja useva i odgoj životinja, lov i srodne uslužne delatnosti) čine oko 4.2% od ukupnog broja zaposlenih lica u EU-27, sto odgovara približno 8.7 miliona radnika. Struktura zaposlenih u poljoprivredi čine (i) zaposleni radnici u poljoprivrednoj delatnost, (ii) redovna poljoprivredna radna snaga, (iii) rukovodioci farmi. U pogledu nesreća radu sa fatalnim ishodom (smrtnih slučajeva) kao i profesionalnih oboljenja to je jedan o četiri najopasnijih sektora delatnosti (uz građevinarstvo, transport i skladištenje i proizvodnu delatnost). Prema procena Međunarodne Organizacije Rada (MOR), oko 170.000 radnika koji rade u poljoprivrednom sektoru umire svake godine. Oko milion poljoprivrednih radnika su ozbiljno povređeni u nesrećama na radnom mestu koje uključuje i upotrebu mehanizaciju ili su otrovani zbog upotrebe pesticida ili drugih agrohemijskih sredstva. Radnici u poljoprivredi su izloženi brojnim nesrećama na radnom mestu, a posebno teškim povredama kao i povreda sa smrtnim ishodom. Uprkos postojanju Zakona o zaštiti na radu, nesreće na radu u ovoj delatnosti se povećavaju svake godine.
U ovom radu prikazani su statistički pokazatelji koji se odnose na nesreće na radu bez smrtnih ishoda i nesreće sa smrtnim ishodom u sektoru poljoprivrede, kao i stopa incidencije u zemljama članicama Evropske Unije (EU-27), i u RS Makedonija u periodu 2016 do 2020. Za vrednosti broja nezgoda na radu (nefatalnih i fatalnih) u EU-27 korišćena je baza podataka Eurostat-a, dok za RS Makedonija korišćeni su podaci relevantnih institucija koje sabiraju podatke za nesreće na radu. Za izračunavanje vrednosti stope incidencije korišćena je metodologija Evropske statistike o nezgodama na radu (ESAW).
Izvršena statistička analiza pokazuje da je broj nesreća sa fatalnim-smrtnim ishodom na radu u sektoru poljoprivrede u EU-27 u 2020 godine smanjen u odnosu na 2016. U RS Makedoniji u 2021 godine došlo je do povećanja broja nefatalnih nesreča na radu, kao i smanjenje nesreća sa fatalnim ishodom u sektoru poljoprivrede u odnosu na broju nesreća u 2017. No, u RS Makedoniji vrednost stope incidencije za nesreće na radu sa fatalnim ishodom u sektoru poljoprivrede u 2021 godine je veći od prosečne vrednosti u EU-27.
***Ključne reči**: poljoprivredni sektor, nefatalne i fatalne nesreće na radu, stopa incidencije.*

RHEOLOGICAL PROPERTIES AND NUTRITIONAL VALUE OF SORGHUM FLOUR AND SORGHUM-BASED GLUTEN–FREE BAKERY PRODUCTS

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In the last few years sorghum production and utilization experienced a huge increase in the food industry. It is thanks to its outstanding nutritional and functional properties as a gluten free material. Depending on genotype, it is a good source of polyphenols and vitamins (tocopherols, vitamin B complexes) and contains a high amount of slowly digestible and resistant starch fractions. Sorghum starch also has a relatively high gelatinization temperature at 70–76°C, which results in longer cooking time and higher energy demand, thus lowering its cooking quality. According to previous studies physical treatments can improve the pasting and functional properties of cereal flours. In this study the effect of physical (heat, radiation) treatments on the functional and rheological properties (water and oil absorption capacities [WAC/OAC], swelling index), and nutritional characteristics (starch content and composition, polyphenol and protein content) of commercial sorghum flour were evaluated. Gluten–free breads were also developed using sorghum as base material with the addition of other gluten free ingredients (fiber, starch) and utilization of heat treatment. Baking loss, volume, specific volume and formal ratio of the final products were evaluated alongside their texture profile (hardness, springiness) using a texture profile analyser. An organoleptic evaluation was also conducted with untrained testers. Heat treatment proved to be beneficial to improve the functional properties of sorghum flour with a 20% increase in WAC, and sorghum flour had a higher level of WAC compared to wheat, millet or rye. Heat treatment also improved dough development, and the texture profile of breads on day of baking, but resulted in a rapid quality decrease during storage. Gamma radiation caused a significant decrease in swelling index from 6.187 g g^{-1} to 4.93 g g^{-1}, induced by protein degradation. Fiber addition improved the final quality and texture profile of breads. Sorghum bread with 10 % fiber scored the highest among testers during sensory evaluation and higher level fiber content together with heat treatment caused a significant decrease in hardness values as well. Starch analysis showed, that sorghum flour has similar total starch content to wheat, with 73.45±0.64 % and 67.73±1.09 % respectively, while sorghum flour has a higher level of amylopectin and resistant starch content at 88.02±0.60%, and 0.29±0.02 % compared to wheat amylopectin and resistant starch content at 71.05±0.78 %, and 0.14±0.02%. In conclusion physical treatment had a favourable effect on some of the functional properties of sorghum flour and breads, especially WAC and dough development, and the evaluated commercial sorghum flour has a slightly higher resistant starch fraction, which can be utilized further in food development.

Key words: *sorghum, rheology, product development*

BIOGAS PLANT AS A GREEN ENERGY PRODUCER

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The biogas plant uses biogas as its main energy source, which is basically a mixture of combustible and non-combustible gases. Biogas is made by anaerobic fermentation of organic matter. Anaerobic fermentation is the process of decomposition (decay) of organic matter without the presence of air, without the presence of oxygen. In addition to being anaerobic, it is also mesophilic and it is made on about 43°C. The raw material base is a cattle farm, which is an integral part of the system, as well as an agricultural good, within which the plant was built. Biogas is the fuel for the SUS engine that is shaft-connected to the generator(CHP). As an output product, a plant generates two forms of energy - electrical, 999kWh and heat, 1200kW, as well as high-quality organic fertilizer, post-fermentation residue, which, if separated, is divided into liquid and solid phase. The plant delivers electricity to the power system. Heat, which occurs in two forms, hot water in the heat circuit 90/60 and hot air at about 500°C, in equal parts, and about 20% more installed capacity compared to electrical. The process, of course, is heated by own producted heat energy. The rest is available, for the exteric consumer. The plant is in operation 365 days a year, which means that the process of production and delivery of electricity energy is continuous. The plant is not in operation, only when the grid is in a voltage-free state (island operation is not allowed) and when some of the elements of CHP are planned or emergency out of operation. Biogas plants contribute to environmental protection and socio-economic benefits. They represent an indispensable part of a rounded agricultural and energy cycle. They can easily turn useless, unusable into useful. As input, they use substrates and materials, which essentially represent a potential problem and risk for the environment, and as output substrates, they have electrical and other forms of energy. They support the energy stability of the part of the system to which they are connected and strengthen it at the same time. They also represent a source of high-quality organic material that, through long-term application, significantly improves the quality of the soil to which it is applied. In addition to other renewable sources, it is the only renewable source, along with hydro, that has continuity in production.
Key words: *biogas, renewable energy, green energy*

BIOGASNO POSTROJENJE KAO PROIZVODJAČ ZELENE ENERGIJE

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Biogasno postrojenje kao svoj osnovni energent koristi biogas, koji je u osnovi mešavina gorivih i negorivih gasova. On nastaje anaerobnom fermentacijom organskih materija. Anaerobna fermentacija predstavlja proces razlaganja (truljenja) organske materije bez prisustva vazduha, odnosno bez prisustva kiseonika. Osim što je process anaeroban, on je i mezofilan i odigrava se na oko 43°C. Sirovinsku bazu predstavlja farma goveda, koja je sastavni deo sistema, kao i poljoprivredno dobro, u okviru koga je postrojenje i izgradjeno. Biogas je pogonsko gorivo za SUS motor koji je vratilom povezan sa generatorom(CHP). Kao izlazni proizvod, konkretno postrojenje generiše dva oblika energije – električnu, 999kWh i toplotne, 1200kW, kao i visokokvalitetno organsko djubrivo, odnosno postfermentorski ostatak, koji se, ukoliko se separiše, deli na tečnu i čvrstu fazu. Električnu energiju, postrojenje predaje u elektroenergetski sistem. Toplotnu, koja je javlja u dva oblika, topla voda u toplotnom krugu 90/60 i vreo vazduh na oko 500°C, u jednakim delovima, a za oko 20% većem instalisanom kapaciteta u odnosu na električni. Proces se, razume se, greje delom toplotne energije. Ostatak je raspoloživ, za eksternog potrošača. Postrojenje je u pogonu 365 dana u godini, što znači da je process proizvodnje i predaje el. energije kontinualan. Postrojenje nije u pogonu, jedino kada je u mreži beznaponsko stanje(nije dozvoljen ostrvski rad) i kada je neki od elemenata CHP planski ili havarijski van pogona. Biogas postrojenja doprinose zaštiti životne sredine i ostvarenju socio-ekonomskih koristi. Predstavljaju neizostavnu celinu zaokruženog poljoprivrednog, ali i energetskog ciklusa. Mogu da nekorisno, neiskoristivo, lako pretvorore u korisno. Kao ulaz, koriste supstrate i materijale, koji suštinski predstavljaju potencijalni problem i rizik za okolinu, a kao izlazne supstrate, imaju sem električne i druge vidove energije. Potpomažu energetskoj stabilnosti dela sistema na koji su priključene i jačaju ga istovremeno. Predstavlaju i izvor kvalitetnog organskog materijala koji kroz dugogodišnju aplikaciju značajno podstiče poboljšanje kvaliteta zemljišta ne koje se aplicira. Pored ostalih obnovljivih izvora, predstavlja jedini obnovljivi izvor, uz hidro, koji ima kontinuitet u proizvodnji.

Ključne reči: *biogas, obnovljivi izvori, zelena energija*

EFFECT OF NITROGEN FERTILIZATION ON THE QUALITY OF SOYBEAN FLOUR AND PROTEIN ISOLATE

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In general, growth of plants is often limited by the availability of nitrogen. However, for legumes, this limitation is overcome by their symbiotic association with nitrogen-fixing bacteria. Through nodulation, legumes can cover a significant portion of their nitrogen requirement from fixed atmospheric nitrogen, which decreases the need for additional fertilizer in nitrogen-poor soils. Therefore, the use of high dose nitrogen fertilizers can have a negative impact on the nodules' formation and nitrogen fixation activity. For this reason, the investigating the impact of nitrogen fertilization on soybean grain, flour, protein content, and composition is of considerable interest.

Field experiments were designed to determine the effect of three different levels of nitrogen fertilization (0, 70, and 140 kg N/ha) on the physicochemical and functional properties of soybean flour and the protein extraction. The results indicated that the nitrogen fertilization did not affect its ash content. The color measurement revealed that the supplementation with 70 kg and 140 kg of N significantly decreased the L* (lightness) value of soybean grain flour, while it increased the a* (redness) value. However, the 140 kg of nitrogen dose significantly increased the b* (yellowness) value compared with the control sample.

In addition to the evaluation of the effect of nitrogen fertilization on the soybean flour quality, it is interesting to study their effect on the process of protein extraction. In order to extract the protein, the alkaline extraction/acid precipitation method is considered as one of the most efficient, and economical techniques. During this process, the pH of the solvent (water) is adjusted to an alkaline pH, which breaks down the plant matrix to allow the release and dissolution of proteins. The remaining insoluble plant materials are subsequently removed via centrifugation, and the solubilized proteins are precipitated by adjusting an acidic pH, followed by another round of centrifugation. Typically, NaOH solution is utilized in the alkaline extraction step and HCl for acidic precipitation.

During this study, the pH of extraction, pH of precipitation and temperature of extraction were considered as the main factors that can affect the extraction yield and the protein purity. A linear regression model was created using the results obtained from the extraction of soybean protein. The optimization of the results gave a combination of alkaline solution (pH 12.07) and (pH 4.16). To evaluate the effect of the N fertilization on the protein extraction and the protein quality (purity and yield), the extraction was repeated in triplicate for each soybean flour (control, 70, and 140 kg N/ha).

Key words: *Soybean, Protein isolate, Nitrogen fertilization*

CONTROL IN PROCESS INDUSTRY FACILITIES: PROPOSED DISPLAY OF THE STRUCTURE OF INPUT VALUES

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Control in process industry facilities today is based on programmable logic controllers (PLC) for process control and SCADA (Supervisory Control And Data Acquisition) systems for monitoring and controlling the process. Process control is the generation of control signals, which control actuators based on sensor input signals. Signals used for process control and supervision will also be displayed on SCADA devices. Since the way the signals are used is known, the idea is to propose a single input signal structure covering all control and supervision requirements. Input signals can be divided into digital, which has only two possible state values, and analog, which has more discrete states. The idea is to propose a structure of the input signals since the value carried by the signal often needs to be processed to obtain information suitable for control or display. The idea itself is nothing new, and data structures are used in DCS systems (Distributed Control Systems) as already predefined by the manufacturer. In other systems, the control and supervision software designers are let to design the data structures themselves. Therefore, the idea arose to present such a structure as a starting point.

The proposal for the structure of the digital input signal would consist of the fact that the input signal needs to be processed to enable the signal to propagate in time. Taking a certain amount of time for the signal, stable at one of the values, to declare that value has been achieved. The structure must also allow inverting the input signal since the need to invert the input signal arose due to the type of sensor itself.

Analog signals have a discrete set of values for which they would predict corresponding threshold values. They could be defined as very low, low, working, high and very high, indicating that the appropriate value level has been reached. In addition, getting a value or falling below a particular value could be conditioned by time. After the expiration of a specific time, it is declared it has been reached. Discrete values can oscillate due to measurement conditions, technical measurement limitations, and the process. Therefore, it is necessary to add some way of signal filtering to the structure, e.g., mean value or similar. The processed signal should be adapted for display in the process monitoring and control system. Therefore, it should be possible to perform linear scaling of the processed signal with the input of the scaling range.

The proposals are only the first step towards coming up with a solution for processing and displaying input signals in process industry plants to find a relationship between the size of the structure and the ease of its application versus the intended functionality.

Keywords*: digital inputs, analog inputs, SCADA*

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UPRAVLJANJE U POGONIMA PROCESNE INDUSTRIJE: PREDLOG PRIKAZA STRUKTURE ULAZNIH VELIČINA

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Upravljanje u pogonima procesne industrije se danas zasniva na upotrebi programabilnih logičkih kontrolera (PLC) koji upravljaju procesom i SCADA (engl. Supervisory Control And Data Acquisition) sistema za nadzor i kontrolu procesa.
Po definiciji, upravljanje procesom je generisanje upravljačkih signala koji upravljaju izvršnim organima na osnovu ulaznih signala sa senzora. Signali koji se koriste za upravljanje procesom se takođe prikazuju na SCADA uređajima. Pošto je način na koji se signali koriste poznat, potrebno je formirati strukturu ulaznih signala tako da ona obuhvati sve zahteve upravljanja. Ulazni signali se mogu podeliti na digitalne koji mogu imati samo dve moguće vrednosti i analogne sa većim brojem mogućih diskretnih stanja. Signal u izvornom obliku je često potrebno obraditi kako bi se formirala informacija u pogodna za generisanje upravljanje ili za prikaz. Da bi se ovo olakšalo, ideja je da se predloži odgovarajuća struktura ulaznih signala pogodna za obradu. Sama ideja nije nova i takve strukture podatka se koriste u DCS sistemima (eng. Distributed Control Systems) predefinisane od strane proizvođača dok je kod ostalih tipova nadzorno upravljačkih sistema ostavljena sloboda projektantu softvera da je sam osmisli. Na taj način je nastala ideja da se formira i predstavi jedna struktura kao početna tačka za razmatranje mogućeg skupa prihvatljivih rešenja.
Predlog za strukturu digitalnog ulaznog signala se sastoji od toga da je ulazni signal potrebno obraditi na takav način da se, pored registracije sam vrednosti signala, omogući i njegova vremenska propagacija. To znači da je potrebno da signal određeno vreme bude stabilan na jednoj od dve vrednosti da bi se ona proglasila ostvarenom. Struktura takođe mora da omogući invertovanje ulaznog signala što je uslovljeno upotrebom različitih vrsta senzora.
Analogni signali poprimaju vrednosti iz diskretnog skupa koji sadrži veći broj mogućih stanja. Za njih treba predvideti odgovarajuće granične vrednosti, kao što su na primer: jako niska, niska, radna, visoka i jako visoka koje bi davale informaciju da je dostignut odgovarajući nivo vrednosti. Pored toga dostizanje određene vrednosti ili opadanje ispod neke granice bi se moglo i vremenski usloviti, tako da se tek posle isteka određenog vremena određeno stanje proglašava dostignutim. Vrednosti ulaznih signala osciluju usled uslova merenja, tehničkih ograničenja merenja i procesa, tako da je potrebno u strukturu dodati i filtriranje, kao što je izračunavanje srednje vrednosti i sl. Obrađeni signal treba da bude prilagođen za ispis u sistemu za nadzor i upravljanje te stoga treba omogućiti skaliranje procesnog signala.
Prethodno navedeni predlozi su samo prvi korak u rešavanju problema obrade i prikaza ulaznih signala u pogonima procesne industrije sa stanovišta optimizacije veličine strukture i lakoće njene primene uz zadovoljenje predviđene funkcionalnosti.
***Ključne reči**: digitalni ulazi, analogni ulazi, SCADA*

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INFLUENCE OF THE PARTICLE SIZE OF THE WHOLEGRAIN MAIZE FLOUR AFTER SIEVING ON NUTRIENT COMPOSITION IN DIFFERENT FRACTIONS

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Maize (*Zea mays* L.) is one of the most important cereal crops in the world, along with wheat and rice. Considering that maize is naturally gluten-free, and safe for persons suffering from celiac disease, or gluten intolerance, wholegrain maize flour is currently trending in the functional food market. Numerous studies related to the distribution of nutritional components among flour fractions with different particle sizes have so far been conducted on barley, sorghum, rice, peas, and soybeans, while the results related to maize are few.

Maize grain of different genetic backgrounds and kernel colors: white dent, yellow popcorn, red dent, and blue popcorn, was used in this study. After grinding maize grain on a stone mill, the wholegrain flour was sifted through three different mesh sieves: 1700, 710, and 212 μm. The content of the major chemical constituents of maize grain was analyzed in each fraction of the sifted wholegrain flour to determine the influence of the particle size after sieving on the distribution of the major nutrients in different fractions. The distribution of the particle sizes among the investigated wholegrain flour samples showed that the medium particle size (710-212 μm) was predominant in all cases, ranging from 60.97% in red flour to 70.64% in white flour, followed by the smallest (≤212 μm) and the largest fraction (1700-710 μm), on average 22.82% and 11.38%, respectively. An increase in the protein content was observed with a decrease in the particle size of the fraction, predominantly in yellow and blue flour, while in white and red flour, the differences among fractions were less significant. The highest increase with the decrease in the particle size of the fraction was manifested by the oil content, followed by the ash content. The crude fiber content in most cases showed a decrease, which is best seen in the example of yellow flour, from 3.59% in the largest particle size fraction to 1.96% in the smallest particle size fraction. The highest starch content was determined in medium particle size fractions of the white (71.86%), red (68.33%), and blue (68.39%), while the highest starch content of the yellow popcorn genotype flour (65.38%) was determined in the largest particle size fraction. The highest ash and oil content was determined in the smallest particle size fraction.

Considering that the digestibility of diet ingredients varies along with the particle size distribution, the next step of the research would be to determine the exact values of the *in vitro* digestibility of different flour fractions. The fact that the mean particle size of ground maize grains significantly influences nutrient composition, may provide new possibilities of incorporating different wholegrain maize flour fractions in food or feed to meet the specific criteria and dietary needs of different categories of consumers.

Key words: *wholegrain maize flour, particle size, nutritive properties*

UTICAJ VELIČINE ČESTICA INTEGRALNOG KUKURUZNOG BRAŠNA NAKON PROSEJAVNJA NA NUTRITIVNI SASTAV U RAZLIČITIM FRAKCIJAMA

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Kukuruz (Zea mais L.) je jedna od najvažnijih žitarica u svetu, pored pšenice i pirinča. S obzirom da je kukuruz prirodno bez glutena i bezbedan za osobe koje boluju od celijakije, ili intolerancije na gluten, potražnja za integralnim kukuruznim brašno je trenutno u porastu na tržištu funkcionalne hrane. Brojna istraživanja koja se odnose na distribuciju nutritivnih komponenata među frakcijama brašna različite veličine čestica do sada su sprovedena na ječmu, sirku, pirinču, grašku i soji, dok su rezultati vezani za kukuruz malobrojni.

U ovom istraživanju korišćeno je zrno kukuruza različite genetske osnove i boje zrna: beli zuban, žuti kokičar, crveni zuban i plavi kokičar. Nakon mlevenja kukuruznog zrna na mlinu sa kamenom, inegralno brašno je prosejano kroz tri različita sita sa otvorima: 1700, 710 i 212 μm. Sadržaj najznačajnijih hemijskih komponenata kukuruznog zrna analiziran je u svakoj frakciji prosejanog integralnog brašna kako bi se odredio uticaj veličine čestica nakon prosejavanja na raspodelu glavnih hranljivih materija u različitim frakcijama. Distribucija veličina čestica među ispitivanim uzorcima integralnog brašna pokazala je da je u svim slučajevima najzastupljenija bila srednja veličina čestica (710-212 μm), koja se kretala od 60,97% u crvenom do 70,64% u belom brašnu, a zatim najsitnija (≤ 212 μm) i najkrupnija frakcija (1700-710 μm), u proseku 22,82% i 11,38%, redom. Uočeno je povećanje sadržaja proteina sa smanjenjem veličine čestica frakcije, pretežno kod žutog i plavog brašna, dok su kod belog i crvenog brašna razlike među frakcijama bile manje značajne. Najveći porast sa smanjenjem veličine čestica frakcije manifestovao se u sadržaju ulja, zatim u sadržaju pepela. Sadržaj sirove celuloze u većini slučajeva je pokazao pad, što se najbolje vidi na primeru žutog brašna, sa 3,59% u najkrupnijoj frakciji na 1,96% u frakciji sa najsitnijim česticama. Najveći sadržaj skroba utvrđen je u frakcijama srednje veličine čestica belog (71,86%), crvenog (68,33%) i plavog (68,39%), dok je najveći sadržaj skroba u brašnu od žutog kokičara (65,38%) utvrđen u frakciji sa najkrupnijim česticama. Najveći sadržaj pepela i ulja određen je u frakciji najmanje veličine čestica.

S obzirom na to da svarljivost hranljivih sastojaka varira zajedno sa distribucijom veličine čestica, sledeći korak istraživanja bi bio utvrđivanje tačnih vrednosti in vitro svarljivosti različitih frakcija brašna. Činjenica da prosečna veličina čestica mlevenog zrna kukuruza značajno utiče na sadržaj pojedinih hranljivih materija, može da pruži nove mogućnosti za upotrebu različitih frakcija integralnog kukuruznog brašna u formulaciji hrane za ljude i životinje kako bi se zadovoljili specifični kriterijumi i prehrambene potrebe različitih kategorija konzumenata.

Ključne reči: integralno kukuruzno brašno, veličina čestica, hranljiva vrednost

INFLUENCE OF WHEAT AND CORN YIELD AND PRICE PARITY FROM THE CURRENT YEAR ON SOWING STRUCTURE IN THE FOLLOWING YEAR

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Wheat and corn have a significant share in the agricultural production structure in the Republic of Serbia, thus, the subject of this research is the production characteristics and price parity of wheat and corn. The aim of this research is to determine whether there is a correlation between the yield and price parity of wheat and corn from the current year and the sowing structure in the following year. Statistical processing of the analyzed production parameters and price parity was performed using descriptive statistical analysis for the period 2011-2021. Furthermore, a multiple linear regression model was applied in order to determine the influence of yield and price parity from the current year on the sowing structure of the following year. Moreover, analysis of variance was applied to test the significance of the evaluated regression models. According to the obtained results, it was concluded that the average harvested areas under wheat and corn, for the observed period, were about 600 thousand and 996 thousand hectares respectively therefore harvested areas of both observed cultures were relatively stable. The yield of wheat in the observed period was an average of 4.45 t/ha and grew at a rate of 3.10% per year; the total production of wheat was an average of 2.68 million tons and grew at a rate of 2.81% per year. Corn yield averaged 6.28 t/ha and decreased at an annual rate of 0.49%, while total production averaged 6.26 million tons and decreased at an annual rate of 0.72%. The price parity of wheat and corn averaged 0.92 and grew at a rate of 1.30% per year. The results of the first regression model imply that both yield and price parity from the current year has a significant impact on the wheat sowing structure in the following year. It can be expected that an increase in yield by 1 t/ha, will increase the harvested areas by approximately 31 thousand hectares, while an increase in the wheat/corn parity by 1, will increase the harvested areas in the next sowing structure by approximately 57 thousand hectares. The results of the second regression model showed as well that both yield and price parity from the current year has a statistically significant influence on the corn sowing structure in the following year. In other words, an increase in yield by 1 t/ha in the current year impacts an increase in the harvested areas in the following year by approximately 13 thousand hectares, and that an increase in parity by 1 in the current year, effect an increase in the harvested areas in the following year by approximately 49 thousand hectares.
Key words*: wheat, corn, Republic of Serbia*

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UTICAJ PRINOSA I PARITETA CENA PŠENICE I KUKURUZA IZ TEKUĆE GODINE NA SETVENU STRUKTURU NAREDNE GODINE

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Pšenica i kukuruz imaju značajan udeo u strukturi poljoprivredne proizvodnje u Republici Srbiji. S tim u vezi, predmet ovog istraživanja su proizvodne karakteristike i paritet cena pšenice i kukuruza. Cilj ovog istraživanja je da se utvrdi da li postoji veza između prinosa i pariteta cena pšenice i kukuruza iz tekuće godine i setvene strukturu naredne godine ova dva useva. Analiza je izvedena za period od 2011-2021. godine. Statistička obrada analiziranih proizvodnih parametara i pariteta cena izvedena je primenom deskriptivne statističke analize, a za utvrđivanje uticaja prinosa i pariteta cena iz tekuće godine na setvenu strukturu naredne godine primenjen je model višestruke linerne regresije. Za testiranje značajnosti ocenjenih modela primenjena je analiza varijanse regresije. Rezultatima istraživanja utvrđeno je da su prosečne površine pod pšenicom, u posmatranom periodu, iznosile oko 600 hiljada hektara, dok su prosečne površine pod kukuruzom iznosile oko 996 hiljada hektara, površine obe posmatrane kulture bile relativno stabilne u posmatranom periodu. Prinos pšenice u posmatranom periodu iznosio je prosečno 4,45 t/ha i rastao je po stopi od 3,10% godišnje, a ukupna proizvodnja pšenice iznosila je prosečno 2,68 miliona t i rasla je po stopi od 2,81% godišnje. Prinos kukuruza iznosio je prosečno 6,28 t/ha, opadao je po stopi od 0,49% godišnje, a ukupna proizvodnja iznosila je prosečno 6,26 miliona t i opadala je po godišnjoj stopi od 0,72%. Paritet cena pšenice i kukuruza iznosio je prosečno 0,92 i rastao je po stopi od 1,30% godišnje. Rezultatima prvog regresionog modela utvrđeno je da i prinos i paritet cena iz tekuće godine ima značajan uticaj na setvenu strukturu pšenice naredne godine, kao i da se može očekivati da se sa povećanjem prinosa za 1 t/ha površine povećaju za oko 31 hiljadu hektara, dok se sa povećanjem pariteta pšenica/kukuruz za 1 može očekivati povećanje površina u narednoj setvi za oko 57 hiljada hektara. Rezultatima drugog regresionog modela utvrđeno je da i prinos i paritet cena iz tekuće godine imaju statistički značajan uticaj na setvenu strukturu kukuruza naredne godine, tj. da se sa povećanjem prinosa za 1 t/ha u tekućoj godini može očekivati povećanje površina u narednoj godini za oko 13 hiljada hektara, a da se sa povećanjem pariteta za 1 u tekućoj godini može očekivati povećanje površina u narednoj godini za oko 49 hiljada hektara.

