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HDKI HRVATSKO DRUŠTVO KEMIJSKIH INŽENJERA I TEHNOLOGA

EuChemS European Chemical Society

EHEDG EUROPEAN HYGIENIC ENGINEERING & DESIGN GROUP

21 international conference

Ružička days

TODAY SCIENCE – TOMORROW INDUSTRY

September 9–11, 2026 | Vukovar, Croatia

BOOK OF ABSTRACTS

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21

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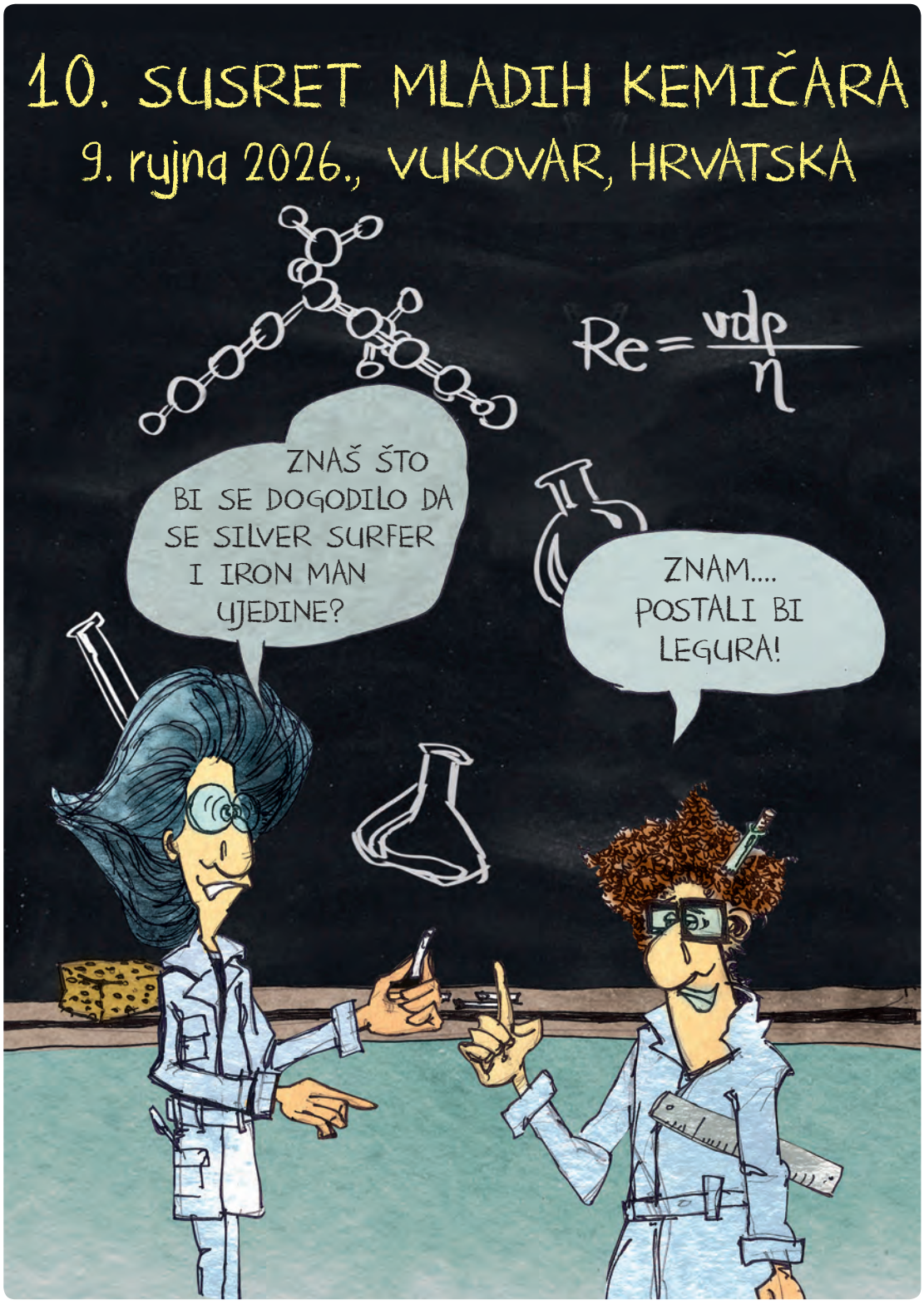
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9. rujna 2026., VUKOVAR, HRVATSKA
$Re = \frac{vdρ}{η}$
ZNAŠ ŠTO BI SE DOGODILO DA SE SILVER SURFER I IRON MAN UJEDINE?
ZNAM.... POSTALI BI LEGURA!