***Ključne reči**: pšenica, kukuruz, Republika Srbija*

Zahvalnica

SHAPING THE PROPERTIES OF OSMO-DEHYDRATED ORANGES IN DIFFERENT SOMOTIC SOLUTIONS

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Orange fruit is characterized by a pleasant smell and a sweet and sour taste. Orange is mainly used for the production of juices and drinks, as well as for the production of sweets. These fruits are an excellent source of many nutrients such as vitamins, carbohydrates, macronutrients, and carotenoids. Orange is the most popular source of vitamin C in the human diet.

Osmotic dehydration is a preservation technique that reduces the water content of fruits and vegetables by immersing them in highly concentrated solutions of sugar (e.g., sucrose, fructose, or glucose) or salt (e.g., sodium chloride). Sucrose is a widely-used and effective substance for the osmotic dehydration of fruits, however, using high concentrations of sugar can have adverse effects on the nutritional value and flavor of the final product. Also, concerns about excessive consumption have spurred the search for alternative osmotic agents. To overcome this, alternative hypertonic solutions such as polyols (maltitol, xylitol, erythritol, etc.), juice concentrates, fructooligosaccharides, and solutions with added beneficial compounds have been explored. Additionally, other unconventional natural sweeteners like honey, jaggery, coconut sugar, stevia, and beet molasses have been used as osmotic agents in various studies. These unconventional osmotic solutions can also serve as a source of flavor and nutrients.

The aim of this study was to evaluate the effect of the different osmotic dehydration solutions on the bioactive compounds and sugars content of the oranges slices. The following solutions were used: xylitol solution, and rosehip juice with the addition of trehalose, molasses, and sucrose as a standard solution. The osmotic dehydration lasted for 3 h and the bioactive compounds such as total polyphenols content, vitamin C content, total carotenoids content and antioxidant activity (evaluated with ABTS radical and Reducing Power) were studied. Additionally, the sugars content (sucrose, glucose, and fructose) were evaluated.

The results showed that the fruits dehydrated in juice concentrates obtained higher amounts of bioactive compounds. The highest value of total polyphenols content and antioxidant activity were obtained for fruits dehydrated in strawberry juice concentrate. Additionally, the value of the total carotenoid content, as well as vitamin C content, was noticed for oranges dehydrated in rosehip juice with the addition of trehalose. However, the samples subjected to osmotic dehydration in xylitol solution has the lowest sugars content, while fruits dehydrated in the other solutions obtained the same amount of the total sugars as for the sucrose.

Key words: *osmotic dehydration, bioactive compounds, sugars content*

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PRODUCTION OF HIGH-FUNCTIONAL ORGANIC APPLES SNACKS THROUGH COMBINATION OF MILD TECHNOLOGIES

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Vacuum impregnation (VI) represents a promising mild non-thermal technology for development of functional foods. In this study, vacuum impregnation combined with drying was used to incorporate prebiotic fructooligosaccharides (FOS) from Yacon juice into organic apple tissues in order to produce snacks with improved prebiotic functionalities.
Apple slices were subjected to VI with Yacon juice (10 minutes; 200 mbar). After impregnation, apple slices were dried at 70 oC for 8 hours in convection oven. On these dehydrated vacuum impregnated apples (dVIA) microbiological shelf-life, technological parameters (*aw*, texture), chemical properties (fructooligosaccharides, polyphenolic compounds and antioxidant activities) and volatile organic compound profiles were investigated during 50 days of storage at room temperature. Moreover, the ability of dVIA to promote the vitality or the growth of selected commercial and type probiotic strains from *Lactobacillus* (*L. rhamnosus* GG and C112) and *Bifidobacterium* (*B. breve* 20091, *B. longum* 20088) genus were evaluated in simulated intestinal fluid (SIF: 0.1% w/v pancreatin, 0.15% w/v Oxgall bile salt, 100 mM phosphate saline buffer pH 8) for 24h.
Vacuum impregnation and thermal dehydration processes resulted in dehydrated vacuum impregnated apple slices (dVIA) with low water activity (aw = 0.3) and increased amount of FOS: 6 times higher, compared to dehydrated apple slices (dA). In addition, dVIA demonstrated a good microbiological and technological stability during the entire storage at room temperature. Principal component analysis of volatile organic molecules profiles revealed only slight differences between dVIA and dA. The storage of 50 days resulted in a flattening of the volatile molecule profiles of apple samples independently from the vacuum impregnation with Yacon juice. The higher amounts of inulin increased the prebiotic properties of the apple slices and promoted the growth and viability of probiotic cells in the simulated intestinal fluid, even after 50 days of storage.
The proposed vacuum impregnation and thermal dehydration process, allowed to obtain organic apples slices with good technological and microbiological stability during a storage of 50 days at room temperature. Moreover, the higher amounts of inulin increased the prebiotic features of apple slices. Thus, the combination of vacuum impregnation and drying is a suitable way for the production of snacks with improved nutritional and functional properties.
Key words*: mild non-thermal technology, functional foods, organic apples* snacks

MOLECULAR AND MORPHOLOGICAL DETECTION OF GLOBODERA ROSTOCHIENSIS (NEMATODA: HETERODERIDAE) IN A SEED POTATO CROP

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Potato (Solanum tuberosum L.) is one of four major food crops in the world beside wheat, maize and rice. The plant originated in the highlands of Peru particularly the region around Lake Titicaca and it was first domesticated at least 7 000 years ago. The food security provided by potato and maize allowed the development and survival of civilizations such as, Huari and Inca for centuries. In the 16th century the Spanish conquistadores searching for the "treasure of the Andes" brought to Europe, beside gold, potato along with its parasites – the potato cyst nematodes (PCN): Globodera rostochiensis (Wollenweber) Behrens and G. pallida (Stone) Behrens, two nematode species that have quarantine status. The morphology of potato cyst nematodes was until recently almost the only way to identify these quarantine organisms. In the last two decades, molecular analyses as new trends in modern agriculture, contributed to faster and more efficient identification of these species and allowed insight into the genetic structure of those parts that were practically inaccessible by morphological studies. The nematodes are present in all European potato growing regions, especially in the Balkan (Helm) peninsula, either PCN or both are reported.

The collected specimens of cysts were found in soil originating from a seed potato crop in a village near Gornji Milanovac after the official phytosanitary control in 2022. Individual cysts were used for DNA extraction with a Dneasy blood & tissue kit. The PCR was done with primers for direct sequencing: TW81 and AB28. The ITS1-5.8S-ITS2 region of PCN is used for confirmation of species identity together with its morphological characterization. According to EPPO Standards, the morphological identification comprised larval and cyst characteristics, namely larval stylet length and stylet knob shape, cyst vulval basin diameter, distance between vulva and anus, Granek´s ratio, and number of cuticular ridges in perineal area.

Results confirmed the species identity. The morphology of our population of G. rostochiensis was similar to the previously reported domestic and foreign populations. The degree of similarity was expressed as a percentage of direct matching i.e. pairwise distances. Phylogenetic analyses indicated a possible ancestor of our PCN population showing evolutionary relationships among world populations of G. rostochiensis and a phylogenetic placement of the Serbian population.

Key words: *PCN, phylogeny, morphology*

MOLEKULARNA I MORFOLOŠKA DETEKCIJA GLOBODERA-E ROSTOCHIENSIS (NEMATODA: HETERODERIDAE) U USEVU SEMENSKOG KROMPIRA

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Krompir (*Solanum tuberosum* L.) je jedan od četiri glavna prehrambena useva u svetu pored pšenice, kukuruza i pirinča. Biljka potiče iz planinskog pojasa Perua, posebno iz regiona oko jezera Titikaka i prvi put je odomaćena pre najmanje 7 000 godina. Sigurnost u hrani koja je nastala gajenjem krompira i kukuruza je omogućila vekovni razvoj i opstanak civilizacija kao što su Huari i Inke. U 16. veku su španski osvajači tražeći "blago sa Anda" pored zlata, u Evropu doneli i krompir zajedno sa parazitnim nematodama-cistolikim nematodama krompira (CNK): *Globodera rostochiensis* (Wollenweber) Behrens i *G. pallida* (Stone) Behrens, dve nematodne vrste koje imaju karantinski status.
Morfologija cistolikih nematoda krompira je do skoro bila jedini način identifikacije ovih karantinskih organizama. U poslednje dve decenije, molekularne analize kao novi trendovi u modernoj poljoprivredi, su doprineli bržoj i efikasnijoj identifikaciji ovih vrsta, omogućavajaći uvid u genetičku strukturu onih delova koji su praktično bili nedostupni morfološkim studijama. Nematode su prisutne u svim evropskim regionima gajenja krompira, posebno na Balkanskom (Humskom) poluostrvu, pojedinačno ili obe zajedno.
Prikupljeni uzorci cista su pronađeni u zemlji poreklom iz useva semenskog krompira u selu pored Gornjeg Milanovca, posle zvanične fitosanitarne kontrole. Pojedinačne ciste su korišćene za ekstrakciju DNK sa Dneasy blood & tissue kitom. PCR je urađen sa prajmerima za direktno sekvenciranje: TW81 and AB28. ITS1-5.8S-ITS2 regioni CNK su korišćeni za potvrdu identiteta vrste, zajedno sa morfološkom karakterizacijom. Prema EPPO Standardu, morfološka identifikacija obuhvata karakteristike larvi i cisti, zapravo dužinu i oblik stileta larvi, prečnik vulvalnog bazena cisti, distancu između vulve i anusa, Granekov odnos i broj kutikularnih nabora u perianalnoj oblasti.
Rezultati su potvrdili identitet vrste. Morfologija naše populacije *G. rostochiensis* je bila slična prethodno opisanim domaćim i stranim populacijama. Stepen sličnosti je predstavljen i kao procenat direktnog sparivanja, tj. parne distance. Filogenetske analize su ukazale na mogućeg pretka naše populacije CNK, predstavljajući evolutivne odnose svetskih populacija *G. rostochiensis* i filogenetsko mesto srpske populacije.
Ključne reči: *CNK, filogenija, morfologija*

EFFLUENTS FROM INDUSTRIAL PROCESSING OF THE FOOD OF ANIMAL ORIGIN AS MEDIA FOR BIOCONTROL AGENTS PRODUCTION

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Intensive food production to feed the growing human population requires significant material and energy resources, simultaneously generating large amount of waste, whose treatment adds an additional cost to the overall production process. Wastewater arising from meat and dairy processing industries contain large amounts of organic and inorganic nutrients, which present heavy environmental burden, but, on the other hand, could serve as nutrient sources for microbial growth and metabolic activity. The aim of this study was to investigate suitability of meat processing wastewater and whey from dairy industry as media for growth of biocontrol strain Bacillus velezensis IP22, exhibiting antifungal and antibacterial activity against wide range of plant pathogens. This approach resulted in obtaining valued-added biocontrol agents which could be applied in sustainable plant disease management. The investigated plant pathogens were Xanthomonas campestris, the black rot pathogen of cruciferous crops, Xanthomonas euvesicatoria, pepper bacterial spot pathogen, and Aspergillus flavus, corn fungal pathogen producing aflatoxins. The monitoring of bacterial growth in the selected food industry effluents-based media has shown suitability of meat processing wastewater and whey from dairy industry as excellent substrates for multiplication of Bacillus velezensis IP22 and increase in viable cell number. The peak of antibacterial and antifungal activity was observed after three days of cultivation. Inhibition zone diameters against bacterial and fungal pathogens were compared between the meat processing wastewater medium, whey-based medium and nutrient broth as the commercial chemically defined medium. The both waste-based media have contributed to antibacterial and antifungal activity in similar degree, with highly comparable inhibition zone diameters against Xanthomonas campestris, Xanthomonas euvesicatoria and Aspergillus flavus, where the higher level of resistance of fungal pathogen towards the tested biocontrol agents was observed. Furthermore, biocontrol activity of the cultivation broths obtained using the waste-based media was slightly lower compared to the nutrient broth medium, suggesting the possibility to replace the expensive chemically defined medium with a complex medium alternative, which had shown no inhibitory effects to growth and metabolic activity of Bacillus velezensis IP22. In this way the biocontrol agents' production cost would be significantly reduced, resulting in higher market competitiveness of the final biocontrol product. This approach based on circular economy principles promotes responsible and maximized resource utilization through reuse of food industry effluents for production of value added products, opening a chapter of possibilities to establish industrial symbiosis network between companies in different industry branches.
Key words: *meat processing wastewater, whey, Bacillus velezensis*

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EFLUENTI IZ INDUSTRIJSKE PRERADE HRANE ŽIVOTINJSKOG POREKLA KAO MEDIJUMI ZA PROIZVODNJU BIOKONTROLNIH AGENASA

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Intenzivna proizvodnja hrane za ishranu rastuće ljudske populacije zahteva značajne materijalne i energetske resurse, istovremeno generišući velike količine otpada čiji tretman predstavlja dodatni trošak celokupnom proizvodnom procesu. Otpadne vode iz industrijske prerade mesa i mleka sadrže velike količine organskih i neorganskih nutrijenata, koji predstavljaju opterećenje za životnu sredinu, ali takođe mogu poslužiti kao izvor hranljivih materija za rast mikroorganizama. Cilj ovog rada bio je ispitivanje mogućnost primene otpadnih voda iz prerade mesa i surutke iz mlečne industrije kao medijuma za rast biokontrolnog soja *Bacillus velezensis* IP22, koji pokazuje antifungalno i antibakterijsko dejstvo protiv širokog spektra biljnih patogena. Ovaj pristup je rezultirao dobijanjem biokontrolnih agenasa sa dodatom vrednošću koji bi se mogli primeniti u održivom suzbijanju biljnih bolesti. Ispitivani biljni patogeni bili su *Xanthomonas campestris*, izazivač crne truleži biljaka iz porodice kupusnjača, *Xanthomonas euvesicatoria*, izazivač bakterijske pegavosti paprika, i *Aspergillus flavus*, fungalni patogen kukuruza koji proizvodi aflatoksine. Praćenje rasta bakterija u odabranim podlogama na bazi efluenata prehrambene industrije pokazalo je pogodnost otpadnih voda iz prerade mesa i surutke iz mlečne industrije kao odličnih supstrata za umnožavanje *Bacillus velezensis* IP22 i povećanje broja živih ćelija. Maksimum antibakterijske i antifungalne aktivnosti primećen je nakon tri dana kultivacije. Prečnici zona inhibicije protiv bakterijskih i fungalnih patogena upoređeni su između medijuma na bazi otpadne vode iz prerade mesa, medijuma na bazi surutke i hranljivog bujona kao komercijalnog hemijski definisanog medijuma. Oba medijuma na bazi industrijskog otpada su u sličnom stepenu doprinela antibakterijskoj i antifungalnoj aktivnosti, sa uporedivim prečnicima zona inhibicije protiv *Xanthomonas campestris*, *Xanthomonas euvesicatoria* i *Aspergillus flavus*, pri čemu je uočen veći nivo otpornosti fungalnog patogena prema ispitivanim biokontrolnim agensima. Biokontrolna aktivnost postignuta primenom kultivacionih tečnosti dobijenih korišćenjem medijuma na bazi otpada bila je nešto niža u poređenju sa hranljivim bujonom, što sugeriše mogućnost da se skupa hemijski definisana podloga zameni kompleksnim alternativnim medijuma, koji nisu pokazali inhibitorne efekte na rast i metaboličku aktivnost *Bacillus velezensis* IP22. Na ovaj način bi se značajno smanjili troškovi proizvodnje biokontrolnih agenasa, što bi rezultovalo većom tržišnom konkurentnošću finalnog proizvoda za biokontrolu. Ovaj pristup zasnovan na principima cirkularne ekonomije promoviše odgovorno i maksimalno korišćenje resursa kroz ponovnu upotrebu otpadnih voda prehrambene industrije za dobijanje proizvoda sa dodatom vrednošću, otvarajući novo poglavlje mogućnosti uspostavljanja mreže industrijske simbioze između kompanija u različitim industrijskim granama.

***Ključne reči**: otpadna voda iz prerade mesa, surutka, Bacillus velezensis*

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A COMPARATIVE ANALYSIS OF NUTRITIONAL VALUE OF FISH AND VEGAN FISH ANALOGUES

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Due to the increasing number of people consciously excluding products of animal origin from their diet, food producers have started to market products that are to be an alternative to animal meat, including fish meat. Such activities are related to the requirements of consumers who, despite limiting the consumption of meat, do not want to give up the sensory features as well as texture, consistency and other that characterize these groups of products. However, in addition to assure the external and internal appearance of fish analogue products, the important issue should be focuses on the nutritional value to delivered to body all necessary compounds. A vegetable fish meat alternative should be a source of easily digestible protein, high-quality fats, minerals and vitamins. These ingredients are a source of nutrients that are used by our body as a building material, as well as a source of energy. Fish meat is a source of valuable ingredients in the human diet. Fish protein contains all the essential amino acids, the content of which is higher than the FAO/WHO standard. In addition to the important role of fish meat protein, the nutritional importance of fish fats should also be taken into account. Fish meat provides essential unsaturated fatty acids, which are responsible, among others, for the proper functioning of the circulatory system.
The aim of the study was to compare the nutritional value of fish and their vegan alternatives. Four types of fish were analyzed: Atlantic salmon, Rainbow trout, tuna and Atlantic cod, as well as their plant-based alternatives. The research consisted of two stages. In the first, nutrients were determined in the meat of commercially available fish of salmon, trout, tuna, and cod. The analyses of the dry matter and water content, fat content, protein content as well as ash content were analyzed. In the second stage, the composition of plant-based alternatives to salmon, trout, tuna, and cod was determined. A comparison of the content of ingredients within the groups of products of animal and plant origin was made, and the results of fish meat with plant alternatives were compared.
Based on the obtained results, it was found that fish meat plant based alternatives were characterized by lower content of nutrients compared to fish meat. However, when comparing the values obtained for fish meat, it can be observed that salmon and trout meat is characterized by a richer nutritional value compared to cod meat. The same trend was observed for the plant-based alternatives of salmon, trout, tuna, and cod. In addition, it can be noticed that fish meat analogues were characterized by a lower content of dry substance than fish meat.
***Key words**: fish, fish analogues, nutritional value*

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AMMONIUM REMOVAL FROM AQUEOUS SOLUTION IN PRESENCE OF ORGANIC COMPOUNDS, USING BIOCHAR FROM BANANA LEAVES

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With the imminent threat of water contamination and its increasingly expensive treatment, the challenge of finding solutions that focus on the use of environmentally friendly and low-cost systems, operations and, above all, materials to meet the needs of conserve vital resource. Under this concept, the use of adsorbent materials that have the capacity to remove pollutants from water, especially those that are responsible for eutrophication such as ammonium and phosphates, and that are also easily accessible, organic and low cost, have gained increasing importance in research. One of the most studied materials is biochar, due to its physical and chemical characteristics that make it one of the best solutions with regard to water treatment, additionally if the biochar is made through biomass that is considered as waste from the agricultural sector and whose final disposal tends to generate an environmental problem different from the one mentioned at the beginning. As part of the analysis, the biochar made from of banana leaves was characterized by measuring the zeta potential, specific surface area (BET measurements) and morphology (SEM), moreover FT-IR measurements were used to specify the functional groups of biochar; the effect of biochar production circumstances (pyrolysis temperature) was determined. The purpose of this study is to investigate the efficiency of biochar as an adsorbent of ammonium in aqueous solutions in the presence of organic compounds such as lactose, bovine serum albumin and acetic acid. The effect of pH on adsorption kinetics and adsorption capacity also was investigated by means of batch experiments. The kinetics of the adsorption and adsorption isotherms (Langmuir, Freundlich and BET) were modelled. The results show that the highest ammonium removal rate occurs at pH 9 with a dose of 500mg of biochar.. The results show that biochar is an excellent solution to remove ammonia from water.

***Key words**: biochar, adsorption, ammonium removal*

INFLUENCE OF DIFFERENT PACKAGING METHODS ON BIOGENIC AMINES IN *PETROVSKÁ KLOBÁSA* PRODUCED IN TRADITIONAL AND INDUSTRIAL CONDITIONS

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The aim of this paper was to determine the influence of different packaging conditions on biogenic amines (BA) content in dry fermented sausage *Petrovská klobása* produced in traditional room (B1) and industrial ripening chamber (B3). Total BA content was expressed as the sum of nine biogenic amines (tryptamine, phenylethylamine, putrescine, cadaverine, histamine, serotonin, tyramin, spermidine and spermine) determined by HPLC-DAD. After finishing the drying process, the sausages were divided into three subgroups. The first subgroup of sausages was stored unpackaged (B1n, B3n), while the other two were packed in a vacuum (B1v, B3v) and in a modified atmosphere packaging (B1m, B3m), respectively. Analyses were performed at the end of drying period (90th day B1, 45th day B3), during the storage period (120th day) and at the of storage period (270th day).
At the end of drying period, total BA content in sausages produced in traditional room was 174 mg/kg, and in sausages produced in industrial ripening chamber was 77.8 mg/kg. During the storage period total BA content slightly increased and reached 187 mg/kg (B1n) and 96 mg/kg (B3n) in unpackaged sausages, 228 mg/kg (B1v) and 133 mg/kg (B3v) in vacuum-packed sausages, and 178 mg/kg (B1m) and 122 (B3m) in modified-atmosphere sausages on 120th day. At the end of storage period total content was higher in all sausage groups (B1n 284 mg/kg; B1m 223 mg/kg; B3n 305 mg/kg; B3v 332 mg/kg; B3m 295 mg/kg), except in B1v where this value was slightly lower ($P > 0.05$). Total BA content on 120th day was significantly higher ($P < 0.05$) in sausage samples produced in traditional conditions, while at the end of storage period this value was significantly higher ($P < 0.05$) in sausages produced in industrial conditions, except for unpacked sausages, where differences was not statistically significant ($P > 0.05$). The influence of packaging methods on total BA content of biogenic amines was not significant ($P > 0.05$) for sausage samples examined in this study.
Total level of biogenic amines in all investigated samples did not exceed 332 mg/kg, being lower than the proposed limit of 1000 mg/kg for total BA content in food, which is considered dangerous.
Key words*: traditional fermented sausage, packaging conditions, biogenic amines*

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UTICAJ RAZLIČITIH NAČINA PAKOVANJA NA SADRŽAJ BIOGENIH AMINA U PETROVAČKOJ KOBASICI PROIZVEDNOJ U TRADICIONALNIM I INDUSTRIJSKIM USLOVIMA

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Cilj ovog rada bio je da se ispita uticaj različitih uslova pakovanja na sadržaj biogenih amina (BA) u suvoj fermentisanoj *Petrovačkoj kobasici*, proizvednoj u tradicionalnim (B1) i industrijskim uslovima (B3). Ukupan sadržaj BA izražen je kao suma devet biogenih amina (triptamin, feniletilamin, putrescin, kadaverin, histamin, serotonin, tiramin, spermidin i spermin) određenih primenom tečne hromatografije visoke rezolucije (HPLC) i detektora sa serijom dioda (DAD).
Nakon završetka procesa sušenja, kobasice su podeljene u tri podgrupe. Prva podgrupa kobasica je skladištena neupakovana (B1n, B3n), dok su druge dve podgrupe upakovane u vakum (B1v, B3v) i modifikovanu atmosferu gasova (B1m, B3m), respektivno. Ukupan sadržaj biogenih amina određen je na kraju procesa sušenja (90. dan B1, 45. dan B3), 120tog dana skladištenja i na kraju procesa skladištenja (270. dan).
Ukupan sadržaj BA na kraju procesa sušenje u kobasicama proizvedenim na tradicionalan način iznosio je 174 mg/kg, a u kobasicama proizvedenim u industrijskim uslovima iznosio je 77,8 mg/kg. Tokom perioda skladištenja ukupan sadržaj BA je blago rastao i dostigao 187 mg/kg (B1n) i 96 mg/kg (B3n) u neupakovanim kobasicama, 228 mg/kg (B1v) i 133 mg/kg (B3v) u kobasicama upakovanim u vakuumu, i 178 mg/kg (B1m) i 122 (B3m) u kobasicama upakovanim u modifikovanoj atmosferi 120. dana skladištenja. Na kraju perioda skladištenja, ukupan sadržaj BA u svim grupama kobasica je bio viši (B1n 284 mg/kg; B1m 223 mg/kg; B3n 305 mg/kg; B3v 332 mg/kg; B3m 295 mg/kg), izuzev grupe B1v u kojoj je ta vrednost bila nešto niža ($P > 0,05$). Ukupan sadržaj BA 120. dana bio je znatno viši ($P < 0,05$) u uzorcima kobasica proizvedenim na tradicionalan način, dok je na kraju perioda skladištenja ova vrednost bila značajno viša u kobasicama proizvedenim u industrijskim uslovima, izuzev kod neupakovanih kobasica gde razlika nije bila statistički značajna ($P > 0,05$). Način pakovanja nije značajno uticao na ukupan sadržaj BA u uzorcima kobasicama ispitanih u ovom istraživanju.
Ukupan sadržaj biogenih amina u svim ispitanim uzorcima dostigao je maksimalnu od 332 mg/kg, što je niže od propisane granice od 1000 mg/kg koja se smatra opasnom po zdravlje ljudi.
***Ključne reči**: tradicionalne fermentisane kobasice, način pakovanja, biogenic amini*

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COLOR CHARACTERISTICS OF TRADITIONALLY PROCESSED RED PAPRIKA POWDERS AND DRY-FERMENTED SAUSAGES

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The most famous traditional dry-fermented sausages from the northwestern part of Serbia are *Lemeški kulen* and *Petrovačka kobasica*. *Lemeška paprika* (sweet) and *Petrovačka paprika* (hot), in a form of a dry powder, are used abundantly in their production process, respectively. Due to this fact, the first goal of this study was to examine the quality characteristics of *Lemeška* and *Petrovačka paprika* powders, produced out of pepper fruits grown in different areas of Bačka region. The paprika powders were produced and analyzed throughout five production seasons. Moisture content, ash, acid-insoluble ash, ether extract content, capsanthin concentration, i.e. ASTA value, and capsaicin content were determined. There were no significant differences ($P > 0.05$) in moisture, ash, acid-insoluble ash, as well as ether extract content between *Lemeška* and *Petrovačka paprika*. On the contrary, significant differences ($P < 0.05$) between ASTA values, capsanthin, and capsaicin content were noticed. The average ASTA values for *Lemeška* and *Petrovačka paprika* were 210 and 131, respectively, fulfilling the requirements for categorization as best-quality sweet and hot paprika regarding coloring potential, according to Serbian legislation. The typical rich red color, which is one of the main characteristics of both aforementioned traditional dry-fermented sausages, mostly originates from the addition of red paprika powder. In order to see how the addition of different quality red paprika powders influences the color of dry-fermented sausages, the color of the *Lemeški kulen* and *Petrovačka kobasica* was determined by measuring CIE *L*, a*, b** color characteristics. Furthermore, the moisture and fat content of both dry-fermented sausages were determined in order to help with interpretation of results related to color. Sample sausages have also been collected and analyzed throughout five production seasons. Significant differences between the investigated dry-fermented sausages have only been noticed in *L** value. Overall results of this study confirm that the addition of high-quality red paprika powder had a significant positive effect on the formation of the typical red color of *Lemeški kulen* and *Petrovačka kobasica*.
***Key words**: dry-fermented sausages, red paprika powder, color characteristics*

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KARAKTERISTIKE BOJE TRADICIONALNE CRVENE ZAČINSKE PAPRIKE I FERMENTISANIH SUVIH KOBASICA

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Lemeški kulen i *Petrovačka kobasica* predstavljaju najpoznatije tradicionalne fermentisane suve kobasice iz severozapadnog dela Srbije. Tokom njihovog procesa proizvodnje obilato se koristi *Lemeška paprika* (slatka), odnosno *Petrovačka paprika* (ljuta), u formi suvog praha, redom. Upravo zbog toga, prvi cilj ovog istraživanja bio je ispitivanje kvalitativnih karakteristika *Lemeške* i *Petrovačke paprike*, koje su proizvedene od plodova paprika gajenih u različitim krajevima Bačke. Ispitivana crvena mlevena začinska paprika je proizvedena, uzorkovana i analizirana tokom pet proizvodnih sezona. Vršeno je određivanje sadržaja vlage, pepela, pepela nerastvornog u HCl (pesak), etarskog ekstrakta, koncentracije kapsantina, odnosno ASTA vrednost, kao i koncentracije kapsaicina. Utvrđene razlike u sadržaju vlage, pepela, peska, kao i etarskog ekstrakta između *Lemeške* i *Petrovačke paprike* nisu bile statistički značajne ($P > 0.05$). Nasuprot tome, statistički značajna razlika ($P < 0.05$) primećena je između ASTA vrednosti, koncentracije kapsantina kao i kapsaicina. Prosečne ASTA vrednosti za *Lemešku* i *Petrovačku* papriku iznosile su 210 i 131, redom, čime su prema srpskoj regulativi bili ispunjeni uslovi za svrstavanje ovih uzoraka paprike u najviše kategorije prema kvalitetu slatke i ljute paprike. Jedna od glavnih karakteristika prethodno pomenutih tradicionalnih fermentisanih suvih kobasica je njihova intezivna crvena boja, koja ponajviše potiče od dodate mlevene začinske paprike. Kako bi se odredio uticaj mlevene začinske paprike različitog kvaliteta na boju tradicionalnih fermentisanih kobasica, boja *Lemeškog kulena* i *Petrovačke kobasice* određena je prema CIE *L*, a*, b** sistemu. Pored toga, sadržaj vlage i masti u obe fermentisane kobasice je takođe analiziran kako bi se interpretirali rezultati boje. Uzorci kobasica su takođe prikupljani i analizirani tokom pet proizvodnih sezona. Statistički značajna razlika ($P < 0.05$) između prethodno navedenih suvih fermentisanih kobasica primećena je jedino za *L** vrednost. Na osnovu svih rezultata ove studije može se zaključiti da dodatak visoko kvalitetne mlevene začinske paprike ima značajan pozitivan uticaj na formiranje tipične crvene boje *Lemeškog kulena* i *Petrvačke kobasice.*

***Ključne reči**: fermentisane suve kobasice, mlevena začinska paprika, karakteristike boje*

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CHANGES OF QUALITY INDICATORS OF CUCUMBER HYBRID SEEDS DURING AGING

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Cucumber in the Republic of Serbia is grown on about 3.020 ha with an average with a yield of 12.6 t ha^{-1}, with reference to at 2008, we see a trend of decreasing surfaces under this plant species but also the growth average yield per unit area. The aim of the research was to evaluate the effect of year and seed hybrids on the most significant indicators seed quality of cucumber. The obtained results should contribute to the understanding of the decrease in the value of quality indicators of highly hybrid seeds cucumber during aging. Testing the quality of seeds of three different hybrids of cucumber: Centauro F1, Edona F1 and Solatio F1, was carried out during five years (2018 - 2022) in the Laboratory for Testing the Quality of Seeds and Planting Material of the Institute for Plant Protection and Environment, Belgrade.

Analysis of germination energy, total germination, abnormal seedlings and dead seeds cucumber showed highly significant differences ($r<0.01$) under the influence of individual factors of year (A) and hybrid seed (B), as well as their interaction (A × B).

Observed by year, the average values of the germination energy in the examined hybrids of cucumber decrease and the lowest is 89% in the fifth year (2022), as expected. A significantly lower germination energy was recorded in the Edona F1 hybrid in all the examined years, compared to the other two hybrids. Also, the Edona F1 hybrid recorded the fastest decline of this indicator, which is confirmed by the highest CV of 6.46%. The achieved values of total germination by years and hybrids had the same tendency as the obtained values of germination energy. The average total germination of the examined hybrids by year slowly decreases and is the lowest at 94% in the fifth year (2022). The obtained values of total germination after five years of assessment are high, because they exceed the legal minimum of 80% for placing cucumber seeds on the market.

A significant decrease in total germination was recorded only in the Edona F1 hybrid at the third year (2020) of the test, in the other two hybrids no significant decrease in the value of total germination per year was noted. Based on these results, we can state that cucumber hybrids lose viability more slowly.

Taking into consideration 15 pairs (five years, three hibrids), the strongest positive correlation was established between germination energy and total germination ($r = 0.95635$, $p<0.001$) and between abnormal seedlings and dead seeds ($r = 0.92301$, $p<0.001$). As expected, a negative and highly significant ($p < 0.001$) correlation was established between germination energy and: abnormal seedlings ($r = -0.94535$) and dead seeds ($r = -0.93255$). Likewise, a strongest negative ($p < 0.001$) correlation was found between total germination and: abnormal seedlings ($r = - 0.97497$) and dead seeds ($r = -0.98545$).

The obtained results indicate that the germination energy and total germination of highly hybrid conventional cucumber seeds decreases significantly after the third year of aging, but only in the case of the Edona F1 hybrid.

Key words: *cucumber, hybrid, germination*

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PROMENA POKAZATELJA KVALITETA SEMENA HIBRIDA KRASTAVCA TOKOM STARENJA

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Krastavac se u Srbiji gaji na oko 3.020 ha sa prosečnim prinosom od 12,6 t ha^{-1}, u odnosu na 2008. godinu, uočava se trend smanjenja površina pod ovom biljnom vrstom, ali i prosečan porast prinosa po jedinici površine. Cilj istraživanja je bio da se izvrši ocena uticaja godine i hibrida semena na najznačajnije pokazatelje kvaliteta semena krastavca. Dobijeni rezultati treba da daju doprinos razumevanju smanjenja vrednosti pokazatelja kvaliteta visoko hibridnog semena krastavca tokom starenja. Ispitivanje kvaliteta semena tri različita hibrida krastavca: Centauro F1, Edona F1 i Solatio F1, izvedena su tokom pet godina (2018 - 2022) u Laboratoriji za ispitivanje kvaliteta semena i sadnog materijala Instituta za zaštitu bilja i životnu sredinu Beograd.

Analiza energije klijanja, ukupne klijavosti, nenormalnih klijanaca i mrtvog semena krastavca pokazala je visoko značajne razlike ($p<0,01$) pod uticajem pojedinačnih faktora godina (A) i hibrida semena (B), kao i njihove interakcija (A × B).

Posmatrano po godinama prosečne vrednosti energije klijanja kod ispitivanih hibrida krastavca opadaju i najniža je 89% u petoj godini (2022), kao što se i očekivalo. Značajno niža energija klijanja zabeležena je kod hibrida Edona F1 u svim ispitivanim godinama, u poređenu sa ostala dva hibrida. Takođe, kod hibrida Edona F1 zabeleženo je i najbrže opadanje ovog pokazatelja, što potvrđuje i najveći CV 6,46%. Ostvarene vrednosti ukupne klijavosti po godinama i hibridima imale su istu tendenciju kao i dobijene vrednosti energije klijanja. Prosečna ukupna klijavost ispitivanih hibrida po godinama sporo opada i najniža je 94% u petoj (2022) godini. Dobijene vrednosti ukupne klijavosti posle pet godina ocenjivanja su visoke, jer prelaze zakonom dozvoljeni minimum od 80% za stavljanje semena krastavca u promet.

Značajno smanjenje ukupne klijavosti zabeleženo je samo kod hibrida Edona F1 tek u trećoj (2020) godini ispitivanja, kod ostala dva hibrida nije konstatovano značajno smanjenje vrednosti ukupne klijavosti po godinama. Na osnovu ovih rezultata možemo konstatovati da hibridi krastavca sporije gube životnu sposobnost.

Uzimajuću u obzir 15 parova (pet godina, tri hibrida), utvrđena je jaka pozitivna korelacija između energije klijanja i ukupne klijavosti ($r = 0,95635$, $p<0,001$) i između broja nenormalnih klijanaca i mrtvog semena ($r = 0,92301$, $p<0,001$). Kao što se očekivalo, konstatovana visoka negativna korelacija ($p < 0.001$) između energije klijanja: procenta nenormalnih klijanaca ($r = -0,94535$) i mrtvog semena ($r = -0,93255$). Takođe, jaka negativna korelacija ($p < 0,001$) konstatovana je između ukupne klijavosti: nenormalnih klijanaca ($r = - 0,97497$) i mrtvog semena ($r = -0,98545$).

Dobijeni rezultati ukazuju da se energija klijanja i ukupna klijavost visoko hibridnog konvencionalnog semena krastavca zanačajno smajuje tek od treće godine starenja, ali samo kod hibrida Edona F1.

Key words: *krastavac, hybrid, klijavost*

ZAHVALNOST: Ministarstvo obrazovanja, nauke i tehnološkog razvoja Republike Srbije, Ugovor br. 451-03-68/2022-14/200010

OATS AS POTENTIAL BREWING RAW MATERIAL

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Beer is one of the oldest and, at present, the most consumed alcoholic beverage in the world. Beer market is extremely competitive, so many brewers are facing an ever increasing challenge to become more cost-effective, while, at the same time, maintaining or improving product quality. As a result, barley malt is often partially replaced with various adjuncts - unmalted barley, wheat, rice, oats, corn, triticale, which leads to increased beer variety, sensory modification of the beer and a lower price of production. In the Middle Ages, oats presented the most widespread brewing cereal, but lost their significance since barley proved to be more suitable for malting and brewing purposes. However, using oats as a raw material in brewing has recently become the focus of increased interest due to studies that have shown that oats can be tolerated by people who suffer from coeliac disease, which requires a lifelong strict gluten-free diet.
Oats are rich in protein, lipids, β-glucan and consequently have less starch than barley. Compared to other adjuncts, using oats in brewing seems appealing due to their higher husk content, which can accelerate lautering. Although advantageous from a nutritional point of view, high β-glucan and protein content can cause technical problems, including prolonged beer filtration time and haze in the final product.
The objective of this study was to evaluate the possibility of unmalted oats application as partial substitute for barley malt in wort and beer production, in a different proportions (10, 30, and 50%), with or without addition of commercial enzyme for wort viscosity reduction – Ultraflo Max (Novozymes, Denmark). With an increase in oats content in the grist, wort viscosity increased, which was corrected with the addition of commercial enzyme. The highest value of this parameter was obtained in wort produced with 50% oats content in the grist without enzyme addition (2.228 mPa·s) which was reduced to 1.589 mPa·s when enzyme was added to the wort. The highest ethanol content was obtained for beer produced with the 10% of oats in the grist (3.18%), when enzyme was applied. Replacement of the barley malt with unmalted oats did not have a negative impact on beer fermentation, even at the highest oats content in the grist (50%). Overall the obtained results indicate that oats had good technological parameters and could be used as a partial substitute for barley malt in beer production.
Key words: *Oats, Adjuncts, Beer*

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OVAS KAO POTENCIJALNA SIROVINA U PROIZVODNJI PIVA

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Pivo je jedno od najstarijih i trenutno, najkonzumiranijih alkoholnih pića na svetu. Tržište piva je izuzetno konkurentno, tako da se mnogi pivari suočavaju sa sve većim izazovom da proizvodnja bude što isplativija, a da se istovremeno zadrži ili poboljša kvalitet proizvoda. Kao rezultat toga, ječmeni slad se često zamenjuje raznim surogatima - nesladovanim ječmom, pšenicom, pirinčem, ovsom, kukuruzom, tritikaleom, što dovodi do različitosti na tržištu piva, ali i do niže cene proizvodnje. U srednjem veku, ovas je bio najrasprostranjenija žitarica u proizvodnji piva, ali je izgubio na značaju jer se ječam pokazao pogodnijim. Međutim, korišćenje ovsa kao sirovine u pivarstvu je u poslednje vreme došlo u fokus, zbog studija koje su pokazale da ovas mogu tolerisati i ljudi koji pate od celijakije, koja zahteva doživotnu ishranu bez glutena. Ovas je žitarica bogata proteinima, lipidima, β-glukanom i samim tim - sadrži manje skroba od ječma. U poređenju sa drugim surogatima, korišćenje ovsa u pivarstvu ima prednost zbog većeg sadržaja plevice, što ubrzava proces bistrenja sladovine. Iako je koristan sa nutritivne tačke gledišta, visok sadržaj β-glukana i proteina može izazvati tehničke probleme, uključujući produženo vreme filtracije piva, kao i zamućenje finalnog proizvoda.
Cilj ovog istraživanja je bila procena mogućnosti primene nesladovanog ovsa kao delimične zamene ječmenog slada u proizvodnji sladovine i piva, u različitim udelima (10, 30 i 50%), sa ili bez dodatka komercijalnog enzima za smanjenje viskoznosti sladovine – Ultraflo Max (Novozymes, Danska). Sa povećanjem udela ovsa u usipku, povećavala se i viskoznost sladovine, što je korigovano dodatkom komercijalnog enzima. Najveća vrednost ovog parametra određena je u sladovini proizvedenoj sa 50% udela ovsa u usipku bez dodatka enzima (2,228 mPa·s), koja je smanjena na 1,589 mPa·s, usled dodavanja enzima. Najveći sadržaj etanola dobijen je u pivu proizvedenom sa 10% ovsa u usipku (3,18%), uz dodatak enzima. Zamena ječmenog slada nesladovanim ovsom nije imala negativan uticaj na fermentaciju piva, čak ni pri najvećem sadržaju ovsa (50%). Dobijeni rezultati pokazuju da ovas ima dobre tehnološke parametre i da se može koristiti kao delimična zamena za ječmeni slad u proizvodnji piva.
Ključne reči: *Ovas, Nesladovane sirovine, Pivo*

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PRODUCTION OF CARBON NANO PARTICLES FROM BIOMASS

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Carbon nanoparticles are becoming an increasingly interesting material in research. Carbon, as the most abundant element on the planet, is present in various allotropic modifications. The best-known forms of carbon are graphite, diamond, coal, and recently new forms such as graphene and other spherical forms, nanotubes, have been discovered. Nanoparticles mean particles with sizes between 1 and 100 nm in one dimension. There are different areas of their application, from medicine, biology, electronics, thermotechnics, development of composite materials, storage of thermal and electrical energy, etc. The production of carbon nanoparticles can be done in different ways depending on the raw material used for that purpose. Spherical carbon nanoparticles can be obtained from carbon vapors, for example by evaporation of graphite electrodes in a helium atmosphere. Arc discharge, laser ablation and chemical vapor deposition (CVD) are basic methods for carbon nanotube synthesis. Graphene sheets were first obtained using mechanical splitting of graphite with adhesive tape. New techniques are based on obtaining graphene sheets by splitting or cutting materials, such as graphite or nanotubes using a range of physical or chemical methods. These methods are costly and use nonrenewable source for carbon particles production. Other way is to use simpler methods and renewable source such as biomass. Recently, biomass has been used as a raw material for the production of carbon nanoparticles of various shapes, spherical, graphene, nanotubes, etc. Different types of biomass use, such as as cotton, corncobs, camphor leaves, miscanthus etc. The methods used for this purpose are carbonization and graphitization. however, to obtain specific forms of carbon particles, additional treatments such as grinding, chemical treatments or various catalysts are applied. The production of carbon nanoparticles from biomass is a promising method, and the obtained product finds various applications as soil quality improvers, in batteries, catalysts, for the production of nanofluids, etc.
Key words: *carbon nano particles, biomass, carbonization*

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PROIZVODNJA UGLJENIČNIH NANOČESTICA OD BIOMASE

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Ugljenične nanočestice postaju sve češće korišćeni materijal u naučnim istraživanjima. Ugljenik, kao najzastupljeniji element na planeti, prisutan je u različitim alotropskim modifikacijama. Najpoznatiji oblici ugljenika su grafit, dijamant, ugalj, a nedavno su otkriveni i novi oblici kao što su grafen i drugi sferni oblici, nanocevi. Nanočestice označavaju čestice veličine između 1 i 100 nm u jednoj dimenziji. Postoje različite oblasti njihove primene, od medicine, biologije, elektronike, termotehnike, razvoja kompozitnih materijala, skladištenja toplotne i električne energije itd. Proizvodnja ugljeničnih nanočestica može se vršiti na različite načine u zavisnosti od sirovine koja se koristi za tu svrhu. Sferne ugljenične nanočestice se mogu dobiti iz ugljeničnih para, na primer isparavanjem grafitnih elektroda u atmosferi helijuma. Lučno pražnjenje, laserska ablacija i hemijsko taloženje pare (CVD) su osnovne metode za sintezu ugljeničnih nanocevi. Grafen je prvo dobijen mehaničkim cepanjem grafita pomoću lepljive trake. Nove tehnike se zasnivaju na dobijanju listova grafena cepanjem ili sečenjem materijala, kao što su grafit ili nanocevi, korišćenjem niza fizičkih ili hemijskih metoda. Ove metode su skupe i koriste neobnovljive izvore za proizvodnju ugljeničnih čestica. Drugi način je korišćenje jednostavnijih metoda i obnovljivih izvora kao što je biomasa. Biomasa se u poslednje vreme koristi kao sirovina za proizvodnju ugljeničnih nanočestica različitih oblika, sfernih, grafena, nanocevi, itd. Koriste se različite vrste biomase, kao što su pamuk, kočanka kukuruza, lišće kamfora, miskantusa itd. U ovu ovu svrhu se koriste metodi kao što su karbonizacija i grafitizacija. Međutim, da bi se dobili specifični oblici ugljeničnih čestica, primenjuju se dodatni tretmani kao što su mlevenje, hemijski tretmani ili različiti katalizatori. Proizvodnja ugljeničnih nanočestica iz biomase je perspektivna metoda, a dobijeni proizvodi nalaze različite primene kao poboljšivači kvaliteta zemljišta, u baterijama, katalizatorima, za proizvodnju nanofluida itd.

***Ključne reči**: ugljenične nanočestice, biomasa, karbonizacija*

BIOGAS FOR SUSTAINABLE COMMUNITIES: CASE STUDIES

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The technology of anaerobic digestion (AD) has been historically used as a waste treatment option for processing strong organic wastes. However, its potential for biogas recovery from waste material makes it one of the most attractive renewable energy options. The resulting biogas can be used directly for heating and lighting, in CHP engines for electricity production, or purified to biomethane and injected to the grid. Various renewable heat and green gas incentives further contribute to the uptake and expansion of the technology. The advantage of AD is that it can be scaled up or down based on the specific in-field conditions and waste availability, and as such, it can provide a wide range of benefits regardless of how economically developed the country is.

This talk will cover several examples of the implementation of AD, ranging from the basic, fixed dome model used in rural India, examples of community-scale and on-farm AD digesters used in Europe, and finally industrial, large-scale reactors used in the UK. It will include the issues of scaling and the multiple benefits obtained regardless of the scale. The size of reactors is proportionate to the amount of waste available and ultimately the output biogas being produced. Furthermore, the total scale of investment dictates the monitoring of the process and the end use of the produced gas. The household and community scale reactors usually opt for the onsite use of biogas for heating, but they often achieve lower than optimal biogas yields. However, the case studies in this talk will also cover good examples of industrial-scale reactors owned by one of the largest utility companies in the UK. They provide an excellent example of how pairing wastewater treatment with AD can result in electricity self-sufficient sites, where the electricity produced from biogas can not only meet their own operational needs but also be sold back to the public grid for profit. Furthermore, once when the technical know-how within the wastewater treatment sites has been established, further development of the AD portfolio is enabled, with multiple stand-alone independent AD plants built for a range of feedstocks. In addition to the profit obtained from biogas utilisation, these sites make a profit from charging gate fees for the received waste and from sales of remaining digestate as fertiliser. This makes a highly profitable business model which, despite high initial investment, can become a significant income generator for a utility company, converting waste into a valuable resource.

Key words: *biogas generation, community scale AD, scaling AD, biogas utilisation*

BIOGAS ZA SAMOODRŽIVE ZAJEDNICE: PRIMERI IZ PRAKSE

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Tehnologija anaerobne digestije (AD) ima dugu istoriju primene u preradi otpada sa visokim organskim sadržajem. Potencijal ove tehnologije za proizvodnju biogasa iz organskog otpada čini je jednom od najatraktivnijih opcija za proizvodnju obnovljive energije. Proizvedeni biogas može se direktno koristiti za grejanje i osvetljenje, može biti preveden u električnu energiju, ili prečišćen do biometana koji je moguće koristiti u okviru nacionalne gasne mreze. Razne povlastice za proizvodnju obnovljive energije i ekoloških goriva doprinose razvoju i ekspanziji ove tehnologije. Prednost AD tehnologije je da ona može biti fleksibilna i prilagođena uslovima na terenu i količini dostupnog otpada- shodno ovim faktorima veličina reaktora i samog ulaganja u proces može biti pravilno izabrana. Usled pomenute fleksibilnosti, AD može da proizvede široki spektar dobrobiti bez obzira na to koliko je zemlja u kojoj se primenjuje ekonomski razvijena.

Ova prezentacija će pokriti nekoliko primera primene AD tehnologie, počev od jednostavnih, malih reaktora korišćenih u ruralnim oblastima u Indiji, preko primera reaktora srednje veličine korišćenih na evropskim farmama, sve do velikih industrijskih reaktora korišćenih u Britaniji. Posebna pažnja će biti posvećena pravilnom prilagođavanju tehnologije uslovima na terenu i dobrobiti koju pruža bez obzira na izabranu veličinu reaktora. Količina dostupnog organskog otpada direktno uslovljava veličinu reaktora i količinu biogasa proizvedenu kao krajnji proizvod ovog procesa. Takođe, nivo ulaganja u AD utiče i na to koliko će proces biti detaljno kontrolisan i praćen, kao i na krajnju primenu proizvedenog gasa. Biogas iz reaktora na nivou pojedinacnih domaćinstava ili malih zajednica se obično koristi direktno za grejanje na samoj lokaciji gde je proizveden, ali prinos gasa u njima je sub-optimalan. Ova prezentacija ce takođe uključiti i odlične primere primene AD tehnologije na industrijskom nivou, u vlasništvu jedne od najvećih kompanija za preradu otpadne vode u Britaniji. Na primeru ove kompanije može se videti kako je, kombinovanjem prerade otpadne vode i AD tehnologije, moguće postići autonomnu proizvodnju električne energije za potrebe industrijskih procesa u okviru same kompanije, kao i dodatni profit prodajom viska proizvedene energije nacionalnoj električnoj mreži. Jednom kada se uspostavi stručnost i dobro razumevanje procesa u okviru kompanije za preradu otpadne vode, moguće je proširiti listu organskog materijala koji je moguće prerađivati u nezavisnim AD reaktorima. Pored profita ostvarenog korišćenjem samog biogasa kao energenta, ovakvi lokaliteti takođe zarađuju naplaćivanjem za preradu otpada, a takođe i od prodaje preostalog materijala nakon AD tretmana koje se koristi kao đubrivo. Ovo čini AD tehnologiju vrlo unosnim poslovnim modelom koji može da postane značajan izvor prihoda za kompaniju koja prerađuje otpadnu vodu i organski otpad, prevodeći otpad u vredan resurs.

***Ključne reči**: proizvodnja biogasa, anaerobna digestija na nivou zajednica, skaliranje anaerobne digestije, korišćenje biogasa*

SMELL THE DIFFERENCE! A NOVEL APPROACH TO SEPARATE HEALTHY AND INFECTED MUSHROOMS.