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Plenarna predavanja
Plenary Lectures

FROM LAB HYPE TO MARKET REALITY: OPPORTUNITIES, CHALLENGES AND HURDLES

Marta Lores[1,2], Aly Castillo[1,2], Laura Rubio[2], María Celeiro[1]
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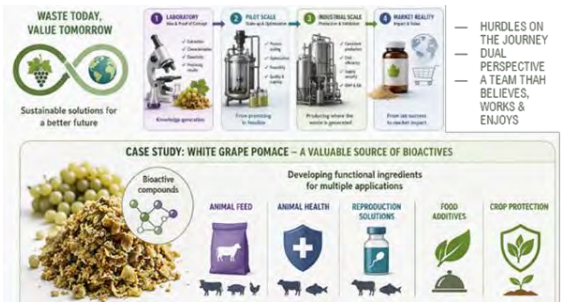
One of the aims of applied research is to solve specific, practical, real-world problems. The process begins in the laboratory, where successes and failures follow one another until a result is achieved that may prove promising. This leads to the pilot scale, where we must assess whether the same approach, on a slightly larger scale, continues to work. Fine-tuning is usually required. The final step is industrial-scale production. In the context of waste recovery – in general, and of agri-food by-products in particular – these steps are critical. There is no point in having a brilliant approach to utilising, for example, bioactive compounds from a specific plant biomass, if we cannot then translate it into the real world. That is not entirely true; of course, at laboratory scale, the results do increase our knowledge. But if we aim to solve the problem of by-products accumulation, we must work at the same scale at which the waste is generated – or as close to it as possible. This talk aims to illustrate the journey from the laboratory to industry through a real-life case study: the use of bioactive compounds from white grape pomace to produce functional ingredients with a wide range of applications. I will describe how we have succeeded in developing prototypes for animal feed, treatments for major diseases in animal production, and semen extenders for artificial reproduction, for use in livestock and aquaculture. But also food additives and crop protection products. Some of these products are already on the market, whilst others are at earlier stages of development. The journey will be equally full of rewards and obstacles. Regulatory issues, on the one hand, and the challenges of bringing the developed products to market, on the other, will also be addressed. All of this will be presented from a dual perspective – academic and business – through the lens provided by the scientific leadership of a small and humble spin-off. The struggle is daily and constant, but despite everything it is worth it, especially when supported by a team that believes in what they do, works tirelessly, and enjoys doing so, even if it is not always straightforward. This is the story of a small research group at the University of Santiago de Compostela, in north-western Spain, and its sister organization, the biotechnology-based company i-Grape Laboratory. I hope you enjoy it.

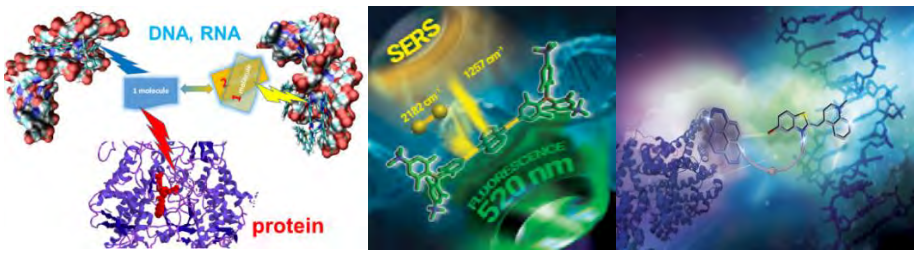
Keywords: grape-pomace; bioactive compounds; functional ingredients; industrial scaling



SEARCH FOR A MULTIPURPOSE ORGANIC DYE: SIMULTANEOUS SENSING OF DNA, RNA AND PROTEINS

Ivo Piantanida
Division of Organic Chemistry and Biochemistry, Ruđer Bošković Institute, Zagreb, Croatia

Bioimaging techniques are pivotal in life sciences, driving the development of innovative tools to probe molecular mechanisms and biophysical properties. Fluorescence methods dominate (>70% usage) owing to their exceptional sensitivity and ease of use, yet they suffer from limitations in fluorescent dyes and biomacromolecules.[1] An ideal solution is a single probe that binds indiscriminately to DNA, RNA, or proteins while generating unique spectroscopic signature for each target (Scheme 1a).



a) b) c)

Scheme 1. a) single dye multi-target selective response [2] b) Fluorimetric and Raman sensing of various DNA/RNA [3] c) single molecule-DNA / BSA specific sensing [4]

This presentation explores three strategies: (i) single chromophores optimized for hydrophobicity and binding to DNA, RNA, and proteins, incorporating advanced Raman spectroscopy for live-cell imaging rivaling fluorescence resolution; (ii) dual-chromophore systems linked by inert or responsive spacers, each targeting specific biomolecules; and (iii) aggregating chromophores where monomer/aggregate forms exhibit distinct biotarget affinities and spectral outputs (Schemes 1b, c). Examples include photo-switchable controls and photodynamic therapy (PDT) applications.