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White button mushroom production (Agaricus bisporus) is a very mould-sensitive process; it is highly susceptible to the infections of different mould species. If the mushroom is infected during production or storage, it could mean a loss of profit during the sale, moreover, it has a negative health effect during consumption. Due to these negative reasons, infections must be monitored and controlled during mushroom production and post-harvest processes like sales.
Regarding different mushroom volatiles, there is a lack of agreement in the literature, because most of the research identifies only a few mushroom volatiles. In a time series experiment, this study examines button mushrooms, precisely the volatiles they release and the primary changes that occur during harmful infections (green mould and cobweb disease). Using headspace - solid phase micro-extraction - gas chromatography - mass spectrometry (HS-SPME-GC-MS) coupled analytical technique, volatile profiles from emissions were determined. 104 compounds were found during the time series experiment and from them, 70 primary volatile compounds were successfully identified using mass spectrum libraries. By the use of several multivariate statistical techniques (Principal Component Analysis, Partial Least Square – Discriminant Analysis, HeatMap), infected mushroom samples were distinguished from healthy samples. 14 compounds (cis-α-bisabolene; β-caryophyllene; tridecane; acetophenone; cymene; isomenthone; 2-decen-1-ol; myrtenol; 2,4-diisocyanatotoluene; dodecane; 4-propylanisole; D-limonene; 2-heptanone-6-methyl; cyclooctane.) described the healthy mushroom samples, while 15 compounds (megastigma-4,6,8-triene; thujopsene; β-cadinene; patchulane; isocaryophyllene; cedr-8-ene; β-guaiene; aromadendrane; α-chamigrene; 2-pentanone,4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]hept-2-yl)-; β-elemene; nonane; cedr-8(15)-ene; isopatchoulane; longifolene.) indicated the presence of green mould disease, Trichoderma aggressivum. Three of these compounds (patchulane; isocaryophyllene and longifolene) indicated the green mould disease in an early stage. Only five compounds (2-nonene, decane, 3-undecene, undecane, and 5-undecene) were found which indicated cobweb (Dactylium dendroides) disease.
Only by the use of mushroom and mould volatile compounds, it was possible to discriminate healthy mushroom samples from infected samples in a very early infection state. Therefore the method allows us to the early detection of mushroom infections. The found compounds can be applied to further research on the early detection of infected mushrooms in packaged mushroom products. These compounds may also aid in the detection of infections in commercially available mushrooms, extending their shelf-life.
Key words: *HS-SPME (head space-solid-phase microextraction), GC-MS (gas chromatography-mass spectrometry), Agaricus bisporus, Trichoderma aggressivum (green mould disease), Dactylium dendroides (cobweb disease)*

PHYSICAL AND CHEMICAL PROPERTIES AND MICROBIOLOGICAL QUALITY CONTROL OF CARROT ROOTS

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Carrot (Daucus carota L.) is a biennial vegetable which originates from Central Asia. It belongs to the group of plants that grow in temperate climates and its root, which can be sweet, mildly sweet and aromatic, is used in food preparation. The root of the carrot has an exceptional nutritional and biological value, its main characteristics being high content of sugar, proteins, crude fibers, minerals, vitamins and specific etheric oils. It is also known as a good source of β-carotene, as well as provitamin A. Carrot roots can be consumed fresh, but they are most often used for preparing baby food, for the production of fruit juices and nectars and they can also undergo the process of freezing or drying.

The aim of this work is to examine the physical and chemical properties, as well as to perform the microbiological quality control of carrot roots. As a part of the analysis, the following properties were examined: water activity (a_w), pH, acid content (e.g. citric acid), carbohydrate, protein and fat content in fresh and dried carrot roots. Water activity was measured using an avemeter (Pawkit), while pH value was measured with a pH meter (InoLabWTW, Germany). Acid content was determined using the volumetric titration method with NaOH. Carbohydrate content was determined by the volumetric Luff Schoorl titration method. Protein content was determined by the Kjeldahl method, while fat content was determined by Soxhlet extraction method. During the microbiological quality control of fresh and dried carrot roots, the samples were subjected to the bacteria that cause food spoilage, such as Salmonella spp., Listeria monocytogenes and Enteriobacteriaceae. All methods were based on the SRPS EN ISO standard, namely Salmonella spp. SRPS EN ISO 6579-1:2017, Listeria monocytogenes SRPS EN ISO 11290-1:2017, Enterobacteriaceae SRPS EN ISO 21528-2:2017. The results of our tests indicated that fresh and dried carrot roots contain a low fat content, but are a good source of carbohydrates. Performed microbiological methods to test the frequency of Salmonella spp., Listeria monocytogenes and Enterobacteriaceae, showed the absence of Salmonella spp. and Listeria monocytogenes and the presence of Enterobacteriaceae (less than 10cfu/ml).

Key words: *carrot, chemical properties, microbiological control*

FIZIČKO – HEMIJSKA SVOJSTVA I MIKROBIOLOŠKA KONTROLA KVALITETA KORENA MRKVE

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Mrkva (Daucus carota L.) je dvogodišnja povrtarska biljka koja vodi poreklo iz središnje Azije. Spada u biljke umerenog klimata, čiji se koren koristi u ishrani, koji može biti sladak, slabo sladak i aromatičan. Koren mrkve ima izuzetnu hranljivu i biološku vrednost, koja se odlikuje visokim sadržajem šećera, proteina, sirovih vlakana, minerala, vitamina, specifičnih eteričnih ulja. Takođe je poznat kao dobar izvor β-karotena kao provitamina A. Koren mrkve se konzumira u svežem stanju, ali se najčešće koristi za proizvodnju dečije hrane, sokova, nektara, podvrgava se zamrzavanju ili sušenju. Cilj ovog rada je ispitivanje fizičko-hemijskih svojstava i mikrobiološka kontrola korena mrkve. U okviru analize ispitana je aktivnost vode (a_w), pH, sadržaj kiselina (kao limunska), sadržaj ugljenih hidrata, proteina, masti u svežem i osušenom korenu mrkve. Aktivnost vode merena je avemetrom (Pawkit). pH vrednost merena je pH metrom (InoLabWTW, Nemačka). Sadržaj kiselina određen je volumetrijskom metodom, titracijom sa NaOH. Sadržaj ugljenih hidrata je određen volumetrijskom metodom po Luff Schoorlu. Sadržaj proteina određen je metodom po Kjeldahlu. Sadržaj masti metodom ekstrakcije po Soxhletu. Mikrobiološka kontrola kvaliteta u svežem i osušenom korenu mrkve obuhvatila je bakterije kvarioce hrane kao što su Salmonella spp., Listeria monocytogenes, Enteriobacteriace. Sve metode su rađene na osnovu SRPS EN ISO standarda i to Salmonela spp. SRPS EN ISO 6579-1:2017, Listeria monocytogenes SRPS EN ISO 11290-1:2017, Enterobacteriaceae SRPS EN ISO 21528-2:2017. Rezultati naših ispitivanja ukazali su da svež i osušen koren mrkve sadrži nizak sadržaj masti, ali da predstavlja dobar izvor ugljenih hidrata. Izvedene mikrobiološke metode u cilju ispitivanja učestalosti Salmonella spp., Listeria monocitogenes i Enterobacteriaceae, pokazale su odsustvo Salmonella spp. i Listeria monocitogenes i prisustvo Enterobacteriaceae (manje od 10cfu/ml).

Ključne reči: *mrkva, hemijska svojstva, mikrobiološka kontrola*

FUNCTIONAL AND TECHNOLOGICAL FEATURES OF MILLING BY-PRODUCTS FERMENTED BY SELECTED MICROBIAL CONSORTIA

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The milling by-products produced during the cereals processing are mainly used as a feed supplement. However, their widely recognized health properties resulted in a gradual increase in their application as ingredients in food formulations. In addition, the fermentation performed with selected microbial consortia represents a useful tool to improve nutritional and functional properties of cereals and bran. This work, developed within the BBI project INGREEN, was aimed to study the functional, nutritional and technological features of a pre-fermented ingredient obtained from the fermentation of a mixture of durum wheat milling by-products by a selected microbial consortium composed of yeasts (Kazachstania unispora and Kazachstania servazii) and lactic acid bacteria (LAB)(Latilactobacillus curvatus, Leuconostoc mesenteroides and Pediococcus pentosaceus) using as reference the unfermented mixture and the same mixture fermented by a baker's yeast.
The selected microbial consortium was well adapted and able to grow faster and rapidly acidify the starting matrix which, after 24 hours of fermentation at room temperature, was characterized by a yeasts and LAB cell load increased by 3 logarithmic cycles and pH values of 3.95.
The fermentation process by the selected microbial consortium improved the complexity of the volatile molecules such as acids, alcohols, ketones and esters. The fermentation by the selected microbial consortia increased the antioxidant activity and the total phenol content. The innovative pre-ferment showed also a better retention and stability of color parameters compared to the unfermented mixture and the mixture fermented by a baker's yeast that resulted more sensitive to browning. In addition, selected microbial consortium was able to significant increase in the fermented mixture the content in short chain fatty acids and unsaturated fatty acids such as linoleic, linolenic and oleic acid, having aromatic, nutritional and health-promoting roles.
Finally, the innovative pre-fermented ingredients demonstrated an increase in prebiotic activity, in both aerobic and anaerobic fermentation models, an increase in bio-active peptides and a reduction in phytic acid content, when compared with both unfermented product and the fermented matrix obtained with a baker's yeast.
Overall, the fermentation by the selected microbial consortium can be considered a valuable way to valorize milling by-products and promote their exploitation as food ingredients.
Key words: *durum wheat by-product, fermentation, valorization*

INFLUENCE OF PRE-TREATMENT WITH ULTRASOUND ON SELECTED PROPERTIES OF VACUUM-DRIED APPLE TISSUE

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Apples are fruits that, in addition to their high nutritional value, are also highly acceptable among consumers. This fruit abounds in many health-promoting substances, it is a good source of fiber, vitamins, and elements essential for health, as well as bioactive compounds with antioxidant properties. Recently there has been an increase in interest in dried fruits and vegetables, which contain a condensed form of nutrients and can be eaten as a snack or included in various products. Drying is the most common food preservation process used in technology. There are many types of this method, which, in addition to the preservative effect, can also cause many undesirable effects in the final product. A particularly effective technique used in fruit processing, allowing to obtain good sensory and nutritional properties, is vacuum drying. This process is carried out at low temperatures and under reduced pressure, thanks to which it effectively inhibits the course of undesirable reactions leading to the deterioration of the product properties as a result of oxidation or thermal degradation. The use of these non-thermal processes as ultrasound prior to drying reduces the drying time and improves the properties of the final product.

The aim of the work was to investigate the effect of pretreatment with ultrasound before vacuum drying on the kinetics of the drying process, as well as on the chemical, physical and structural properties of apples. The material was subjected to ultrasonic waves with a frequency of 21 kHz and a power of 180 W for 30, 45, and 60 minutes. Drying was carried out at a pressure of 4 kPa at temperatures of 40, 55, and 70°C until a constant mass of the product was obtained. The content of total polyphenols was tested in the material, the antioxidant activity against $DPPH^{\bullet}$ and $ABTS^{\bullet+}$ radicals was determined, and the hygroscopic and rehydration properties were determined. Changes in the internal structure of dried apples were determined using electron microscopy. The use of ultrasound for 30 minutes had the greatest impact on shortening the drying time, but only when using lower drying temperatures, i.e. 40 and 55°C, by 14.6 and 7.6%, respectively. The pre-treatment did not significantly affect the changes in hygroscopic properties and the content of total polyphenols and antioxidant activity against the $ABTS^{\bullet+}$ and $DPPH^{\bullet}$ radicals. In the case of the $DPPH^{\bullet}$ radical, significant changes were noted between the materials dried at different temperatures. A longer sonication time led to greater damage to the microstructure of the tested material. The obtained results indicate that the effect of ultrasonic pre-treatment and vacuum drying on food depends on the applied parameters. The use of ultrasounds before vacuum drying can shorten the duration of this process and obtain droughts characterized by more desirable physical and chemical properties of dried apples.

Key words: *ultrasound, vacuum drying, bioactive compounds*

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ANTIPROLIFERATIVE PROPERTIES OF HONEY TYPES FROM THE WESTERN BALKANS

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Honey is a natural sweetener used not only for food, but also for therapeutic purposes. It contains carbohydrates, primarily glucose and fructose (85–95%) but also contains about 200 substances present in small amounts (minerals, proteins, enzymes, amino acids, organic acids, vitamins, polyphenols and others).
The type of honey is characterized by the type of pollen, insect secretions, as well as climatic conditions and soil composition.
The health benefits of honey results from its antioxidant nature, antimicrobial and antiproliferative activity.
Several studies demonstrate the anticancer activity of honey, namely honey shows a chemopreventive effect against various cancer cell lines and tissues in in vitro and in vivo studies. This activity can be explained by different mechanisms including cell cycle arrest, induction of apoptosis, modulation of oxidative stress and immuno-modulation. Therefore, honey can be applied in alternative medical treatment of human tumors.
With the aim to assess the antiproliferative properties of different types of honey characteristic for The Western Balkans, nineteen samples (acacia, linden, heather, sunflower, phacelia, basil, anise, sage, chestnut, hawthorn, buckwheat, lavender and meadow) were collected from different locations in the mentioned region and examined. The quality of honey samples was also tested to ensure that they meet the requirements defined by the national and international legislation.
All tested honey samples were in accordance with the regulations of national and EU regulations.
The antiproliferative activity of honey samples was evaluated using human tumor cell lines HeLa (cervcal carcinoma), MCF7 (breast epithelial adenocarcinoma), HT-29 (colon adenocarcinoma) and MRC-5 (normal fetal lung fibroblasts).
The most active samples were linden honey sample from Fruška gora (IC_{50}^{MCF7} = 7.46 ± 1.18 mg/mL and IC_{50}^{HeLa} = 12.4 ± 2.00 mg/mL) and meadow sample 2 (IC_{50}^{MCF7} = 12.0 ± 0.57 mg/mL, IC_{50}^{HeLa} = 16.9 ± 1.54 mg/mL and IC_{50}^{HT-29} = 23.7 ± 1.33 mg/mL) towards breast (MCF7), cervix (HeLa), and colon (HT-29) cancer cells. The most active samples, linden and meadow 2 also affected the growth of MRC-5 cells derived from healthy lung tissue with IC_{50}^{MRC-5} = 9.93 ± 0.68 mg/mL and IC_{50}^{MRC-5} = 12.9 ± 0.34 mg/mL, respectively. Colon carcinoma cell line HT-29 was the least sensitive to the evaluated samples. Standard (glucose) had lower and uniform cell growth effect with IC_{50} values ranging from 33–40 mg/mL towards all evaluated cell lines, indicating that active components in samples other than sugars contributed to cell growth activity. These compounds are probably polyphenols. Polyphenolic profile investigation will be needed to correlate antiproliferative activities and polyphenol contents for evidences of the mechanisms of their action.
Key words: *honey, antiproliferative properties*

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ANTIPROLIFERATIVNA SVOJSTVA MEDA SA ZAPADNOG BALKANA

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Med je prirodni zaslađivač koji se koristi ne samo u ishrani, već i u terapeutske svrhe. Sadrži ugljene hidrate, pre svega glukozu i fruktozu (85–95%), ali i oko 200 supstanci prisutnih u malim količinama
(minerali, proteini, enzimi, aminokiseline, organske kiseline, vitamini, polifenoli i dr.).
Vrstu meda karakteriše vrsta polena, izlučevine insekata, kao i klimatski uslovi i sastav zemljišta.
Zdravstvene dobrobiti meda proizilaze iz njegove antioksidativne prirode, antimikrobne i antiproliferativne aktivnosti.
Nekoliko studija ukazuje na antikancerogenu aktivnost meda, odnosno med ispoljava hemopreventivni efekat protiv različitih ćelijskih linija i tkiva raka u in vitro i in vivo studijama. Ova aktivnost se može objasniti različitim mehanizmima uključujući zaustavljanje ćelijskog ciklusa, indukciju apoptoze, modulaciju oksidativnog stresa i imuno-modulaciju. Stoga se med može primeniti u alternativnom medicinskom lečenju tumora kod ljudi.
U cilju procene antiproliferativnih svojstava različitih vrsta meda karakterističnih za Zapadni Balkan, prikupljeno je i ispitano devetnaest uzoraka meda (bagrem, lipa, vres, suncokret, facelija, bosiljak, anis, žalfija, kesten, glog, heljda, lavanda i livada) sa različitih lokacija pomenutog regiona. Uzorci meda su ispitani i u pogledu kvaliteta kako bi se osiguralo da ispunjavaju uslove definisane nacionalnom i međunarodnom regulativom.
Svi ispitani uzorci meda bili su u skladu sa propisima nacionalne i EU regulative.
Za procenu antiproliferativne aktivnosti meda korišćene su humane tumorske linije HeLa (karcinom grlića materice), MCF7 (adenokarcinom epitela dojke), HT-29 (adenokarcinom debelog creva) i MRC-5 (normalni fetalni fibroblasti pluća).
Najaktivniji uzorci bili su uzorak lipovog meda sa Fruške gore (IC_{50}^{MCF7} = 7,46 ± 1,18 mg/ml i IC_{50}^{HeLa} = 12,4 ± 2,00 mg/ml) i uzorak livadskog meda 2 (IC_{50}^{MCF7} = 12,0 ± 0,57 mg/ml IC_{50}^{HeLa} = 16,9 ± 1,54 mg/ml /mL i IC_{50}^{HT-29} = 23,7 ± 1,33 mg/ml) prema ćelijama raka dojke (MCF7), grlića materice (HeLa) i debelog creva (HT-29). Antiproliferativno najpotentniji uzorci, uzorak lipovog meda sa Fruške gore i uzorak livadskog meda 2, uticali su, takođe, na rast MRC-5 ćelija fibroblasta pluća sa vrednostima IC_{50}^{MRC-5} = 9,93 ± 0,68 mg/ml i IC_{50}^{MRC-5} = 12,9 ± 0,34 mg/ml, respektivno. Ćelijska linija karcinoma debelog creva HT-29 bila je najmanje osetljiva na ispitivane uzorke. Standard (glukoza) je imao niži i ujednačen uticaj na rast ćelija sa vrednostima IC_{50} u rasponu od 33–40 mg/ml u slučaju svih ćelijskih linija, što ukazuje da su aktivne komponente u uzorcima meda primarno obezbedile antiproliferativnu aktivnost, pre nego šećer. Neophodno je ispitivanje polifenolnog profila da bi se uspostavila korelacija antiproliferativnih aktivnosti i sadržaja polifenola za dobijanje dokaza o mehanizmima njihovog delovanja.
Ključne reči: *med, antiproliferativna aktivnost*

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IMPACT OF THE PANDEMIC LOCK-DOWN OVER THE ROMANIAN AGRICULTURE

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The COVID-19 lockdown as a health crisis measure had a tremendous impact over different economic sectors around the world. If the tertiary sector had the most to suffer given the isolation procedures particularly regarding the hospitality industry, the first two sectors had seen a different impact according to the field of activity. The present paper is screening the situation of the Romanian agriculture based on hard official secondary data during the lock-down period induced by the COVID-19 health crisis. The aim is to underpin the impact of the different restrictions in force during the lock-down and immediately after mostly during the 2020 agricultural year. The analysis is discerning between the winter corps, seeded before any sings of crisis or limitations and grants a particular attention to the spring crops seeded in the spring of 2020 during the deepest mobility freeze as public health protection measures. The specific restrictions applied to farmers and workers involved in agriculture are used to measure the mobility while the comparative analysis of cultivated areas from the reference 2019 and respectively 2020 years are the indication of any area drop that could eventually be associated to the public health restriction. Given the nature of the agricultural activity, particularly connected to field crops cultivation, and the specificities of the restrictions during the specified crisis period combined to the changes in area cultivation during the 2020 year the findings indicate a variation that cannot be linked to the restrictive procedures associated to the public health crisis. One important variable to analyse, the production levels, is not part of the assessment due to the fact that in 2020 the South-East and the Eastern regions of Romania suffered of severe drought, the end result being severely biased by this factor implications. Although with differences, in certain situations less expected, the 2020 agricultural year in terms of agricultural production intentions was barely affected by the pandemic restrictions, lock-don period of after-limitations. The drought effects, not subject of the current paper can be delimited and excluded still the seeding season, during the harshest period indicates “healthy” intentions despite the fear of distribution blocks or other market related concerns. These elements can be regarded equally as market ignorance or determination to cope with hard times, the official data doesn’t make possible a clear distinction between them. The few qualitative assessments covering the period offering certain indications are insufficient to extrapolate the findings at national level.
Key words: *crisis, agricultural production, pandemic restrictions*

COMPARISON OF METHODS FOR THE ANALYSIS OF PARTICLE SIZE DISTRIBUTION IN MAIZE FLOUR

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The analysis of particle size distribution is a frequent task in the different levels of food chain – characterization of raw material, analysis of intermediate or final product. It has a fundamental importance in the milling industry, as it is one of the pillars for determining the type of the product. Several methods are available for determining particle size, with different speeds, resolutions and other performance characteristics and the available resources and demands are the fundamental bases of selection.
In the study, corn flour and grist samples were taken from the sieve column outlets of a maize mill and analysed by three methods (dry sieving, wet and dry laser diffraction) to investigate the size distribution. After comparing the results, it was found that for the fractions of flour, the results of the samples were closely matched for all 3 methods, while for coarser grist samples, the wet and dry laser diffraction methods showed similar results, but different with the dry sieving method. Correlation coefficients for particle size distribution of the flour fractions was significantly higher than 0.9, while these values were lower than 0.4 for grists with higher than 0.8 mm average particle size. For all the samples, the results of both wet and dry laser diffraction methods were heavily loaded with the disturbing factor of very fine (smaller than 20 μm) components, what provided large proportion, especially in the case of volume based measurement.
It was found that laser diffraction gives a more inaccurate value with increasing particle size, but discrepancies are also possible at smaller sizes: the diameter of coarse particles of maize was underestimated by the method, while the diameter of fine particles was overestimated. In order to optimise the laser diffraction method, it would be useful to develop geometry based factors in the model for the fine, medium and coarse particle types. For this kind of sample, the most accurate method is still the sieving, but its resolution is limited.
Key words: *particle size, corn flour and grist, laser diffraction*

VARIABILITY OF THE NUMBER AND WEIGHT OF 1000 SEEDS OF WEEDS PRESENT IN ALFALFA NATURAL SEEDS FROM DIFFERENT LOCATIONS IN SERBIA

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Alfalfa is the most significant perennial and multi-crop forage legume in Serbia. It is highly adaptable in forage production. But seed production faces numerous problems, which causes high variability in seed yield and causes Serbia to be an importer of seeds in some years and an exporter of seeds in others.
One of the problems in this production is the weed seeds that are in the natural alfalfa seed after harvesting. The seeds of these weeds must be removed through processing, after which processed (pure) alfalfa seeds are packaged and placed on the market, as specified in the rulebook on seed quality (Official Gazette of SFRY, 1987 - 47/87, add. to 34/2013) which is harmonized with the rulebook on seed quality in Europe (ISTA 2022). According to it, the minimum purity must be greater than 95%, up to 2% of other species are allowed, and up to 0.5% of weeds, but no quarantine weeds such as dragonfly (Cuscuta spp.) and (Rumex spp.). The quantity, i.e. the number and weight of 1000 weed seeds, determines which system of seed processing will be applied for alfalfa seeds in order to meet the conditions for placing them on the market.
The implemented technology of alfalfa seed production is of great importance on the presence of weed seeds in natural alfalfa seeds: plot selection, soil cultivation, weed control, harvesting... It should be stated that in the later years of exploitation of the alfalfa seed crop, there will be more weeds as a result of crop thinning.
The three-year results of the variability of the number of seeds and the mass of 1000 seeds of detected weeds in the natural seed of five seed lots of alfalfa seeds from different locations in Serbia are presented in this research. Seed lots were harvested in the following regions: surroundings of Zrenjanin, Novo Miloševo, Negotin, Banatsko Karađorđevo, and Srpska Crnja. Weed seeds were detected in five seed lots of natural alfalfa seeds. The seeds of the following weeds were detected: field mustard - Sinapis arvensis L., redroot pigweed - Amaranthus retroflexus L., curly dock - Rumex obtusifolius L., dodder - Cuscuta campestris Yunk., red sorrel - Rumex acetosella L., ribwort plantain - Plantago lanceolata L., broadleaf plantain - Plantago major L., yellow dock - Rumex crispus L., cleavers - Galium aparine L., and bindweed - Convolvus arvensis L.
As expected, the variability of the number of weed seeds detected from the seed lots over three years was high: CV% = 14.78 for wild sorghum - Sorghum halepense (L.) Pers. in the 2022, to CV% = 65.47 for ribwort plantain - Plantago lanceolata L in the 2020. For the mass of 1000 seeds of the examined weeds, the variability was determined from CV% = 5,869 for the ribwort plantain - Plantago lanceolata L. (year 2020), to CV% = 34, 41 for yellow dock - Rumex crispus L. (year 2022).
Key words: *Number of weed seeds, natural alfalfa seeds, weight of 1000 weed seeds.*

VARIJABILNOST BROJA I MASE 1000 SEMENA KOROVA PRISUTNOG U NATURALNOM SEMENU LUCERKE SA RAZLIČITIH LOKALITETA U SRBIJI

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Lucerka je naznačajnija višegodišnja i višeotkosna krmna leguminoza u Srbiji. Visoko je adaptibilna u proizvodnji za krmu. Ali proizvodnja semena se susreće sa brojnim problemima što uzrokuje visoku varijabilnost za prinos semena i uslovljava da Srbija u nekim godinama bude uvoznik a u nekim izvoznik semena. Jedan od problema u ovoj proizvodnji čine i semena korova koji nakon ubiranja budu u naturalnom semenu lucerke. Semena ovih korova moraju se kroz doradu odstraniti, Nakon čega se dorađeno - čisto seme lucerke pakuje i stavlja u promet što precizira pravilnik o kvalitetu semena (Službeni list SFRJ, 1987 - 47/87, dodatak do 34/2013) koji je usklađen sa pravilnikom o kvalitetu semena u Evropi (ISTA 2022). U skladu sa tim, minimalna čistoća semena mora da bude veća od 95%. Dozvoljeno je do 2% drugih vrsta, i do 0, 5% korova, ali u semenu lucerke ne smeju da budu prisutni karantinski korovi kao što su vilina kosica -Cuscuta spp. i štavelj -Rumex spp.

Količina odnosno broj i masa 1000 semena korova određuje koji sistem dorade naturalnog semena lucerke će se primeniti da bi seme ispunilo uslove za stavljanjuje u promet.

Na prisutnost semena korova u naturalnom semenu lucerke od visokog značaja je tehnologija gajenja koja se sprovodi na proizvodnim parcelama: izbor parcele, obrada zemljišta, suzbijanje korova, ubiranje... Treba imati u vidu da će u kasnijim godinama eksploatacije semenskog useva lucerke biti više korova kao rezultat proređivanja useva.

U ovom istraživanju su predstavljeni trogodišnji rezultati varijabilnost broja semena i mase 1000 semena detektovanih korova u naturalnom semenu pet partija semena lucerke sa različitih lokaliteta u Srbiji. Partije semena su ubirane u sledećim regionima: okolina Zrenjanina, Novog Miloševa, Negotina, Banatskog Karađorđeva, i Srpske Crnje. Kod pet partija naturalnog semena lucerke detektovano je seme korova. Detektovano je seme sledećih korova: poljska gorušica - Sinapis arvensis L., običan štir - Amaranthus retroflexus L., štavljaka - Rumex obtusifolius L., vilina kosica - Cuscuta campestris Yunk., mali kiseljak - Rumex acetosella L., uskolisna bokvica - Plantago lanceolata L., širokolisna bokvica - Plantago major L., obični štavelj - Rumex crispus L., prilepača - Galium aparine L., niski poponac - Convolvus arvensis L.

Očekivano, varijabilnost broja semen detektovanih korova, u partijama semena tokom tri godine, je bila visoka za divlji sirak- Sorghum halepense (L.) Pers. (CV% = 14.78 u 2022.), do CV% = 65, 47 za uskolisnu bokvicu - Plantago lanceolata L. u 2020. godini.

Za masu 1000 semena ispitivanih korova utvrđena je varijabilnost od CV% = 5.869 za uskolisnu bokvicu - Plantago lanceolata L. (2020.), do CV% = 34, 41 za obični štavljak - Rumex crispus L. (2022.).

Ključne reči: *Broj semena korova, naturalno seme lucerke, masa 1000 semena korova.*

TOTAL CHANGE IN GERMINATION AND VIGOR OF CERTIFIED COMMERCIAL SEEDS OF THREE ZP MAIZE HYBRIDS DURING A FIVE-YEAR PERIOD (2018-2022)

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In the production and processing of commercial seeds, special emphasis is placed on the quality of the seeds where germination is the most important quality parameter when it comes to the circulation of seed on the market. One of the main challenges of seed production and processing of maize seeds is the storage of seed material in appropriate conditions in order to better preserve germination and vigor during a certain period of time. According to the current legal regulations of the Republic of Serbia, certified maize seeds must meet certain criteria when it comes to germination (Regulation on the quality of seeds of agricultural plants). Germination seed decreases during storage, and testing in accredited laboratories is necessary for the possibility of placing stored seeds on the market.

The aim of this study was to determine the change in total germination and vigor during the storage of certified hybrid maize seeds in a five-year period. The germination of the seeds of three commercial maize hybrids (ZP 704, ZP 873 and ZP 600) was tested once a year, in the period from 2018-2022. The analysis of germination included four batches of hybrid ZP 704, one batch of hybrid ZP 873 and three batches of hybrid ZP 600. A standard germination test was used to test germination. The results were expressed in percentages for each hybrid as an average of all tested batches of that hybrid. The highest average values of total germination and seed vigor of all three examined hybrids were recorded during the first testing in 2018 (ZP 704 - 98.8%/98.8%, ZP 873 - 100%/100%, ZP 600 - 98.3%/98.3%). During the third testing in 2020, halfway through the examined period, a very slight decrease in the average of the total germination and seed vigor of all three examined hybrids was found (ZP 704 - 98.5%/98.5%, ZP 873 - 98%/98 %, ZP 600 – 97.6%/97.6%). In all three hybrids the average germination energy was at the level of total germination. At the end of the test (2022), the seeds of all three tested hybrids had an average total germination above 90% (ZP 704 – 93.7%, ZP 873 – 94%), while the hybrid ZP 600 had an average total germination above 95% (96%). On the other hand, vigor decreased in the seeds of hybrids ZP 704 (92.7%) and ZP 873 (88%) in relation to total germination, while seeds of hybrid ZP 600 had an identical result of total germination and vigor (96%). Hybrid ZP 600 showed the smallest change in total germination of all three tested hybrids during the tested period (98.3% in 2018, 96% in 2022).

Based on the results, it can be concluded that the seed storage conditions were appropriate considering the relatively good results of the overall seed germination of all three hybrids at the end of the examined period. The hybrid ZP 600 is marked as extremely profitable for seed production, which further indicates the very good seed characteristics of its maternal component.

Key words: *maize, germination, vigor*

PROMENA UKUPNE KLIJAVOSTI I ENERGIJE KLIJANJA SERTIFIKOVANOG KOMERCIJALNOG SEMENA TRI ZP HIBRIDA KUKURUZA TOKOM PETOGODIŠNJEG PERIODA (2018-2022)

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U proizvodnji i doradi komercijalnog semena poseban akcenat se stavlja na kvalitet semena, pri čemu klijavost predstavlja najvažniji parametar kvaliteta kada je u pitanju promet semenske robe na tržištu. Jedan od glavnih izazova semenske proizvodnje i dorade semena kukuruza predstavlja skladištenje semenskog materijala u odgovarajućim uslovima u cilju što boljeg očuvanja klijavosti i energije klijanja tokom određenog vremenskog perioda. Prema važećim zakonskim regulativama Republike Srbije, sertifikovano seme kukuruza koje se nalazi u prometu na tržištu mora ispunujavati određene kriterijume kada je u pitanju klijavost (Pravilnik o kvalitetu semena poljoprivrednog bilja). S obzirom da klijavost semena tokom skladištenja opada, neophodno je redovno ispitivanje klijavosti u akreditovanim laboratorijama kao preduslov za plasman skladištenog semena na tržište.
Cilj istraživanja ovog rada je bio da se utvrdi promena ukupne klijavosti i energije klijanja tokom skladištenja sertifikovanog semena hibrida kukuruza u petogodišnjem periodu. Ispitivana je klijavost semena tri komercijalna hibrida kukuruza (ZP 704, ZP 873 i ZP 600), jednom godišnje, u periodu od 2018-2022. godine. U analizu klijavosti bile su uključene četiri partije hibrida ZP 704, jedna partija hibrida ZP 873 i tri partije hibrida ZP 600. Za ispitivanje klijavosti korišćen je standardni test klijavosti “između papira”. Rezultati klijavosti za svaki hibrid su izraženi u vidu proseka rezultata ispitivanih partija tog hibrida.
Najviše prosečne vrednosti ukupne klijavosti i energije klijanja semena sva tri ispitivana hibrida očekivano su zabeležene prilikom prvog testiranja u 2018. godini (ZP 704-98,8%/98,8%; ZP 873-100%/100%; ZP 600-98,3%/98,3%). Na polovini ispitivanog perioda (testiranje u 2020.godini) utvrđeno je blago opadanje prosečne ukupne klijavosti i energije klijanja semena sva tri hibrida (ZP 704-98,5%/98,5%; ZP 873-98%/98%; ZP 600-97,6%/97,6%), pri čemu je prosečna energija klijanja u sva tri slučaja bila u nivou ukupne klijavosti. Na samom kraju ispitivanja (2022), prosečna ukupna klijavost kod sva tri hibrida bila je iznad 90% (ZP 704-93,7%; ZP 873-94%), dok je hibrid ZP 600 imao prosečnu ukupnu klijavost iznad 95% (96%). Dok se na kraju ispitivanog perioda energija klijanja smanjila kod semena hibrida ZP 704 (92,7%) i ZP 873 (88%) u odnosu na ukupnu klijavost, seme hibrida ZP 600 imalo je identičan rezultat ukupne klijavosti i energije klijanja (96%). Hibrid ZP 600 je pokazao najmanju promenu ukupne klijavosti tokom ispitivanog perioda (98,3% u 2018. godini, 96 % u 2022. godini) uz visoke vrednosti ukupne klijavosti i energije klijanja na poslednjem testiranju.
Na osnovu rezultata može se izvesti zaključak da su uslovi skladištenja semena bili odgovarajući s obzirom na relativno dobre rezultate ukupne klijavosti semena sva tri hibrida na kraju ispitivanog perioda. Hibrid ZP 600 je označen kao izuzetno rentabilan za semensku proizvodnju, što dalje ukazuje na jako dobre semenarske karakteristike njegove majčinske komponente.
Ključne reči: *kukuruz, klijavost, energija klijanja*

POLLINATION SERVICE IMPACT ON SUNFLOWER'S YIELD COMPONENTS, GRAIN YIELD AND OIL CONTENT

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The importance of pollination service of insects, especially honey bees, has been very important topic recently, due to disturbance of pollinators via global climate changes, extreme weather patterns and human impact through environmentally unfavorable agriculture practices, such as agri-chemical application. In order to investigate importance of pollination service on sunflower, the most important oil plant in continental climate, an experiment has been conducted at five sites in Northeastern Croatia during year 2022., where impact of pollination at sunflower's yield components, grain yield and oil content has been evaluated through following treatments: CT) open pollination with free access of pollinators to flowers; TI) insect pollination has been prevented by net caps during whole flowering period; HP) only hand pollination has been conducted, whereas net caps disabled insects from pollination, HO) hand pollination and open pollination were conducted, and SE) net caps were removed from sunflowers during 10 minutes period twice during flowering stage, and pollinators were recorded during visits. On each site, five groups of five sunflowers, set up 10 m apart among themselves, were marked and subjected to described treatments at the beginning of flower opening stage, one treatment per one marked sunflower's head. Net caps were removed after flowering stage, and marked sunflowers were picked up at full maturity. Sunflower head diameter, number of fertile and sterile grains, mass of fertile grains, grains moisture and oil content were determined for each head, and grain yield has been recalculated from plant's density and each head grain's mass. Result showed that the most observed pollinator was honeybee (more than 97%), open pollination treatment (CT) yielded the highest head diameter, total number of fertile grains, mass of grains and oil content, followed by treatments HO and SE, whereas treatments without pollinators (HP and TI) recorded up to 18% smaller head diameter, 32% less fertilized grains, 35-39% smaller grain mass and 3-7% less oil content. Grain yield achieved by open pollination treatment (CT) was 5,7 t/ha, whereas denying pollinators visit to sunflower caused grain yield reduction of 35-39%.
Key words: *sunflower, pollination service, oil content*

UTJECAJ USLUGE OPRAŠIVANJA NA KOMPONENTE PRINOSA, UROD ZRNA I SADRŽAJ ULJA SUNCOKRETA

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Važnost usluge oprašivanja insekata, naročito medonosnih pčela, u poslijednje vrijeme postaje važna tema, najviše zbog poremećaja oprašivanja kroz globalne klimatske promjene, ekstremne vremenske pojavnosti te humani utjecaj kroz za okoliš nepovoljne poljoprivredne prakse, kao što je uporaba agro-kemikalija. U svrhu istraživanja važnosti usluge oprašivanja na suncokret, najvažniju uljaricu kontinentalnog klimata, proveden je eksperiment na pet lokaliteta sjeveroistočne Hrvatske tijekom 2022. godine, gdje je mjeren utjecaj oprašivača na komponente uroda, urod i uljnost suncokreta kroz slijedeće tretmane: CT) slobodna polenacija, sa slobodnim pristupom oprašivača cvijetu; TI) polenacija insektima onemogućena postavljanjem zaštite mrežice tijekom cijelog trajanja cvatnje; HP) provođenje samo ručne polenacije, uz postavljanje zaštitne mrežice za sprječavanje oprašivanja insektima; HO) ručna i slobodna polenacija i SE) uklanjanje zaštitnih mrežica na po 10 minuta dva puta tijekom stadija cvatnje, uz motrenje i bilježenje oprašivača. Na svakom lokalitetu, pet grupa od po pet biljaka suncokreta, udaljenih međusobno 10 m, bilo je označeno i podvrgnuto opisanim tretmanima na početku stadija otvaranja cvjetnih glavica, po jedan tretman na po jednu označenu biljku. Zaštitne mrežice bile su uklonjene nakon stadija cvatnje, te je izvršena berba označenih biljaka u stadiju pune zrelosti. Za svaku glavicu posebno izmjereni su promjer glave, broj fertilnih i sterilnih zrna, masa fertilnih zrna, vlaga zrna i uljnost, dok je prinos zrna izračunat iz sklopa biljaka i mase zrna s pojedinačne glavice suncokreta. Rezlutati pokazuju da je najčešće uočeni oprašivač bila medonosna pčela (preko 97%), da je tretman slobodne polenacije (CT) imao najveći promjer glavice, najveći broj fertilnih zrna, masu zrna i sadržaj ulja, kojeg su slijedili tretmani HO i SE, dok su tretmani bez oprašivača (HP i TI) zabilježili i do 18% manji promjer glavice, 32% manje fertilnih zrna, 35-29% manju masu zrna te 3-7% manji sadržaj ulja. Urod zrna postignut slobodnom polenacijom (CT) bio je 5,7 t/ha, dok je uskraćivanje pristupa cvjetu suncokreta oprašivačima rezultiralo urodom manjim 35-39%.

Ključne riječi: *suncokret, usluga oprašivanja, sadržaj ulja*

BINARY ADSORPTION BY BIO-ADSORBENTS

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Wastewater from the textile industry is a complex, multi-component chemical system and consists of many dyes. The extraction and recycling of dyes would be a beneficial solution from an economic and environmental point of view. From the point of view of the circular economy, the most expedient solution is bioadsorption, i.e. by-products produced in other production processes that have adsorption capacity and this makes them suitable for the extraction of dyes. This study aims to investigate the removal of methylene blue (MB) and basic red 9 (BR9) in binary dye solutions by Hungarian Rice Husk (HRH) and Indonesian Rice Husk (IRH) Using the binary dye solutions will help to understand the adsorption mechanism's complexity as well. Fourier-transform infrared spectroscopy (FT-IR) and scanning electron microscope (SEM) measurements have been conducted for characterized the adsorbents. The batch adsorption method was used to determine the equilibrium time and effect of initial concentration on MB and BR9 adsorption. The isotherm and kinetic models were used to evaluate the adsorption of MB and BR9 in binary dye solutions. The nonlinear isotherm models used Extended Langmuir and Brunauer–Emmett–Teller (BET) multilayer. The nonlinear kinetic models used the pseudo-first-order, pseudo-second-order, the Elovich equation, and intra-particle diffusion. The FT-IR results proved that the rice husk is rich in functional groups such as hydroxyl, carboxyl, and phenolic. The rough surfaces of rice husks were founded by SEM analysis. The results showed that the optimum contact time was achieved at 60 min. According to the correlation coefficient (R^2) and nonlinear Chi-square (χ^2), the isotherm model fit with the BET multilayer isotherm, while the kinetic model followed the Elovich equation. The adsorption capacity using HRH was achieved at 12.1 mg/g for MB and 11.9 mg/g for BR9, while the IRH was obtained at 11.1 mg/g for MB and 12.4 mg/g for BR9. The rice husk as a bio-adsorbent is potential material for removing cationic dyes due to efficient, low-cost, and environmentally friendly.
Key words: *adsorption, binary dye solutions, rice husk*

ENGINEERING BACILLUS SP. FOR THE SCALE-UP PRODUCTION OF INDUSTRIAL ENZYMES

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Bacillus subtilis is regarded as generally recognized as safe (GRAS) and has become a model chassis host cell for industrial applications due to its robustness and metabolic versatility. A variety of valuable compounds, including small molecular compounds, proteins and biopolymers, have been produced with engineered B. subtilis microbial platforms. It serves as a common microbial host for the production of enzymes that are utilized in the food-processing industry. Due to its superior capability for transformation, B. subtilis strain 168, and its protease deficient mutants, are often selected for the laboratory production of proteins while A164 is renowned for its mighty secretive capability of heterologous peptides.

These laboratory strains are inferior to less domesticated strains of B. subtilis, such as B. subtilis ATCC 6051a, both in terms of secretory capability and growth properties when cultivated in complex media. However, the specie is genetically recalcitrant and difficult to be manipulated. Generally, the transformation of non-domesticated Bacillus strains can be partly solved by tedious laboratory work and by attempting a range of transformation protocols. However, for non-domesticated strains, it is likely that the transformation efficiency will never reach a level that is suitable for linear DNA-mediated recombination. It is difficult to perform studies with recalcitrant strains unless a fundamental change is made to the transformability of these strains. This presentation described how the model strain was modified step by step and became a powerful cell machine for large scale production of enzymes.

A mutant strain of B. subtilis 6051a, 164T7P, has been constructed by integrating a copy of comK and T7 RNAP coding fragment into the genome. The strain displayed great potential in overexpression of heterologous peptides. To confer the controllability of the expression, T7 RNAP was placed under an inducible promoter PxylA, the expression of foreign peptides can be induced by adding D-xylose or D-xylose rich polymers since B. subtilis is able to produce produce GH11 and GH30 family endoxylanases that are encoded by xynA and xynC. 164T7P, therefore, can be used as a powerful chassis cell for scale-up production of industrial enzymes.

Key words: *biorefinery, enzymes production, Cell factory, Bacillus subtilis*

INŽENJERIZOVANJE BACILLUS VRSTA ZA UVEĆANJE PROIZVODNJE INDUSTRIJSKIH ENZIMA

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Bacillus subtilis ima status generalno bezbednog mikroorganizma (eng. generally recognized as safe – GRAS) i postao je model šasija ćelije domaćina za industrijske pimene zahvaljujući svojoj robusnosti i metaboličkoj raznolikosti. Spektar vrednih jedinjenja, uključujući male molekule, proteine i biopolimere, proizvode se u inženjerizovanim B. subtilis mikrobnim platformama. Uobičajeno se koristi kao ćelija-domaćin za proizvodnju enzima koji se mogu koristiti u prehrambenoj industriji. Zahvaljujući svojoj izuzetnoj sposobnosti transformacije, B. subtilis soj168, i njegov proteaza-deficijentni mutant, su često korišćeni za laboratorijsku proizvodnju proteina, do je soj A164 prepoznat zbog svoje izuzetne sposobnosti sekrecije heterologih proteina.

Ovi laboratorijski sojevi su inferiorniji u odnosu na divlje sojeve B. subtilis, kao što je B. subtilis ATCC 6051a, i u pogledu sekretornih sposobnosti i u pogledu rasta kada se gaje u kompleksnom medijumu. Pa ipak, vrsta je genetički otporna i teška za manipulaciju. Generalno, transformacija divljih Bacillus sojeva se može delimično postići mukotrpnim laboratorijskim radom i isprobavanjem mnogo različitih protokola za transformacije. Ipak, za divlje sojeve, verovatno je da efikasnost transformacije nikad ne dostigne nivo potreban za linearnu DNK-posredovanu rekombinaciju. Teško je izvoditi ispitivanja sa otpornim sojevima ukoliko se ne uvede neka fundamentalna promena u transformativnost ovih sojeva. Ova prezentacija će opisati kako je model soj modifikovan korak po korak kako bi postao moćna ćelijska mašina za intenzivnu proizvodnju enzima u velikim razmerama procesa.

Mutant B. subtilis 6051a, 164T7P, je konstruisan integracijom kopije comK and T7 RNAP kodirajućeg fragmenta u genom. Soj je pokazao izuzetan potencijal za hiperekspresiju heterologih peptide. Da bi se potvrdila kontrolabilnost ekspresije, T7 RNAP je postavljen pod kontrolu inducibionog promotera PxylA, a ekspresija stranih peptide se može indukovati dodatkom D-ksiloze ili D-ksiloza bogatih polimera, budući da B. subtilis proizvodi GH11 i GH30 family endoksilanaza koje su kodirane sa xynA i xynC. Ovim je pokazano da se 164T7P može koristiti kao moćna šasija za uvećanje proizvodnje industrijskih enzima.

Ključne reči: *biorafinerija, enzimska proizvodnja, ćelijska fabrika, Bacillus subtilis*

INFLUENCE OF STRESS / DROUGHT ON WHEAT GRAIN QUALITY

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According to data from the literature, the great importance of water and temperature regime in agricultural production has been established. The World Meteorological Organization (WMO, 1992) defines drought through several phenomena as a prolonged absence or pronounced deficit of precipitation, a period of unexpectedly dry weather in which the lack of precipitation causes a serious hydrological imbalance, a deficit of precipitation that causes a lack of water for a specific activity. According to these phenomena, drought/stress can be divided into meteorological drought, which is caused by a reduced amount of precipitation compared to the multi-year average or a complete absence of precipitation in a certain period of time. hydrological drought is a precipitation deficit over a longer period of time that affects surface and underground water supplies: the flow of water in rivers and streams, the water level in lakes and the level of groundwater. When flows and levels decrease, we speak of a hydrological drought. The beginning of the hydrological drought can lag several months after the beginning of the meteorological drought, but it can also last even after the end of the meteorological drought. Agronomic drought is a short-term lack of water for a period of several weeks in the surface layer of the soil, which occurs at a critical time for plant development, can cause agronomic drought. The onset of an agronomic drought may lag behind a meteorological drought, depending on the condition of the surface layer of the soil. High temperatures, low relative humidity and wind intensify the negative consequences of agronomic drought. The yield and quality of grain are conditioned by the climatic conditions of production, implemented agrotechnical measures, soil fertility and the choice of genotype. Proper agrotechnical measures can create favorable conditions for optimal plant growth and development because the soils of eastern Croatia have different physical, chemical, pedological and biological properties. Therefore, the goal of breeding is the creation of new superior cultivars for various purposes, new technological and climatic conditions of cultivation and tolerance to stressful conditions of the external environment. In recent years, the occurrence of climatic extremes has become frequent both on a global level and in the production area of the Republic of Croatia. Climatic changes with an emphasis on high air temperature and less precipitation significantly affect all stages of growth and development of wheat, resulting in a decrease in yield and grain quality. The goal of the work is to determine the reaction of the wheat genotype to stress conditions in achieving grain yield and grain quality by analyzing the amount and distribution of precipitation depending on the locality of production. Polish experiments were conducted in 2021 and 2022, on three wheat varieties of the Osijek Agricultural Institute (Kraljica, Vulkan, Tika-Taka) at three locations in the Republic of Croatia (Vukovar, Slavonski Brod, Beli Manastir). In the Polish experiment, the usual agrotechnics and fertilization in wheat production were applied (150kg N/ha, 100kg/ha P_2O_5, 120kg/ha K_2O). Weighing of grain yield was done on a truck scale when grain samples were taken for chemical analysis. The yield of natural grain is determined at 14% water content in the grain. The grain water content at harvest was from 9.67% to 13.62%, protein content from 10.37% to 15.85%, gluten from 20.59 to 34.67%, grain hardness from 67.54 to 84 ,73%. The highest grain quality and yield in both years was found in the Kraljica wheat variety, and the decrease in grain yield due to the lack of precipitation in 2023 compared to 2022 was from 27 to 42%, depending on the location of the production experiment. Agrochemical analysis of grain was determined in the laboratory of the Agricultural Institute Osijek on NIR DA 7250
Key words: *wheat, grain quality, grain yield*

UTJECAJ STRESA / SUŠE NA KVALITETU ZRNA PŠENICE

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Prema podatcima iz literature utvrđena je velika značajnost vodo i temperaturnog režima u poljoprivrednoj proizvodnji. Svjetska meteorološka organizacija (WMO, 1992) definira sušu kroz nekoliko pojava produljeni izostanak ili naglašeni deficit oborine, period neočekivano suhog vremena u kojem nedostatak oborine uzrokuje ozbiljnu hidrološku neravnotežu, deficit oborine koji uzrokuje manjak vode za određenu djelatnost. Prema tim pojavama sušu/stres možemo podijeliti na meteorološku sušu koja je uzrokovana smanjenom količinom oborine u odnosu na višegodišnji prosjek ili potpunim izostankom oborine u određenom vremenskom razdoblju. hidrološka suša je deficit oborina u duljem vremenskom razdoblju utječe na površinske i podzemne zalihe vode: na protok vode u rijekama i potocima, na razinu vode u jezerima i na razinu podzemnih voda. Kada se protoci i razine smanje govori se o hidrološkoj suši. Početak hidrološke suše može zaostajati nekoliko mjeseci za početkom meteorološke suše, no i trajati i nakon završetka meteorološke suše. Agronomska suša je kratkoročan manjak vode u razdoblju od nekoliko tjedana u površinskom sloju tla, koji se događa u kritično vrijeme za razvoj biljaka, može uzrokovati agronomsku sušu. Početak agronomske suše može zaostajati za meteorološkom sušom, ovisno o stanju površinskog sloja tla. Visoke temperature, niska relativna vlažnost zraka i vjetar pojačavaju negativne posljedice agronomske suše. Prinos i kvaliteta zrna uvjetovani su klimatskim uvjetima proizvodnje, provedenim agrotehničkim mjerama, plodnosti tla i izborom genotipa. Pravilnim agrotehničkim mjerama mogu se stvoriti povoljni uvjeti za optimalan rast i razvoj biljke jer su tla istočne Hrvatske različitih fizikalnih, kemijskih pedoloških i bioloških svojstava. Radi toga cilj oplemenjivanja je stvaranje novih superiornih kultivara za razne namjene, nove tehnološko-klimatske uvjete uzgoja i tolerantnosti na stresne uvijete vanjske sredine. Posljednjih godina učestala je pojava klimatskih ekstrema kako na globalnoj razini, tako i na proizvodnom području Republike hrvatske. Klimatske promjene s naglaskom na visoku temperaturu zraka i manju količinu oborina značajno utječu na sve faze rasta i razvoja pšenice, posljedica toga je smanjenje prinosa i kvalitete zrna. Cilj rada je analizom količine i rasporeda oborina ovisno o lokalitetu proizvodnje utvrditi reakciju genotipa pšenice na uvjete stresa u postizanju prinosa i kvalitete zrna. Poljski pokusi su provedeni u 2021. i 2022. godini, na tri sorte pšenice Poljoprivrednog instituta Osijek (Kraljica, Vulkan, Tika-Taka) na tri lokaliteta u Republici Hrvatskoj (Vukovar, Slavonski Brod, Beli Manastir). U poljskom pokusu primjena je uobičajena agrotehnika i gnojidba u proizvodnji pšenice (150kg N/ha, 100kg/ha P_2O_5, 120kg/ha K_2O). Vaganje prinosa zrna izvršeno je na kolskoj vagi kada su uzeti uzorci zrna za kemijske analize. Prinos naturalnog zrna je određen na 14% sadržaja vode u zrnu. Sadržaj vode zrna u žetvi bio je od 9,67% do 13,62%, sadržaj proteina od 10,37% do 15,85%, gluten od 20,59 do 34,67%, tvrdoća zrna od 67,54 do 84,73%. Najveća kvaliteta i prinos zrna u obje godine utvrđena je kod sorte pšenice Kraljica, a smanjenje prinosa zrna uslijed nedostatka oborina u 2023. godini u odnosu na 2022. godinu bilo je od 27 do 42% ovisno o lokalitetu proizvodnog pokusa. Agrokemijska analiza zrna određena je u laboratoriju Poljoprivrednog instituta Osijek na NIR DA 7250

Ključne riječi: pšenica, kvaliteta zrna, prinos zrna

POTENTIAL USE OF FAVA BEAN (VICIA FABA L.) IN CREATION OF PLANT BASED SPREADS

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Legumes have gained popularity in recent years due to their high protein content (about twice that of cereals), dietary fiber, minerals, and vitamins, and low fat content. Moreover, legumes possess flexibility to withstand harsh climate conditions, grow in high salinity or clay soil, fix nitrogen, and attract pollinators, making them an agronomically sustainable plant-based source. Fava beans (Vicia faba L.) have a high protein-to-carbohydrate ratio in comparison to other legumes and a beneficial composition of essential amino acids, allowing their dietary intake in appropriate quantities to fulfill the daily requirement when combined with cereals. Plant-based spreads are gaining popularity, and this market is developing fast. Food market need to shift from predominantly soy, almond, and rice-based spreads to more sustainable food sources.

Therefore, the objective of the present work was to evaluate the potential of fava bean for production of plant-based spread, considering nutritional, sensory, textural and colour properties. Three different formulations were created and compared with two commercially available chickpea based spreads that were chosen based on their popularity on the market in Serbia. The results showed that all three fava bean spreads possess significantly ($P<0.05$) higher content of proteins and similar content of fats. Textural analysis performed instrumentally by the Texture Analyzer shows that fava bean spreads were less firm than commercial samples, requiring less work of shear to spread between instrument rigs. However, sensory analysis performed with trained sensory panel showed that all examined samples exhibited acceptable sensory properties, similar to that of Commercial sample 1, particularly in terms of spreadability and noticed graininess. Color properties are highly influenced by the used raw materials and spices, however, the instrumentally measured parameters of colour lightness, redness and yellowness of spread samples were at the comparable and acceptable level.

The present study revealed that fava bean could be exploited in plant-based spreads production, ensuring multiple benefits such as increasing the nutritional quality of the final product.

Key words: *fava bean, legumes, spreads, sensory analysis*

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POTENCIJALNA UPOTREBA BOBA (VICIA FABA L.) U RAZVOJU BILJNIH NAMAZA

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Mahunarke privlače sve veću pažnju poslednjih godina zbog visokog sadržaja proteina (otprilike dvostruko više od žitarica), prehrambenih vlakana, minerala i vitamina i niskog sadržaja masti. Štaviše, mahunarke poseduju fleksibilnost da izdrže oštre klimatske uslove, rastu na tlu sa visokim salinitetom ili čak na glinenom tlu, fiksiraju azot i privlače oprašivače, što ih čini agronomski održivom sirovinom. Bob (Vicia faba L.) ima visok odnos proteina i ugljenih hidrata u poređenju sa drugim mahunarkama i blagotvoran sastav esencijalnih aminokiselina, što omogućava njihov unos ishranom u odgovarajućim količinama, što omogućava da se ispune njihove dnevne potrebe kada se pravilno kombinuju sa žitaricama. Namazi na bazi biljaka postaju sve popularniji, a ovo tržište se brzo razvija. Trendovi u razvoju prehrambenih proizvoda tipa namaza nameću potrebu da se sve više prelazi sa namaza na bazi soje, badema i pirinča pretežno na održivije izvore hrane.
Imajući sve navedeno u vidu, cilj ovog istraživanja bio je da se proceni potencijal boba za proizvodnju biljnog namaza, uzimajući u obzir hranljive, senzorske, teksturne i osobine boje. Kreirane su tri različite formulacije namaza od boba i upoređene sa dva komercijalno dostupna namaza na bazi leblebije koja su izabrana na osnovu njihove popularnosti na tržištu u Srbiji. Rezultati su pokazali da sva tri namaza od boba poseduju značajno ($P<0,05$) veći sadržaj proteina i sličan sadržaj masti u poređenju sa komercijalnim uzorcima. Analiza teksturnih osobina, određenih instrumentalno primenom analizatora teksture, pokazuje da su namazi od boba bili manje čvrsti od komercijalnih uzoraka, što je zahtevalo manji rada smicanja da bi se uzorak rasporedilo između dva korišćena nastavka instruments Međutim, senzorska analiza sprovedena sa panelom treniranih senzorskih ocenjivača pokazala je da su svi ispitivani uzorci pokazali prihvatljiva senzorska svojstva, slična onima kod komercijalnog uzorka 1, posebno u pogledu mazivosti i uočene zrnavosti. Na osobine boje u velikoj meri utiču korišćene sirovine i začini, međutim instrumentalno izmereni parametri svetline boje, udela crvene i žute boje uzoraka namaz bili su uporedivi i na prihvatljivom nivou.
Ovo istraživanje je pokazalo da se bob može iskoristiti u proizvodnji namaza na bazi biljaka, obezbeđujući višestruke prednosti kao što je povećanje nutritivnog kvaliteta finalnog proizvoda.
Ključne reči: *bob, mahunarke, namazi, senzorska analiza*

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THE INFLUENCE OF SHELLAC APPLICATION ON ZEIN FILM PROPERTIES

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The importance of biopolymer materials, in the context of reduction of waste, remained after the use of conventional packaging, with the use of renewable raw materials for their production, justifies an intensive research focus in the field of natural, degradable, edible packaging. Zein is a hydrophobic protein found in corn, and its most common application is as a protective material in the food industry. In this work, zein-based films were synthesized and characterized. A major disadvantage of biopolymer films is their permeability to water vapor and gases. The high hydrophobicity of lipid components in the form of waxes, oils, and resins, which makes them insoluble in water and soluble in typical organic solvents, explains why lipid components are the most effective barriers to water vapor transfer. This is why shellac resin was added to zein films. Shellac was added in two ways: (1) by lamination on the existing dry zein film (samples marked as L), (2) by adding shellac alcohol solution during the synthesis of zein film in a ratio of 50-50 by casting process (samples marked as M). Zein films without the addition of shellac were designated as control samples. Physico-chemical (thickness, moisture content), mechanical (tensile strength and elongation at break) and barrier characteristics (water vapor permeability) were examined for all sample groups. The resulting films are transparent, glossy, light yellow (control) to ocher (samples with added shellac), flexible, non-sticky. The results showed significantly higher values of elongation at break in samples to which shellac was added compared to the control sample. These values are higher for laminated samples. Also, significantly lower water vapor permeability values were found, 10.04 g/(m^2·h) for L samples, 18.41 g/(m^2·h) for M samples, compared to the control pure zein film (40.33 g/(m^2·h)), which is also the biggest contribution of this work. Optimizing the production process, as well as the properties of the obtained biopolymer films, directly affects the expansion of their application.

Key words: *shellac resin, zein film, properties*

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UTICAJ PRIMENE ŠELAKA NA SVOJSTVA ZEIN FILMA

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Značaj biopolimernih materijala, u kontekstu redukcije otpada, zaostalog nakon upotrebe konvencionalne ambalaže, uz upotrebu obnovljivih sirovina za njihovo dobijanje opravdava intenzivan focus istraživanja oblasti prirodne, razgradive, jestive ambalaže. Zein je hidrofoban protein koji se nalazi u kukuruzu, a najčešću primenu nalazi kao zaštitni materijal u prehrambenoj industriji. U ovom radu sintetisani su i okarakterisani filmovi na bazi zeina. Velika mana biopolimernih filmova je njihova propustljivost vodene pare i gasova. Visoka hidrofobnost lipidnih komponenata u vidu voska, ulja, smola, koja ih čini nerastvorljivim u vodi, a rastvorljivim u tipičnim organskim rastvaračima, objašnjava zašto su voskovi najefikasnije prepreke za transfer vodene pare. Zbog toga je zeinskim filmovima dodata šelak smola. Šelak je dodat na dva načina: (1) laminacijom na postojeći suv zeinski film (uzorci označeni kao L), (2) dodatkom šelak alkoholnog rastvora prilikom sinteze zeinskog filma u odnosu 50-50 postupkom razlivanja (uzorci označeni kao M). Zeinski filmovi bez dodatka šelaka su označeni kao kontrolni uzorci. Svim grupama uzoraka ispitane su fizičko-hemijske (debljina, sadržaj vlage), mehaničke (zatezna jačina i izduženje pri kidanju) i barijerne karakteristike (propustljivost vodene pare). Dobijeni filmovi su transparentni, sjajni, svetlo žute (kontrola) do oker boje (uzorci sa dodatkom šelaka), fleksibilni, neleplјivi. Rezultati su pokazali značajno veće vrednosti izduženja pri kidanju kod uzoraka kojima je dodat šelak u odnosu na kontrolni uzorak. Ove vrednosti su veče kod laminiranih uzoraka. Takođe, konstatovane su značajno manje vrednosti propustljivosti vodene pare 10,04 g/(m^2·h) kod L uzoraka, 18.41 g/(m^2·h) kod M uzoraka, u odnosu na kontrolni čist zeinski film (40.33 g/(m^2·h)), što ujedno predstavlja i najveći doprinos ovog rada. Optimizacija postupka proizvodnje, ali i osobina dobijenih bipolimernih filmova direktno utiče na proširivanje pravca njihove primene.

Ključne reči: *šelak smola, zein film, svojstva*

APPLICATION OF LAVENDER AND MINT ESSENTIAL OILS FOR IMPROVEMENT OF ALFALFA (MEDICAGO SATIVA L.) SEED QUALITY

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Natural allelopathic substances are products or metabolites of some plants, released into the environment, and they have the potential to be used in sustainable agricultural management systems. A sustainable system includes the use of natural resources for plant protection, diseases, pests, and weed control without the use of synthetic chemicals. Essential oils (Eos) are well-known metabolites utilised in agriculture.
From previous studies, it was known that Eos have toxic effects on phytopathogens as well as an inhibitory effect on seed germination. Less research has been done on the Eo's ability to reduce dormancy and boost germination. The study's objective was to ascertain the significance of Eo's impact on alfalfa (Medicago sativa L.) seed dormancy.
The seed material of four different varieties of Medicago sativa was used for the experiment (Zaječarka, Banatska, K-28, Novosadska). Two essential oils, lavender (Lavandula angustifolia Mill.) and mint (Mentha piperita L.) were applied to seeds at four concentrations—1%, 0.5%, 0.2%, and 0.02%—along with water as a control. Lavender and mint essential oils used in the experiment are commercial oils obtained from mint leaves and fresh lavender flowers by distillation. Germination, dormant seeds and dead seeds were evaluated in a laboratory setting according to ISTA rules, in Petry dishes on filter paper. A germination cabinet was the equipment for seed germination.
Results showed that the type of Eos had no discernible influence on germinated seeds, dormancy, and dead seeds. The oil concentration was the most significant factor affecting physiological characteristics. Both oils in concentrations of -1% and 0.5% inhibited seed germination 100%. The maximum germination at 91,66% was achieved with the Novosadska variety using lavender oil at a concentration of 0.02%, while dormancy was reduced. Varieties Zaječarka and Banatska had the highest level of dead and dormant seeds, when lavender and mint Eos were applied at a concentration of 0.2%.
This study showed that both Eos at a concentration of 0.02% had a stimulatory effect on seed germination and simultaneously reduced seed dormancy, emphasizing their potential use for seed quality improvement in organic farming.
Key words: *essential oils, concentration, dormancy*

PRIMENA ESENCIJALNIH ULJA LAVANDE I NANE ZA POBOLJŠANJE KVALITETA SEMENA LUCERKE (MEDICAGO SATIVA L.)

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Prirodne alelopatske supstance su proizvodi ili metaboliti nekih biljaka, koje biljka otpušta u životnu sredinu, i imaju potencijal da se koriste u upravljanju sistema održive poljoprivrede. Održiv sistem uključuje korišćenje prirodnih resursa za zaštitu bilja, suzbijanje bolesti, štetočina i korova bez upotrebe sintetičkih hemikalija. Esencijalna ulja (Eu) su dobro poznati metaboliti koji se koriste u poljoprivredi.
Iz ranijih istraživanja poznato je da Eu imaju toksično dejstvo na fitopatogene, kao i inhibitorno dejstvo na klijanje semena. Manje istraživanja je rađeno o sposobnosti Eu da smanje mirovanje i povećaju klijavost semena. Cilj studije je bio da se utvrdi značaj delovanja Eu na mirovanje (dormantnost) semena lucerke (Medicago sativa L.).
Za ogled korišćen je semenski materijal četiri sorte lucerke (Zaječarka, Banatska, K-28, Novosadska). Dva Eu, lavanda (Lavandula angustifolia Mill.) i nana (Mentha piperita L.) primenjena su na semenu lucerke u četiri koncentracije — 1%, 0,5%, 0,2% i 0,02% — zajedno sa vodom kao kontrolom. Ulja nane i lavande korišćena u eksperimentu su komercijalna ulja dobijena destilacijom listova nane i svežih cvetova lavande. Klijavost, dormantnost i mrtvo seme su procenjeni u laboratorijskim uslovima prema ISTA pravilima, u petrijevim posudama na filter papiru. Klijanje je rađeno u komori za klijanje.
Rezultati su pokazali da vrsta Eu nije imala vidljiv uticaj na klijanje semena, mirovanje i mrtvo seme. Koncentracija ulja je bila najznačajniji faktor koji je uticao na fiziološke karakteristike. Oba ulja u koncentracijama od 1% i 0,5% su inhibirala klijanje 100%. Maksimalna klijavost 91,66% je postignuta kod sorte Novosadska uz korišćenje ulja lavande u koncentraciji 0,02%, dok se mirovanje smanjilo. Sorte Zaječarka i Banatska su imali najviši nivo mrtvog i dormantnog semena, kada su tretirane uljem lavande i nane u koncentraciji od 0,2%.
Ova studija je pokazala da su oba Eu u koncentraciji od 0,02% imala stimulativni efekat na klijavost semena, i istovremeno smanjila mirovanje semena, naglašavajući njihovu potencijalnu primenu za poboljšanje kvaliteta semena u organskoj poljoprivredi.
Ključne reči: *esencijalna ulja, koncentracija, dormantnost.*

EUROPEAN CRANBERRYBUSH (VIBURNUM OPULUS L.) FRUIT AND SEED: SOME PHYSICAL PROPERTIES

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The physical properties of fruits and seeds are one of the important parameters in the design of machines and processes for harvesting, handling, storage, grading, conveying, and packaging. European Cranberrybush (Viburnum Opulus L.) is an endemic and organic fruit mostly grown in Turkey, Poland, Lithuania, Russia and Ukraine. It is used as traditional and folk medicine due to the belief that it positively affects human health, particularly kidney stone disease. The high amount of polyphenolics, phenolic acids and anthocyanins, and organic acids bring alternative consumption methods such as fruit juice, nectar, jam, marmalade, pickle, vinegar, and food supplement, tea, granola bar or ingredient of bread, cookie, pudding and cake. In this study, the physical properties of European Cranberrybush fruit and seed were evaluated and compared. The moisture (wet basis) of fruit (86.15%) and seed (56.97%) were determined. The average length, width, thickness, geometric mean diameter, sphericity, surface area and 1000-unit mass were of fruit 11.33 mm, 9.98 mm, 9.57 mm, 10.23 mm, 1.03, 320.68 mm^2 and 647.24 g, respectively. Corresponding values for seed were 7.62 mm, 6.04 mm, 1.82 mm, 4.36 mm, 2.42, 59.94 mm^2 and 37.64 g, respectively. The bulk density, true density, porosity, projected area and perimeter of fruit were 544.24 kg/m^3, 41.94 kg/m^3, 3.33%, 1.15 cm^2 and 4.03 cm, while the same value for seed was 340.05 kg/m^3, 960.97 kg/m^3, 64.44%, 0.45 cm^2 and 2.51 cm, respectively. The color values of L*, a*, b*, C and α for fruit (29.88, 30.88, 21.33, 37.53, and 34.64) were found lower than seeds (42.99, 30.90, 32.04, 44.52, and 46.06). In conclusion, the obtained data showed that the European Cranberrybush has one of the smallest fruit and seed in the Caprifoliaceae family.

Key words: *Physical measurements, Image processing, Colour*

FROM HOME VERTICAL GARDEN TO FUNCTIONAL VERTICAL FARM WITH THE USE OF AUTOMATION

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The concept of vertical farms is slowly but surely becoming more current and an attractive field of research in the future. The daily increase in population requires adequate resources, which include, in addition to energy, food production. The concept of vertical plant cultivation has the potential to meet this demand, especially in urban and densely populated areas.

The goal of vertical plant cultivation is to increase agricultural production per unit of the area by optimizing costs and maximally satisfying the requirements of sustainable development. In this way, vertical farming would be applied globally and solve the problem of feeding a large part of the world's population.

Also, one of the main goals of vertical farming is the food of good quality, with minimal (or no) content of substances harmful to human health, and whose production occurs continuously throughout the year. Today, people have recognized the need for healthy food and the preservation of natural resources (environmental protection and sustainable development). That is why they often start creating their own home vertical gardens. The concept of vertical cultivation of plants is closely related to organic food production since, in vertical systems, pesticides, fungicides, and herbicides are significantly reduced or completely eliminated.

This paper traces the transition process from a vertical home garden to a functional vertical farm. At the beginning of this process, it is necessary to monitor the critical technical parameters of the system (temperature, humidity, carbon dioxide, oxygen content, pH...), which requires the introduction of sensors into the process. The next step is the management of process variables, that is, controlling lighting, air flow and water flow, nutrients, protection of plants from diseases and pests, etc. Finally, during the transition, it is necessary to take care of energy efficiency, minimization of water consumption, and optimization of the values of all process parameters while respecting the economic indicators and profitability of the entire project.

The concept of a vertical garden, with an analysis of its strengths and weaknesses and the potential for developing such systems, was carried out on the example of a real plant in an agricultural household.

Key words: *vertical farms, automation, organic food production*

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OD KUĆNE VERTIKALNE BAŠTE DO FUNKCIONALNE VERTIKALNE FARME PRIMENOM AUTOMATIKE

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Koncept vertikalnih farmi polako ali sigurno postaje sve aktuelniji i atraktivno polje istraživanja u budućnosti. Svakodnevni porast populacije zahteva i adekvatne resursima koji uključuju, pored energije, i proizvodnju hrane. Koncept vertikalnog uzgoja biljaka ima potencijal da odgovori na ovaj zahtev, pre svega u urbanim sredinama i gusto naseljnim oblastima.

Cilj vertikalnog uzgoja biljaka je da se poveća poljoprivredna proizvodnja po jedinici površine a da se pri tome optimizuju troškovi i maksimalno zadovolje zahtevi održivog razvoja. Na ovaj način, koncept vertikalnog farminga bi bio primenjen na globalnom nivou i rešavao bi problem ishrane velikog dela svetske populacije.

Takodje, jedan od glavnih ciljeva vertikalnog farminga jeste hrana koja je dobrog kvaliteta, sa minimalnim (ili bez) sadržaja materija škodljivih za ljudsko zdravlje i čija se proizvodnja kontinualno odvija tokom čitave godine. Ljudi su danas prepoznali potrebu za zdravom hranom i očuvanjem prirodnih resursa (zaštita životne sredine i održivi razvoj) i zato se sad već neretko upuštaju u izradu sopstvenih kućnih vertikalnih bašti. Koncept vertikalnog uzgoja biljaka je usko povezana sa organskom proizvodnjom hrane pošto je u vertikalnim sistemima korišćenje pesticida, fungicida i herbicida značajno smanjeno ili potpuno izbačeno

Ovaj rad prati proces tranzicije od kućne vertikalne bašte do funkcionalne vertikalne farme. Na početku ovog procesa, potrebno je obezbediti nadzor nad ključnim tehničkih parametrima sistema (temperatura, vlažnost, sadržaj ugljen-dioksida i kiseonika, pH...), što zahteva uvodjenje senzora u proces. Sledeći korak jeste upravljanje procesnim veličinama, odnosno upravljanje osvetljenjem, protokom vazduha i protokom vode, hranivima, zaštitom biljaka od bolesti i štetočina itd. Finalno, prilikom tranzicije potrebno je voditi računa o energetskoj efikasnosti, minimizaciji potrošnje vode i optimizaciji vrednosti svih parametara procesa uz uvažavanje ekonomskih pokazatelja i isplativosti celog projekta.

Koncept vetikalne bašte sa analizom dobrih strana i slabosti, i potencijalom za razvoj ovakvih sistema je izvršen na primeru realnog pogona u jednom poljoprivrednom domaćinstvu.

Ključne reči: *vertikalne farme, automatika, organska proizvodnja hrane*

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POTENTIAL USE OF PUMPKIN SEED OIL PROCESSING BY-PRODUCT TO IMPROVE QUALITY OF GLUTEN-FREE CRACKERS

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As a consequence of the growing population of health-conscious individuals, there is a trend toward the fortification of conventional bakery products with nutrient-rich ingredients to produce nutritionally improved or health-enhancing goods, such as high-protein, high-fibre, and low-glycaemic-index products. This trend is particularly prevalent in the development of gluten-free products. The use of unconventional gluten-free flours that are not rich in starch components can significantly improve the nutritional quality of this type of product. In that sense, pumpkin seed press cake, a by-product of oil production and a source of nutritionally valuable compounds such as dietary fibre, proteins, essential fatty acids, antioxidant compounds, and minerals, represents a chance to reduce the nutritional deficiencies of gluten-free products. Therefore, the objective of the present work was to evaluate the effect of pumpkin seed press-cake flour addition on gluten-free cracker formulation, considering nutritional and sensory characteristics as well as the glycaemic index, polyphenolic content, and antioxidant activity of the final product. Three different crackers were formulated: a control cracker prepared with 100% chickpea flour and crackers containing 20% and 35% of the cold-pressed pumpkin seed cake flour instead of chickpea flour. The proximate composition of the crackers obtained is a function of the gradual substitution of chickpea flour with pumpkin seed cake flour, with the presence of pumpkin seed cake flour influencing the higher content of proteins, fats, and ash in crackers while decreasing the total carbohydrate content. Due to the high dietary fibre and protein content of the used raw materials, the investigated crackers may have the claims "high in fibre" and "source of protein". The incorporation of pumpkin seed press cake flours resulted in higher values of total phenolic content and antioxidant activity. All tested crackers had a moderate glycaemic index, but substituting pumpkin seed press cake flour for chickpea flour at both levels (20 and 35%) significantly reduced cracker glycaemic index. Sensory evaluation of crackers showed that all examined samples exhibited acceptable sensory properties, implying that the presence of pumpkin seed press-cake flour did not diminish but rather improve some sensory attributes, such as taste and flavour. The present study revealed that this by-product could be exploited in gluten-free cracker production, ensuring multiple benefits such as increasing the nutritional quality of the final product, enhancing total phenolic content and antioxidant activity, and reducing the glycaemic index of bakery foods, thus concomitantly supporting the concept of industrial symbiosis and revaluing by-products of the food industry.
Key words: *gluten-free crackers, pumpkin seed oil processing by-products, glycaemic index*

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POTENCIJAL BRAŠNA OD POGAČE SEMENA ULJANE TIKVE GOLICE KAO SIROVINE U PROIZVODNJI NUTRITIVNO OBOGAĆENIH BEZGLUTENSKIH KREKERA

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Povećana svest savremenog društva o odnosu hrane i zdravlja nametnula je pojavu trenda ka obogaćivanju konvencionalnih pekarskih proizvoda bogatim hranljivim sastojcima u cilju proizvodnje nutritivno unapređenih proizvoda, kao što su proizvodi bogati proteinima, vlaknima i proizvodi niskog glikemijskog indeksa. Ovaj trend je posebno zastupljen u razvoju bezglutenskih proizvoda. Upotreba nekonvencionalnih bezglutenskih brašna, koje karakterišu manji sadržaj skroba, može značajno poboljšati nutritivni kvalitet ove vrste proizvoda. U tom smislu, pogača semena uljane tikve golice, kao nusproizvod proizvodnje ulja i izvor nutritivno vrednih jedinjenja kao što su dijetalna vlakna, proteini, esencijalne masne kiseline, antioksidativna jedinjenja i minerali, predstavlja adekvatnu sirovinu za proizvodnju bezglutenskih proizvoda odgovarajućeg nutritivnog profila. Stoga je cilj ovog rada bio da se proceni uticaj dodatka brašna od pogače semena uljane tikve golice na kvalitet bezglutenskih krekera, uzimajući u obzir nutritivne i senzorske karakteristike, kao i glikemijski indeks, sadržaj polifenola i antioksidativnu aktivnost finalnog proizvoda. Formulisana su tri različita krekera: kontrolni kreker pripremljen sa 100% brašna od leblebije i krekeri koji sadrže brašno od pogače semena uljane tikve golice u dva nivoa supstitucije (20% i 35%). Hemijski sastav dobijenih krekera je u značajnoj meri zavisio od sirovina korišćenih u formulaciji pri čemu je prisustvo brašna od pogače semena uljane tikve golice uticao na povećanje sadržaja proteina, masti i pepela u krekerima uz smanjenje ukupnog sadržaja ugljenih hidrata. Zbog visokog sadržaja dijetetskih vlakana i proteina u korišćenim sirovinama, novokreirani bezglutenski krekeri mogu biti nosioci nutritivnih izjava kao što su "bogati vlaknima" i "izvor proteina". Supstitucija brašna leblebije sa brašnom od pogače semena uljane tikve golice povećala je sadržaj ukupnih fenola te poboljšala antioksidativnu aktivnost krekera. Svi ispitivani krekeri su imali umeren glikemijski indeks, dok je prisustvo brašna od pogače semena uljane tikve golice značajno uticala na smanjenje glikemijskog indeksa. Senzorska analiza krekera pokazala je da su svi ispitivani uzorci pokazali prihvatljiva senzorska svojstva, pri čemu je prisustvo brašna od pogače semena uljane tikve golice uticao na poboljšanje pojedinih senzorskih svojstava kao što su ukus i aroma. Na osnovu rezultata ovog istraživanja može se zaključiti da se nusproizvod proizvodnje ulja iz semena tikve golice može iskoristiti u proizvodnji bezglutenskih krekera, obezbeđujući višestruke prednosti kao što su povećanje nutritivnog kvaliteta finalnog proizvoda, povećanje ukupnog sadržaja fenola i antioksidativne aktivnosti i smanjenje glikemijskog indeksa, istovremeno podržavajući koncept industrijske simbioze i revalorizacije nusproizvoda prehrambene industrije.
Ključne reči: *bezglutenski krekeri, pogača semena uljane tikve golice, glikemijski indeks*

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CREATING STRUCTURE AND TEXTURE OF PLANT-BASED FISH ANALOGUE USING 3D FOOD PRINTING

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Plant-based alternatives to animal products have been gaining popularity in recent years. Products such as plant-based meat and dairy substitutes are already widely available, but a niche category that is forecast to grow significantly in the coming years is plant-based fish substitutes. Among many challenges related to creating plant-based fish alternatives, one of the biggest is to replicate the fine structure and texture characteristic of fish flesh. Various methods for shaping the structure and texture are recently being investigated. One innovative and promising technology is the extrusion-based 3D food printing. In this method layers are deposited by a moving syringe nozzle loaded with the material supply by extrusion. Depending on the materials used in extrusion processes, the binding mechanisms can occur by the accommodation of layers controlled by the rheological properties of the materials, solidification upon cooling or hydrogel-forming extrusion. The aim of this study was to create a plant-based product imitating fish with nutritional and sensory properties using extrusion-based 3D food printing technology, to analyze the structure and the texture of the product and to compare the results with those obtained for the real fish.
The fish analogue was created from plant-based proteins, fats and additives aiming at shaping the colour and flavour, and also from water. A mixture with the required density was processed according to a previously developed digital model using an extrusion-based 3D food printer.
Once the fish analogue was produced, it was subjected to the heat treatment. Afterwards, the textural properties were analyzed. Additionally, the structure was evaluated by comparing images taken from a tomograph. The obtained results were compared to those obtained for fish flesh. Furthermore, a sensory analysis of fish and their plant-based alternatives was carried out with particular emphasis on textural properties. The texture analysis showed that the plant-based fish substitutes differ in mechanical strength from fish flesh. The obtained results indicate that the differences between fish and fish substitutes were not only seen in the instrumental analysis, but also in the sensory analysis. Based on the results, it can be concluded that although 3D food printing technology can be used to produce vegan fish substitutes, achieving a texture that perfectly mimics that of fish flesh still remains a challenge.
Key words: *3D food printing, plant-based fish analogue, texture*

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DEVELOPMENT AND OPTIMIZATION OF A GREEN EXTRACTION OF BIOACTIVE COMPOUNDS FROM OLIVE LEAVES USING NATURAL DEEP EUTECTIC SOLVENTS

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Natural deep eutectic solvents (NADES) are currently emerging as a new class of green solvents that are effectively used as alternative extraction media of bioactive compounds from raw natural materials and biomass. Some of their most important advantages are their high solvation activity of various polar and non-polar compounds, their properties can be tailored by task-specifically selection of the starting constituents as well as that they can also act as "protective agents" for the extracted bioactive compounds and thus they can be used -as they are- and without any purification or isolation step in the development of novel materials.
In this context, we present here a greener approach for the efficient extraction of bioactive compounds from olive leaves derived from of olive trees of Greek flora. Ultrasound Assisted Extraction (UAE) method was used as a high energy technique, in order to simultaneously minimize the extraction time and maximize the yield. Olive leaves were selected since they consist an important by-product of the olive oil harvesting procedure and the olive oil industry that is simultaneously a valuable and reach source of important bioactive compounds such as hydroxytyrosol, oleoeuropein etc. The components of NADES have significant influence on their physicochemical properties and solubilization ability which affect their extraction efficiency. Herein, seven NADES derived from naturally occurring compounds (e.g. betaine, lactic acid, levulinic acid, glucose etc.) were synthesized and examined as extraction media.
The implementation of the NADESs screening, indicated the Glucose:Lactic acid NADES as the most effective extraction media and the process was optimized using the selected NADES by performing Experimental Design applying a symmetrical three-level Box-Behnken design (BBD). The selected independent variables for the optimization process were the NADES-to-water ratio, the extraction time, the ultrasound power, while the selected responses were the total phenolic (TPC), the total flavonoid content (TFC) as well as the antioxidant activity of the NADES-extracts. From thiw study using the experimental design, not only the optimal extraction conditions were found, but also important information was obtained regarding the correlation between the examined parameters and their effect on the selected responses. Finally, the NADES-extracts were further characterized by performing by LC/MS/MS analysis in an effort to investigate their phytochemical profile.
Overall, the proposed optimized methodology resulted in the efficient extraction of bioactive compounds and could be considered as a competitive alternative to conventional processes.
Key words*: Natural Deep Eutectic Solvents, Olive leaves, Ultrasound assisted extraction*

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NATURAL DEEP EUTECTIC SOLVENTS AND IONIC LIQUIDS AS TOOLS FOR THE DEVELOPMENT OF GREENER PROCESSES

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Green chemistry possesses the spirit of sustainable development and is entering as a dynamic force to a constantly increasing number of chemical processes in the 21st century. In the chemical world, strategies for increasing sustainability often require the redesign of reactions and modifications of existing chemical processes aiming, among other things, at the prevention of waste, minimization of byproducts, reduction of chemicals used as solvents and auxiliaries in a wide range of laboratory and industrial applications.

Natural Deep Eutectic Solvents (NADES), eutectic mixtures comprised of natural products (primary and secondary metabolites such as organic acids, polyols, amino acids, carbohydrates etc), have been characterized as the green solvents of the 21st century. They possess favorable properties and advantages over common organic solvents such as low vapor pressure, high extractive capacity, low production costs, low toxicity and high biodegradability. The extended hydrogen bond array formed among the molecules of a NADES creates a unique medium, ideal for the extraction of bioactive compounds. Moreover, the NADES environment acts as "storage medium" for the air- and light-sensitive bioactive compounds, protecting them from degradation. One additional characteristic feature of NADES as extraction solvents is that by carefully selecting the components of the NADES one can achieve enhanced bioactivity of the final extract: unlike the case of all the other extraction solvents, which have to be removed from the extract after the process, NADES can be retained and the as-obtained extract (NADES containing the bioactive compounds) has high added value, stemming from the combination of the bioactivity of the NADES's components and the extracted bioactive molecules. The array of potential applications of NADESs spams from organic synthesis, enzyme-catalyzed reactions, extraction processes, drug delivery, CO_2 capture and storage, biocompatible nanosystems and many more. Specific NADESs can effectively act as crosslinking and gelating agents for the formation of biopolymer films and hydrogels.

Ionic liquids (ILs) are liquids composed entirely of ions and are synthesized by the combination of a bulky organic asymmetric cation and an organic or inorganic anion. ILs usually have melting points lower than 100◦C and, in many cases, they are liquids at room temperature. Biocompatible Ionic Liquids (Bio-ILs) are a new class of ILs that are task-specifically designed to derive from naturally occurring compounds and/or derivatives thereof, as well as molecules well known for their biocompatibility (e.g., active pharmaceutical ingredients or non-toxic bioactive compounds) in terms of sustainability and biocompatibility. The advantageous and tunable physicochemical and pharmaceutical profiles of this new generation of ILs have resulted in their application in a vast variety of scientific fields, including organic catalysis, lubricants, separation processes and pharmaceutics, with the later one being the most investigated so far.

The present lecture will emphasize the multifaceted character of NADESs and Bio-ILs presenting case studies on their applications as solvents for extraction of valuable phytochemicals from plants and biomass as well as their ability to act as vehicles for drug delivery and their applications in the preparation of smart and functional materials.

Key words: *Green solvents, Natural Deep Eutectic Solvents, Bio-Ionic Liquids*

PRIRODNE EUTEKTIČKE SMEŠE I JONSKE TEČNOSTI KAO ALATI U RAZVOJU ZELENIH PROCESA

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Zelena hemija poseduje duh održivog razvoja i ulazi kao dinamični činilac u rastuće polje hemijskih procesa u 21. veku. U svetu hemije, strategije za unapređenje održivosti procesa često zahtevaju redizajn reakcija i modifikacije postojećih hemijskih procesa, sa ciljem, između ostalog, da spreče nastanak otpadnih ili sporednih tokova i smanjenje potrošnje rastvarača u velikom broju laboratorijskih i industrijskih primena.

Prirodne eutektičke smeše (eng. natural deep eutectic solvents – NADES) predstavljaju smeše prirodnih proizvoda: primarnih ili sekundarnih metabolita kao što su organske kiseline, polioli, aminokiseline, ugljenihidrati i sl. i označeni su kao zeleni rastvarači 21. veka. Oni poseduju pogodne karakteristike i prednosti nad klasičnim organskim rastvaračima, kao što su nizak napon pare, visok ekstraktivni kapacitet, mali troškovi proizvodnje, mala toksičnost i visoka biodegradabilnost. Proširen spektar vodoničnih veza formiran u okviru NADES čine ih medijumima jedinstvenih osobina, idealnim za ekstrakcije bioaktivnih jedinjenja. Takođe, okruženje NADES se ponaša kao "zaštitni medijum" za bioaktivna jedinjenja koja su osetljiva na vazduh ili svetlost, štiteći ih od razgradnje. Još jedna važna krakteristika je da pažljivim odabirom rastvarača koji ulaze u sastav NADES možemo postići unapređenu bioaktivnost finalnog ekstrakta: nasuprot situaciji kod svih drugih rastavarača koji se moraju ukloniti nakon ekstrakcije, NADES se mogu zadržati i dobijen ekstrakti se mogu koristiti kao takvi (NADES sa bioaktivnim ekstrahovanim jedinjenjem) i imati visoku dodatnu vrednost koja potiče od kombinacije bioaktivnosti NADES komponenata i ekstrahovanih bioaktivnih molekula. Spektar potencijalnih primena NADES obuhvata organske sinteze, ekstrakcije, enzimski katalizovane reakcije, sisteme za isporuku lekova, "zarobljavanje" i čuvanje CO_2, biokompatibilnost nanosistema i mnoge druge. Specifični NADES mogu se efikasno ponašati kao umreživači i gelirajući agensi za formiranje biopolimernih filmova i hidrogelova.

Jonske tečnosti (eng. ionic liquid – IL) se sastoje kompletno od jona i sintetišu se kombinacijom velikog organskog asimetričnog katjona i organskog ili neorganskog anjona. ILs obično imaju tačku topljenja nižu od 100°C i, u mnogim slučajevima, tečni su na sobnoj temperaturi. Biojonske tečnosti (eng. biocompatibile inonic liquid – Bio-IL) su nova klasa IL koje se dizajniraju za određenu namenu, tako da sadrže prirodne komponente i/ili njihove derivate, kao i molekule poznate biokompatibilnosti (npr. aktivna farmaceutska jedinjenja ili netoksična bioaktivna jedinjenja). Prednosti i podesiv fizikohemijski i farmaceutski profil ove nove generacije ILs je doveo do primena u velikom broju naučnih oblasti, uključujući organsku katalizu, lubrikante, separacione procese i farmaceutike, koji su i najviše ispitivani do sada.

Ovo predavanje će istaći višestruk karakter NADES i Bio-IL kroz različite studije vezane za njihove primene kao rastvarača za ekstrakcije vrednih jedinjenja iz biljaka i biomase kao i njihove sposobnosti da se koriste za isporuku lekova u pripremi pametnih i funkcionalnih materijala.

Ključne reči: *Zeleni rastvarači, prirodni eutektički rastvarači, biojonske tečnosti*

BIOETHANOL PRODUCTION FROM CORN BY SIMULTANEOUS SACCHARIFICATION AND FERMENTATION USING BAKER'S AND DISTELLERS YEAST

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Bioethanol is one of the and most promising widely used renewable biofuels with long history as environmentally friendly alternative to replace fossil fuels, especially in transportation sector. Nowadays, bioethanol is mainly produced worldwide from first-generation raw materials including various sugar-containing feedstocks (sugar beet, sugar cane, molasses, sweet sorghum, and fruits) and starch-containing feedstocks (corn, wheat, rice, triticale, potato, cassava, etc.). Since the first-generation feedstocks are usually edible crops there is significant research effort for the development of bioethanol production from second-generation (lignocellulose) and third-generation (algal biomass) feedstocks as cheaper and worldwide available carbohydrate sources. However, corn remains to be the primary feedstock that is still used for about half of the world's bioethanol production. The development of bioethanol production from corn includes improvement in three major steps in ethanol production such as (i) cereal pretreatment and starch hydrolysis using technical enzymes to obtain fermentable sugars, (ii) fermentation of sugars to ethanol by most convenient Saccharomyces cerevisiae yeast, and (iii) ethanol separation from fermented media by distillation and its purification by rectification and absolutization techniques. Baker's yeast was traditionally used as a starter culture in ethanol production due to its low cost, easy availability, and tolerance to a wide pH range. However, modern biotechnology developed highly efficient distiller's S. cerevisiae strains which can achieve ethanol concentrations up to 20% v/v because they can tolerate an increase in ethanol concentration, high fermentation temperatures, osmotic stress, and are able to compete with contamination during fermentation. In general, there are two technological techniques that are commonly used in industrial bioethanol production referred to as separated hydrolysis and fermentation (SHF), and simultaneous scarification and fermentation (SSF). In this work, SHF and SSF techniques were investigated and compared for bioethanol production from corn by baker's yeast and distiller's yeast. It was found that the SSF process was significantly more efficient for ethanol production than the SHF process, especially when baker's yeast was used as producing microorganism. The results showed that the SSF process integrates the advantages of the application of appropriate technical amylase and superior distiller yeast. Starch conversion to ethanol in the SSF process reached 91% of the theoretical for baker's yeast and 94% for distiller's yeast. Ethanol yield of 37,2 mL and 38,5 mL per 100 g of corn was obtained by baker's and distiller's yeast, respectively.
Key words: *bioethanol, corn, yeast*

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PROIZVODNJA BIOETANOLA IZ KUKURUZA PRIMENOM SIMULTANE SAHARIFIKACIJE I FERMENTACIJE POMOĆU PEKARSKOG I DESTILERIJSKOG KVASCA

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Bioetanol je jedno od najperspektivnijih obnovljivih biogoriva sa širokom primenom i dugom istorijom primene kao ekološki prihvatljiva alternativa za fosilna goriva, posebno u transportnom sektoru. Danas se bioetanol u svetu u najvećoj meri proizvodi od sirovina prve generacije koje koje sadrže šećer (šećerna repa, šećerna trska, melasa, slatki sirak i voće) i sirovina koje sadrže skrob (kao što su kukuruz, pšenica, pirinač, tritikale, krompir, manioka itd.). Kako se sirovine prve generacije mogu primeniti i kao hrana, postoje značajni istraživački napori za razvoj proizvodnje bioetanola iz sirovina druge generacije (lignoceluloznih) i treće generacije (biomasa algi) kao jeftinijih i lako dostupnih izvora ugljenih hidrata. Međutim, kukuruz ostaje primarna sirovina koja se još uvek koristi za oko polovinu svetske proizvodnje bioetanola. Razvoj proizvodnje bioetanola iz kukuruza uključuje unapređenje u tri osnovne faze u proizvodnji etanola, kao što su (i) predtretman zrna i hidroliza skroba pomoću tehničkih enzima za dobijanje fermentabilnih šećera, (ii) fermentacija šećera u etanol pomoću najpogodnijeg kvasca Saccharomices cerevisiae, i (iii) izdvajanje etanola iz fermentisanog medijuma destilacijom i njegovo prečišćavanje tehnikama rektifikacije i apsolutizacije. Pekarski kvasac se tradicionalno koristi kao starter kultura u proizvodnji etanola zbog niske cene, lake dostupnosti i tolerancije na širok raspon pH vrednosti. Međutim, moderna biotehnologija razvila je visoko efikasne destilerijske sojeve S. cerevisiae koji mogu da postignu koncentracije etanola do 20% v/v jer imaju sposobnost da tolerišu povećanje koncentracije etanola, visoke temperature fermentacije, osmotski stres i sposobni su da spreče kontaminaciju tokom fermentacije. Uopšteno govoreći, postoje dva tehnološka postupka koji se obično koriste u industrijskoj proizvodnji bioetanola, a nazivaju se odvojena hidroliza i fermentacija (SHF) i simultana skarifikacija i fermentacija (SSF). U ovom radu su ispitani i upoređeni SHF i SSF postupak za proizvodnju bioetanola iz kukuruza primenom pekarskog kvasca i destilerijskog soja kvasca. Utvrđeno je da je SSF postupak bio značajno efikasniji za proizvodnju bioetanola od SHF postupka, posebno u slučaju primene pekarskog kvasca kao proizvodnog mikroorganizma. Rezultati su pokazali da SSF postupak integriše prednosti primene odgovarajućih tehničkih amilaza i superiornog destilerijskog soja kvasca. Konverzija skroba u etanol u SSF procesu dostigla je 91% teoretskog za pekarski kvasac i 94% za destilerski kvasac. Prinos etanola od 37,2 ml/100 g kukuruza ostvaren je primenom pekarskog kvasca, odnosno i 38,5 mL/100 g primenom destilerijskog kvasca.
Ključne reči: *bioetanol, kukuruz, kvasac*

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EFFECT OF HOT WATER TREATMENTS ON APPLE ROT CAUSED BY NEOFABRAEA ALBA

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Global annual apple production currently exceeds 50 million tons, which coincides with a higher market demands each year. Apples are stored for several months, and require the development of postharvest technologies to reduce economical losses and to maintain fruit quality. Postharvest fungal infections cause major losses on apple fruits, whereas pathogens causing latent infections present hardly predictable threats. Neofabraea alba is a postharvest pathogen that causes bull's eye rot on pome fruits, especially on apples. Difficulties in pathogen control are caused by late symptom appearance on fruits and the lack of possibility to use synthetic fungicides in postharvest period. Therefore, hot water treatments represent an acceptable alternative method for the postharvest rot control on apples. In this study, the aim was to determine the temperature of water and fruit exposure time to hot water treatment that successfully inhibits rot development caused by N. alba. For the experiment, two morphologically different isolates of N. alba (J67/2 and J117) were selected. N. alba isolates were previously incubated in darkness on 2% malt-extract agar plates, at 20 ℃ for 21 days. Apple fruits (cv. Granny Smith) were incubated at room temperature for 24h before treatment, surface-sterilized with 70% ethanol and artificially inoculated with mycelium plugs (Ø 3 mm) of N. alba isolates prior to treatment. The applied treatments were as follows: temperatures of 50, 52 and 53 °C with exposure periods of 3 and 4 minutes (Treatment: T1= 50 °C and 3 min; T2=50 °C and 4 min; T3= 52 °C and 3 min; T4=52°C and 4 min; T5=53°C and 3 min; T6=53°C and 4 min). After inoculation, apple fruits were dipped in hot distilled water of the defined temperature for the defined exposure period. Afterwards, the fruits were dried and placed in aseptic plastic chambers and stored. Half of the apple fruits were incubated at room temperature for 21 days (rot development was measured after 7, 14, and 21 days of incubation), and the other half was stored under normal atmosphere cold storage (3 °C) for 90 days. After termination of the storage period, rot development caused by N. alba formed around the inoculation site was measured (mm) and values were expressed as a percentage in comparison to the untreated control. The results showed that the applied treatments significantly affected rot development, regardless of the storing conditions. The smallest rot diameter was registered on fruits treated at 53 °C for 4 minutes (T6). In this treatment, fruits inoculated with isolate J117 had higher rot inhibition rate (79.51%) after NA storing, compared to storing at room temperature. In contrast, fruits inoculated with isolate J67/2 showed a higher inhibition rate after storing at room temperature for 21 days. Treatment 1 (T1) showed significantly lower inhibition in comparison to other treatments. The highest inhibition of necrosis development caused by N. alba was registered after treatment at 53 °C for 4 minutes and additional incubation in NA storage. However, additional research is needed to determine the effectiveness of the treatments on different cultivars, as well as more detailed studies on the negative effects of hot water treatments on quality parameters of apple fruit.

Keywords: *Neofabraea alba, apple, hot water treatment*

EFEKAT TRETMANA TOPLOM VODOM NA TRULEŽ PLODA JABUKE PROUZROKOVANOM NEOFABRAEA ALBA

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Sve veći zahtevi tržišta na svetskom nivou utiču na povećanje proizvodnje jabuke koje trenutačno premašuje 50 miliona tona godišnje. S obzirom da se jabuka skladišti po nekoliko meseci, zahteva se unapređenje tehnologija nakon berbe, kako bi se održao kvalitet plodova i redukovali ekonomski gubici. Najznačajniji uzročnici propadanja plodova jabuke nakon berbe čine fitopatogene gljive, a patogeni koji uzrokuju latentne infekcije prouzrokuju štete čija se visina teško može predvideti. Neofabraea alba prepoznatljiva po simptomu "bikovo oko", predstavlja skladišnog prouzrokovača truleži ploda jabučastog voća, pretežno jabuke. Usled kasne pojave simptoma na plodovima i nemogućnosti upotrebe sintetičkih fungicida nakon berbe plodova otežana je kontrola patogena. Shodno tome, tretmani toplom vodom predstavljaju odgovarajuću alternativnu metodu za suzbijanje truleži ploda jabuke nakon berbe. Cilj istraživanja je bio definisanje temperature vode i vremenskog izlaganja plodova tretmanu, koje bi uspešno inhibirale razvoj nekroze prouzrokovane vrstom Neofabraea alba. Za potrebe ogleda izabrana su dva morfološki različita Neofabraea alba izolata (J67/2 i J117). N. alba izolati su prethodno uzgajani na 2% malt agar podlozi u potpunom mraku, pri temperaturi od 20 °C tokom 21 dan. Pre početka tretmana, plodovi jabuke (sorte greni smit) inkubirani su na sobnoj temperaturi 24 h, a potom površinski dezinfikovani 70-procentnim etanolom i veštački inokulisani fragmentima micelije N. alba izolata (Ø 3 mm). Tretmani toplom vodom primenjeni su pri temperaturama od 50, 52 i 53 °C sa vremenskim izlaganjem od 3 i 4 minuta (Tretman: T1= 50 °C i 3 min; T2=50 °C i 4 min; T3= 52 °C i 3 min; T4=52°C i 4 min; T5=53°C i 3 min; T6=53°C i 4 min). Nakon veštačke inokulacije, plodovi jabuke su potapani u destilovanu vodu odgovarajuće temperature pri definisanom periodu izlaganja. Po završetku, plodovi su osušeni i postavljeni u plastične kutije i čuvani pri dva različita metoda inkubacije. Polovina plodova jabuke transportovano je u hladnjaču normalne atmosfere (3°C), gde je inkubacija trajala 90 dana, dok je druga polovina jabuka inkubirana u uslovima sobne temperature tokom 21 dan (razvoj nekroze je praćen nakon 7, 14 i 21 dan inkubacije). Nakon završetka inkubacije, razvoj nekroze prouzrokovan N. alba oko inokulisanog mesta izmeren je pod pravim uglom (mm), a zatim su vrednosti izražene kao procenat inhibicije u odnosu na kontrolu. Rezultati ukazuju na značajan efekat tretmana na razvoj nekroze, pri oba načina inkubacije. Najmanji prečnik nekrotičnih lezija registrovan je na plodovima tretiranim pri temperaturi vode od 53 °C tokom 4 minuta (T6). U ovom tretmanu, plodovi inokulisani izolatom J117 su nakon skladištenja u NA hladnjači imali veću stopu inhibicije (79,51%), u poređenju sa inkubacijom na sobnoj temperaturi. Nasuprot tome, plodovi inokulisani izolatom J67/2 ukazuju na veću stopu inhibicije nakon inkubacije na sobnoj temperaturi tokom 21 dan. Osim toga, Tretman 1 (T1= 50 °C i 3 min) pokazao je značajno nižu inhibiciju u odnosu na ostale primenjene tretmane. Najznačajnija inhibicija razvoja nekroze u ogledu uočena je nakon tretmana na 53 °C tokom 4 minuta (T6) kombinujući sa skladištenjem u NA hladnjači. Međutim, potrebna su dodatna istraživanja kako bi se utvrdila efikasnost tretmana toplom vodom na različitim sortama, kao i detaljnije ispitivanje negativnih efekata tretmana na kvalitativne karakteristike ploda jabuke.

Ključne reči: *Neofabraea alba, jabuka, tretman toplom vodom*

CHANGES OF FATTY ACIDS OF THE PATAGONIAN SQUID (LOLIGO GAHI D'ORBIGNY) DURING AIR CHILLING AND WITH EFFECTS OF ACID WHEY IMMERSION

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Fishing and aquaculture have an important role in society's development. Maintaining oceans is not only the best environmental stewardship, but also ensures sustainable growth for the omega-3 industry as a whole. Seafood is the best way to consume EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) simply because of all the other nutrients that are part of the fish. EPA and DHA are long-chain omega-3 polyunsaturated fatty acids (O-3s) that are abundant in fish, shellfish and some algae and genetically engineered plants. High omega-3 choices include salmon, tuna, mackerel and squids. Most government recommendations suggest consuming 2-3 servings of fatty fish per week to achieve 250 mg of EPA and DHA per day. The global organization for EPA & DHA omega-3s (GOED) recommends consuming 500 mg of combined EPA and DHA per day for general health and higher quantities for specific life stages or health conditions. Most of the global population consumes significantly less EPA and DHA than recommended thus specific food supplements have oil made from the by-products of the squid meat production industry, which is relatively high in DHA. Loss of balance of n-6 and n-3 polyunsaturated fatty acids in the diet has been joined specific diseases. The body needs EPA & DHA omega-3s to develop and function optimally in every stage of life. EPA and DHA are converted into compounds with lower molecular weight associated with off-flavors (e.g. aldehydes, ketones, alcohols) thus reduce the nutritional value of fishery products. Marine lipids are now the subject of a great deal of attention due to their high content of ω3 polyunsaturated fatty acids (PUFA), which have shown a positive role in preventing certain human diseases. Cephalopods represent a highly interesting biological group in sea due to their nutritional value for human health and for their commercial significance.
The aim of this study was to use fatty acid analysis as a method for determining changes of two types of thawed squid Loligo gahi d'Orbigny samples one immersed in acid whey and the other only under traditional chilling, both stored for 8 days at 6 ± 1°C. Here, n=52 individual squids Loligo gahi d'Orbigny that were caught in the Atlantic coast of Argentine Patagonia. Loligo gahi is found off the Pacific and Atlantic coasts of South America from southern Peru to Argentina. The loliginid squid Loligo gahi (d'Orbigny, 1835) is one of the two major squid species exploited by the fishery in the Falkland Islands.
The results of DHA and EPA were compared with the results on days of storage. Samples were analyzed on days 2, 4, 6, and 8. The mantle length of the squid averaged to 11.5 ± 0.5 cm. On the last day of storage (day 8), the C20:5n3 content was 2% higher and the C22:6n3 content was 80% higher in the whey-treated samples. The data suggested that immersion of squid mantles in acid whey may be beneficial storage technique. The changes in sensory properties, color, total volatile nitrogen (TVB-N), pH and water holding capacity were also determined.
Key words: *squid Loligo gahi d'Orbigny, chilled storage, acid whey, EPA and DHA.*

PROMJENE MASNIH KISELINA KOD PATAGONSKE LIGNJE (LOLIGO GAHI D'ORBIGNY) TIJEKOM ZRAČNOG HLAĐENJA I HLAĐENJA S UČINCIMA POTAPANJA U KISELU SIRUTKU

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Ribolov i akvakultura imaju važnu ulogu u razvoju društva. Održavanje oceana nije samo najbolje upravljanje okolišem, već također i osigurava održivi rast cijele industrije omega-3 masnih kiselina. Konzumiranje plodova mora najbolji je način unošenja EPA i DHA te svih ostalih nutrijenata kojima je riba bogata. EPA i DHA su dugolančane omega-3 polinezasićene masne kiseline (O-3) kojima obiluje plava riba, školjke, neke alge i genetski modificirane biljke. Izbori s visokim udjelom omega-3 masnih kiselina prvenstveno su: losos, tuna, skuša i lignja. Većina vladinih organizacija koje se bave zaštitom zdravlja predlažu konzumaciju 2-3 porcije masne ribe tjedno kako bi se unijelo prosječno 250 mg EPA i DHA dnevno. Globalna organizacija za EPA i DHA omega-3 masne kiseline (GOED) preporučuje konzumaciju 500 mg kombiniranih EPA i DHA dnevno, te veće količine za određena životna razdoblja ili zdravstvena stanja. Većina svjetske populacije konzumira znatno manje EPA i DHA od preporučenog unosa i zato su cijenjeni dodaci prehrani obogaćeni uljem od nusproizvoda prerade lignji jer spomenuto ulje ima relativno visok udio DHA.

Gubitak ravnoteže n-6 i n-3 višestruko nezasićenih masnih kiselina u prehrani povezuje se sa specifičnim bolestima. Tijelu su potrebne EPA i DHA omega-3 za razvoj i optimalno funkcioniranje u svakoj životnoj dobi. EPA i DHA prelaze u spojeve niže molekulske težine povezane s neugodnim okusima (npr. aldehidi, ketoni, alkoholi) čime se smanjuje nutritivna vrijednost proizvoda ribarstva. Lipidi iz plodova mora danas su predmet velike pozornosti zbog visokog udjela ω3 polinezasićenih masnih kiselina (PUFA) koje su pokazale pozitivnu ulogu u prevenciji određenih bolesti kod ljudi. Glavonošci predstavljaju vrlo zanimljivu biološku skupinu u moru zbog svoje hranjive vrijednosti i komercijalnog značaja.

Cilj ovog istraživanja bio je koristiti promjene sastava masnih kiselina odmrznutih uzoraka lignji Loligo gahi d'Orbigny kao metode za detekciju kvalitete lignji uronjenih u kiselu sirutku i skladištenih uz tradicionalno hlađenje. Obje skupine uzoraka bile su pohranjene 8 dana na 6 ± 1ºC. Istraživani su uzorci, n=52, pojedinačne lignje Loligo gahi d'Orbigny ulovljene na Atlantskoj obali argentinske Patagonije. Loligo gahi obitava uz pacifičku i atlantsku obalu Južne Amerike od južnog Perua do Argentine. Loligo gahi (d'Orbigny, 1835.) jedna je od dviju glavnih vrsta lignji koje se iskorištavaju u ribolovu na Falklandskim otocima.

Rezultati DHA i EPA uspoređivani su svakog drugog dana skladištenja. Uzorci su analizirani 2., 4., 6. i 8. dana. Prosječna duljina plašta lignje iznosila je 11,5 ± 0,5 cm. Posljednjeg dana skladištenja (8. dan) sadržaj C20:5n3 bio je 2% veći, a sadržaj C22:6n3 bio je 80% veći u uzorcima tretiranim sirutkom.

Podaci sugeriraju da bi uranjanje plašta lignje u kiselu sirutku mogla biti korisna tehnika skladištenja. Također su mjerene promjene senzorskih svojstava, boje, ukupnog hlapljivog dušika (TVB-N), pH i kapaciteta zadržavanja vode.

Ključne riječi: *lignja Loligo gahi d'Orbigny, hladno skladištenje, kisela sirutka, EPA i DHA.*

DYED TEXTILE WASTE AS A RAW MATERIAL FOR THE PREPARATION OF FERMENTATION MEDIA

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Textile production is growing every year, following the increase in population on Earth. In 2021, the world production of textile materials was 113 MT and it was estimated that in the next 10 yearsit would increase by 43 % reaching 156 MT in 2030. The textiles produced usually are a mixture of natural and synthetic fibers. In addition, fabrics are subjected to various finishing processes to improve their functional and aesthetic properties. For this purpose, dyes (direct, acidic and auxiliary) and chemicals are used to give usable properties (fireproof, antistatic, waterproof and analgesic properties). Used chemicals improve fabric properties, but prevent their natural degradation in the environment. These waste is mainly stored or burned and only slightly recycled. Therefore, textile waste belongs to the group of high-pots not biodegradable and have a negative impact on the natural environment. For this reason, scientists around the world are looking for new textile waste processing solutions.

An alternative way of processing textile waste containing natural fibers may be their acid hydrolysis and use of such liquid media in the fermentation processes of the production of biogas, bioethanol, lactic acid.

In our investigation it was used a colored cotton yarn (CO) and colored cotton yarns with polyester additives (CO/PA) and polyamides (CO/PES). Acid hydrolysis was made with a 2% H_3PO_4 solution in a 50 mL Paar pressure reactor, at 140°C, by 2h. The samples were neutralized with $NH_3 \cdot H_2O$ to pH = 7-7.5. Then, glucose concentration in hydrolysates was examined with high-performance liquid chromatography HPLC (Sykam GmbH, Eresing Germany, with an S1125 pump system, S 5300 autosampler, S 4115 column thermostat and RI S 3585 detector) and the elemental composition was analyzed using an emission spectrometer ICP-OES (ICAP 7000 SERIES from Thermo). In the next stage of work, Saccharomyces Cerevisiae strains were selected that the best growing on media containing cotton hydrolysates. Hydrolysates were sterilized at 121 °C for 15 min. and transferred to a 96-channel plate at 180 µL and inoculated with 20 µL of an inoculum suspension of yeast cells in MEB medium (Merck Millipore, Bedford, MA, USA). The cultivation of yeast was carried out at 25 °C for 72 h in a Thermo Scientific Multiskan GO UV/VIS spectrophotometer (Thermo Fisher Scientific, Waltham, MA USA), measuring the absorbance of the solutions at a wavelength of 620 nm. The increase in absorbance was proportional to the turbidity of the solution caused by the proliferation of microorganisms.

Key words: *cotton textile waste, polyester/polyamide fibers, dyed cotton, acidic hydrolysis, ethanol fermentation*

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MODEL PROCEDURE FOR BIOGAS PRODUCTION FROM TEXTILE WASTE

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The textile industry is facing an important challenge related to environmental issues, we produce more and more textiles every year. Currently, 63% of textiles are made from petrochemical raw materials, and only 37% from natural fibers. The most common natural fibers used in the production of textiles are cotton and wool. When it comes to synthetic fibers, polyester and polyamide fibers are produced the most. The production of textile materials is constantly increasing, and with it the amount of waste generated. Most of this waste is landfilled or incinerated, and only a small amount is recycled. In order to counteract this problem, new methods of processing and reusing such materials are being sought. A new method of processing textile waste containing natural fibers (e.g. cotton, wool) and polymer additives (polyesters, polyamides) may be their acid hydrolysis and the use of such liquid media in fermentation processes for the production of bioproducts (e.g. biogas, bioethanol, lactic acid, microbial protein additives).
The paper presents a procedure of thermally assisted acid hydrolysis of natural fibers (cotton, wool) and cotton fibers with additions of polyesters and polyamides, optimized to obtain the highest possible amounts of glucose or amino acids. In the hydrolysis processes, 2% phosphoric (V) acid was used, and the reactions were carried out in batch pressurized reactors with a stirrer at 140°C for 2 hours. The hydrolysates obtained in this way were used as components of fermentation substrates for the production of biogas. The sugar component consisted of cotton and cotton hydrolysates with the addition of polyesters and polyamides, while the protein component consisted of wool hydrolysates. Biogas production was carried out in a bioreactor with a working capacity of 10 dm^3 for a period of 20 days. It was noted that higher yields of biogas production were obtained when the fermentation substrate contained fiber hydrolysates without synthetic additives. The total volume of biogas produced for cotton hydrolysates was 26.55 dm^3, for cotton hydrolysates with the addition of polyamides it was 3.4 dm^3, while for cotton hydrolysates with the addition of polyesters it was 0.7 dm^3. The average percentage of methane for biogas samples containing cotton hydrolysate was 71%, cotton with polyamide 69%, and cotton with polyester 66%.
Key words: *cotton waste utilization; acidic hydrolysis of cotton, biogas production*

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COMPARISON OF ICP-OES AND GFAAS TECHNIQUES FOR DETERMINATION MINERAL CONTENT IN WHEAT AND WHEAT PRODUCTS MATRIX

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In modern society, it has become necessary that every food product possess nutritional label. One part of the nutritional value of food is micronutrients, especially minerals. They can be determined by different analytical techniques such as inductively coupled flame atomic absorption spectroscopy (FAAS), graphite furnace atomic absorption spectrometry (GFAAS), plasma-optical emission spectroscopy (ICP-OES) and inductively coupled plasma-mass-spectrometry (ICP-MS). These techniques differ according to the number of elements that can be determined, the levels of determination, the number of samples that can be determined and the sample volume. Wheat contain substantial share of minerals iron (Fe) and Zinc (Zn). A lot of human population especially woman and children's in poor countries suffers from deficient of these micronutrients. Therefore is necessary to measure their content in wheat and wheat products such as different kinds of bread that are staple food. Therefore, the aim of the study was to determine Fe and Zn in wheat grain and milling streams by GFAAS and ICP-OES to compare them.
Three old wheat cultivars Rumska crvenka (DOI: 10.18730/ZAEHP), Crnozrna (DOI: 10.18730/ZAFXX) and Stara Banatka (DOI: 10.18730/ZAG0*) was first milled in a Bühler pneumatic laboratory mill MLU 202 (Uzwil, Switzerland). The eight milling streams were obtained six flours and two by-products. Fe and Zn content of twenty seven samples (24 samples of milling streams and 3 of wheat grain) was determined by GFAAS and ICP-OES techniques.
The results of the study showed that the correlations between GFAAS and ICP-OES techniques for determination of Fe and Zn were positive and statistically significant. The higher correlation (r=0.9447) was gained for determination of Zn content, whereas for Fe content was a little bit lower (r=0.9358). Furthermore, analysis of variance (ANOVA) showed statistical differentiation among the results of mineral content in milling streams determined by two techniques. The values of both minerals determined by GFAAS in the milling streams of grain endosperm were lower than the values obtained by the ICP-OES technique, while in the milling streams from the outer parts of the grain they were higher.
From results it can be concluded that is better to use GFAAS technique for determination of minerals if necessary to evaluate nutritive value of wheat and wheat products.
Key words: *minerals, analytical techniques, wheat and wheat products*

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POREĐENJE ICP-OES I GFAAS TEHNIKA ZA ODREĐIVANJE SADRŽAJA MINERALA U MATRIKSIMA PŠENICE I PROIZVODA OD PŠENICE

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U savremenom društvu postalo je neophodno da svaki prehrambeni proizvod ima nutritivnu oznaku. Jedan deo nutritivne vrednosti hrane čine mikronutrijenti, a pogotovo minerali. Oni se mogu odrediti različitim analitičkim tehnikama kao što je induktivno spregnuta plamena atomska apsorpciona spektroskopija (FAAS), atomska apsorpciona spektrometrija sa razaranjem uzorka u grafitnoj peći (GFAAS), plazma-optička emisiona spektroskopija (ICP-OES) i induktivno spregnuta plazma-masena spektrometrija (ICP-MS). Ove tehnike se razlikuju prema broju elemenata koje mogu odrediti, koncentraciji uzorka i broju uzoraka koji se mogu odrediti kao i zapremini uzorka koja je potrebna za analizu. Pšenica sadrži značajan udeo minerala gvožđa (Fe) i cinka (Zn). Veliki broj ljudi, posebno žena i dece u siromašnim zemljama, pati od nedostatka ovih mikronutrijenata. Zbog toga je neophodno odrediti sadržaj ovih minerala u pšenici i pšeničnim proizvodima kao što su različite vrste hleba koji su osnovna hrana. Stoga je cilj studije bio da se pomoću GFAAS i ICP-OES odredi sadržaj Fe i Zn u zrnu pšenice i proizvodima mlevenja kako bi se mogli uporediti rezultati dobijeni pomoću ove dve tehnike.

Tri stare sorte pšenice Rumska crvenka (DOI: 10.18730/ZAEHP), Crnozrna (DOI: 10.18730/ZAFXX) i Stara Banatka (DOI: 10.18730/ZAG0*) prvo su samlevene na Bühler-vom pneumatskom laboratorijskom mlinu MLU 202 (Uzwil, Switzerland). Dobijeno je osam pasaža od čega 6 frakcija brašna i dve frakcije nusproizvoda. Sadržaj Fe i Zn u dvadeset sedam uzoraka (24 uzorka pasaža i 3 zrna pšenice) određen je pomoću GFAAS i ICP-OES tehnike.

Rezultati studije su pokazali da su korelacije između GFAAS i ICP-OES tehnika za određivanje Fe i Zn pozitivne i statistički značajne. Veća korelacija (r=0,9447) dobijena je za određivanje sadržaja Zn, dok je za sadržaj Fe nešto niža (r=0,9358). Pored toga, analiza varijanse (ANOVA) pokazala je statističku diferencijaciju između rezultata sadržaja minerala u mlevenim tokovima utvrđenim dvema tehnikama. Vrednosti oba minerala utvrđene GFAAS u mlevenim tokovima endosperma zrna bile su niže od vrednosti dobijenih ICP-OES tehnikom, dok su u mlevenim tokovima iz spoljašnjih delova zrna bile veće.

Iz rezultata se može zaključiti da je bolje koristiti GFAAS tehniku za određivanje minerala ako je potrebno za procenu nutritivne vrednosti pšenice i pšeničnih proizvoda.

Ključne reči: *minerali, analitičke tehnike, pšenica i proizvodi od pšenice*

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INFLUENCE OF PHYTOPATHOGENIC FUNGI ON QUALITY PARAMETERS OF GREEN BEAN SEEDS IN A FIVE-YEAR PERIOD

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Green beans are among the most essential legumes because of their nutritional value. However, the production of green beans in Serbia is in a significant decline due to significantly reduced yields, as well as the sown areas. Diseases caused by phytopathogenic fungi affect the reduced yield of green beans. The most common diseases affecting economic losses and reduced seed yield are Fusarium spp., Sclerotinia sclerotiorum, Alternaria spp., Macrophomina phaseolina, Penicillium spp. and Aspergillus spp. In addition to the negative impact on total germination and seed quality, some phytopathogenic fungi can produce mycotoxins, adversely affecting human health. In addition, some phytopathogenic fungi can produce mycotoxins, which can adversely affect human health. In this paper, the quality parameters of two varieties of green beans on the territory of Smederevska Palanka were monitored over a period of five years. Detection of phytopathogenic fungi was carried out using filter paper and potato dextrose agar method. The presence of Alternaria spp. was detected in 5% (2018) and 2022., Alternaria spp. 2%, Fusarium spp. (4%). A significant decline in total germination was determined in 2020. and amounted to 75% for Šumadinka and 70% for Palanačka Rana. In the last observed year, the presence of other fungi was determined, apropos a higher percentage of diseased seeds. However, other phytopathogenic fungi were detected in both varietes using potato dextrose agar: Aspergilus (1-3%), Penicillium spp. (1-4%), Rhisopus spp. (3%) and Rhizoctonia solani (2-3%). The total germination and energy of the observed green bean varieties were significantly different from each other ($p<0.05$). The moisture was 12.5-11.5 (2018) for both varieties, while last year it was 10.5-10.9% (2022) and did not differ statistically between varieties ($p>0.05$). The impact of phytopathogenic fungi on green beans was reflected in the reduction of total germination, and therefore in seed quality and yield. The priority of future research is the application of biotreatments that will contribute to seed protection and improve total germination, and thus the yield in the field.

Key words: *effects, germination, phytopathogenic*

UTICAJ FITOPATOGENIH GLJIVA NA PARAMETRE KVALITETA SEMENA BORANIJE U PETOGODIŠNJEM PERIODU

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Boranija zbog svoje nutritivne vrednosti spada u najvažnije mahunarke u Srbiji. Međutim, proizvodnja boranije u Srbiji je u značajnom opadanju usled značajno smanjenih zasejanih površina i prinosa. Fitopatogene gljive koje se prenose putem semena utiču na smanjene prinose i kvalitet boranije. Najčešće bolesti koje utiču na ekonomske gubitke i smanjen prinos boranije su izazvane fitopatogenim gljivama: Alternaria spp., Sclerotinia sclerotiorum, Fusarium spp., Macrophomina phaseolina i Penicillium spp. Aspergillus spp. i duge. Takođe, pored negativnog uticaja na ukupnu klijavost i kvalitet semena neke fitopatgene gljive mogu produkovati miktoksine koje imaju štetan uticaj na zdravlje ljudi. U ovom radu praćeni su parametri kvaliteta dve sorte semena boranije na teritoriji Smederevske Palanke u petogodišnjem periodu. Detekcija prisutnih gljiva izvršena je primenom metode na filter papiru i krompirovog dekstroznog agara. Najveća ukupna klijavost je kod sorte Šumadinka 88%, energija je iznosila 83% (2018), dok je najmanja ukupna klijavost određena 2022. i iznosila je 65%, a energija 58%. У 2020. utvrđen je značajan pad ukupne klijavosti i iznosio je 75% za Šumadinku i 70% za Palanačku Ranu. Prisustvo fitopatogenih metodom na filter papiru 2018. godine detektovano je prisustvo Alternaria spp. (5%) i Fusarium spp. (4%). Znatno manju klijavost semena, a samim tim i prinos imala je Palanačka Rana sa ukupnom klijavošću 77%, a energija 75% (2018), dok poslednje posmatrane godine ukupna iznosila klijavost 66%, a energija klijavosti 59%. Detektovano je prisustvo Alternaria spp. 5% (2018), a 2022. Alternaria spp. 2% i Fusarium spp. 4%. U poslednjoj posmatranoj godini utvrđeno je prisustvo drugih gljiva kod obe sorte, odnosno veći procenat obolelog semena primenog krompirovog dekstroznog agara: Aspergilus (1-3%), Penicillium spp. (1-4%), Rhisopus spp. (3%) i Rhizoctonia solani (2-3%). Vlažnost boranije za obe sorte je iznosila 12,5-11,5 (2018), dok je prošle godine iznosila 10,5-10,9% (2022) i nije se statistički razlikovala između sorti ($p>0,05$). Uticaj fitopatogenih gljiva na boraniji značajno su uticale na smanjenu ukupnu klijavost, a samim tim na kvalitet semena i prinos. Prioritet budućih istraživanja je primena biotretmana koji će doprineti zaštiti semena i poboljšati ukupnu klijavost, a samim tim i prinos na polju.

Ključne reči: *uticaj, klijavost, fitopatogeni*

FAT CONTENT IN FINELY COMMINUTED COOKED AND LIVER SAUSAGES ON SERBIAN RETAIL MARKET

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Finely comminuted cooked sausages and liver sausages, which belong to emulsion type of sausages, are among the most popular meat products worldwide. Taste, convenience and low price are just a few of the reasons why these products are so popular. On the other hand, these meat products have a high content of fat that is required for sensory perception of juiciness, flavor and texture. However, fat from meat and meat products contain high amount of saturated fatty acids, which are frequently recognized as dietary elements that may contribute to the development of chronic noncommunicable diseases. Consequently, high fat content, typically 20–30% in finely comminuted cooked sausages and up to 40% in some liver sausages/pates, may be perceived negatively by consumers, as consumers nowadays become more aware of the link between food and health.

The aim of this paper was to conduct a comparative analysis of the fat content in total of 34 meat samples produced by 14 most represented meat producers on the Serbian retail market. Twenty one (n=21) sample belonged to a group of finely comminuted sausages (11 were chicken hot dogs and 10 pork hot dogs) and thirteen (n=13) samples belonged to a group of liver sausages (13 liver pates).

Fat content in the finely comminuted cooked sausages ranged from 13.5 to 20.9 g/100 g, of which fat span in chicken hot dogs was from 13.5 to 20.7 g/100 g and in pork hot dogs was from 15.5 to 20.9 g/100 g. The most of the chicken hot dogs samples (27.3%) contained between 18 and 19 g/100 g of fat, while spans of 13-14, 14-15 and 16-17 g/100 g were noted in 18.2% samples, separately. The highest fat content among chicken hot dog samples of 19-20 and 20-21 g/100 g ranges was found in two groups of 9.1% samples. The largest group of pork hot dogs (40%) was characterized by fat content of 16-17 g/100 g, while two groups of 20% of samples contained between 15-16 g/100 g and 20-21 g/100 g fat share. Fat content between 17-18 and 19-20 g/100 g were detected in two groups of 10% of samples.

The fat content in the examined samples of liver sausages varied from 22.1 to 32.0 g/100 g. In the majority of the liver pate samples (30.8%) fat content ranged from 23 to 24 g/100 g. In two groups of 23.1% samples, fat content ranged from 22 to 23 and from 25 to 26 g/100g. Fat content from 24 to 25, from 30 to 31 and from 32 to 33 g/100 g were detected in three groups of 7.7% of samples, separately.

The fat content of finely comminuted cooked sausages and liver sausages produced by the 14 represented meat producers on the Serbian retail market was consistent with literature data and represents normal fat contents in that type of meat products. As most current dietary guidelines recommend keeping relative fat intake to 30% of total daily energy, meat processors can think about the reducing fat content.

Key words: *fat content, finely comminuted sausages, liver sausages*

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SADRŽAJ MASTI FINO USITNJENIH BARENIH I KUVANIH KOBASICA NA SRPSKOM TRŽIŠTU

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Fino usitnjene barene i kuvane kobasice, koje pripadaju proizvodima od mesa u tipu emulzija, ubrajaju se među najpopularnije proizvode od mesa u svetu. Ukus, jednostavna upotreba i niska cena samo su neki od razloga zbog kojih su ovi proizvodi toliko popularni. S druge strane, ove proizvode od mesa karakteriše visok sadržaj masti koja je neophodna za senzorsku percepciju sočnosti, ukusa i teksture. Međutim, mast iz mesa i proizvoda od mesa sadrži veliku količinu zasićenih masnih kiselina, koje se često prepoznaju kao komponente hrane koje mogu doprineti razvoju hroničnih nezaraznih bolesti. Shodno tome, visok sadržaj masti, koji se u fino usitnjenim barenim kobasicama kreće u intervalu od 20-30%, a u nekim kuvanim kobasicama/paštetama i do 40%, potrošači mogu negativno da ocene, pošto potrošači danas postaju svesniji veze između ishrane i zdravlja.

Cilj ovog rada bio je da se izvrši komparativna analiza sadržaja masti u ukupno 34 proizvoda od 14 najzastupljenijih proizvođača na maloprodajnom tržištu Srbije. Dvadeset jedan (n=21) uzorak pripadao je grupi fino usitnjenih barenih kobasica (11 uzoraka viršli od pilećeg mesa i 10 uzoraka viršli od svinjskog mesa), a trinaest (n=13) uzoraka je pripadalo grupi kuvanih kobasica (13 jetrenih pašteta).

Sadržaj masti u fino usitnjenim barenim kobasicama kretao se u intervalu od 13,5 do 20,9 g/100 g, od čega je sadržaj masti kod viršli od pilećeg mesa bio u intervalu od 13,5 do 20,7 g/100 g, a kod viršli od svinjskog mesa od 15,5 do 20,9 g/100 g. Najveći broj uzoraka pilećih viršli (27,3%) sadržao je između 18 i 19 g/100 g masti, dok su intervali od 13-14, 14-15 i 16-17 g/100 g zabeleženi u 18,2% uzoraka, za svaki interval. Najviši sadržaj masti među ispitanim uzorcima viršli od pilećeg mesa od 19-20 i 20-21 g/100 g pronađen je u dve grupe od 9,1% uzoraka. Najveću grupu viršli od svinjskog mesa (40%) karakterisao je sadržaj masti od 16-17 g/100 g, dok su dve grupe od 20% uzoraka sadržale između 15-16 g/100 g i 20-21 g/100 g. Sadržaj masti između 17-18 i 19-20 g/100 g detektovan je u dve grupe od po 10% uzoraka.

Sadržaj masti u ispitivanim uzorcima kuvanih kobasica kretao se u intervalu od 22,1 do 32,0 g/100 g. U većini uzoraka jetrenih pašteta (30,8%) sadržaj masti se kretao od 23 do 24 g/100 g. U dve grupe od 23,1% uzoraka, sadržaj masti se kretao od 22 do 23 i od 25 do 26 g/100g. Sadržaj masti od 24-25, 30-31 i 32-33 g/100 g detektovan je u tri grupe od 7,7% uzoraka.

Sadržaj masti u fino usitnjenim barenim i kuvanim kobasicama zastupljenim na maloprodajnom tržištu Srbije je u skladu sa literaturnim podacima i predstavlja normalan sadržaj masti za tu grupu proizvoda od mesa. Kako većina aktuelnih vodiča o ishrani preporučuje da ukupan dnevni unos masti ne bude veći od 30 % ukupnog dnevnog energetskog unosa, proizvođači proizvoda od mesa mogu razmišljati o smanjenju sadržaja masti.

Ključne reči: *sadržaj masti, fino usitnjene barene kobasice, kuvane kobasice*

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