[1] Walter, A. Mannheim, J. Caruana, C. J Imaging Modalities for Biological and Preclinical Research: A Compendium, *IOP Publishing* 2021.
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[4] Smidlehner, T., Badovinac, M., and Piantanida, I. Pyrene-cyanine conjugates as multipurpose fluorescent probes for non-covalent recognition of ds-DNA, RNA and proteins, *New J. Chem.* 2018, *42*, 6655-6663.

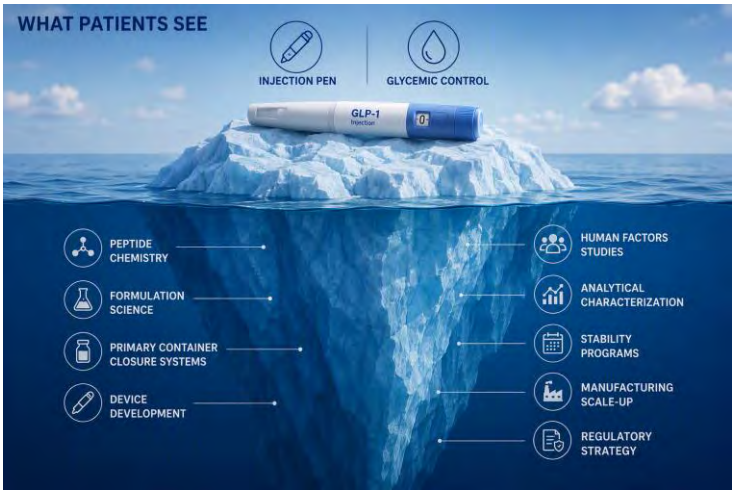
Pozvana predavanja
Invited Lectures

A TINY HORMONE. A BIG STORY. THE HIDDEN SCIENCE BEHIND A SIMPLE CLICK

Violeta Cindrić
PLIVA Hrvatska d.o.o., Prilaz baruna Filipovića 25, 10000 Zagreb, Croatia

GLP-1 medicines have transformed the treatment of diabetes and obesity, becoming one of the most discussed topics in modern healthcare and beyond. Yet behind what appears to be a simple injection pen lies a remarkable story of science and innovation.
This lecture follows the journey behind the development of a (generic) GLP-1 product for diabetes and weight management, highlighting the challenges of developing a complex peptide medicine combined with a medical device for drug delivery. Through an accessible yet scientifically engaging perspective, it provides insights into the scientific, technological, regulatory, and operational challenges encountered during a complex drug development program. Particular emphasis will be placed on the complexity of peptide-based medicines, the unique demands of drug-device combination products, advanced analytical characterization, and evolving regulatory expectations that ultimately transform a complex concept into a successfully developed, approved, and launched medicine.

Keywords: GLP-1, peptide therapeutics, drug-device combination products, pharmaceutical generic drug development, analytical characterization



COASTAL ECOSYSTEMS UNDER MULTIPLE PRESSURES: CLIMATE CHANGE, PLASTIC POLLUTION AND SUSTAINABLE MANAGEMENT STRATEGIES

Corinne Sabine Corbau
Università degli Studi di Ferrara, Dipartimento di Scienze dell'Ambiente e della Prevenzione, Corso Ercole I d'Este 32, 44121 - Ferrara, Italy

From sea-level rise to microplastic contamination, coastal ecosystems provide a unique window into the cumulative impacts of human activities on the planet.
As interfaces between land and sea, coastal environments are among the most dynamic and valuable ecosystems on Earth. However, they face intensifying pressures such as climate change, sea level rise, coastal erosion, extreme weather events, and the growing accumulation of plastic debris and microplastics. These combined factors are transforming coastal landscapes and challenging the resilience of both natural habitats and human communities.
This lecture will examine how climate change and plastic pollution are reshaping coastal ecosystems, with examples from the Mediterranean and Adriatic areas. Particular attention will be given to the occurrence, transport, and accumulation of marine litter and microplastics on beaches, dunes, wetlands, and nearshore areas, highlighting their effects on ecosystem health, biodiversity, and environmental quality.
The presentation will highlight how progress in environmental monitoring and assessment, such as geospatial technologies, remote sensing, UAV surveys, artificial intelligence, and integrated vulnerability frameworks are transforming our ability to detect, quantify, and anticipate coastal change across spatial and temporal scales. Beyond enhancing environmental monitoring, these methods facilitate the development of predictive, resilience-oriented strategies, enabling a transition from reactive management to proactive adaptation in the face of accelerating environmental change.
Finally, the lecture will discuss emerging strategies to enhance coastal resilience, such as nature-based solutions, circular economy approaches, and sustainable governance practices. By considering coastal ecosystems as critical interfaces where climate change, plastic pollution, and biodiversity loss intersect, the lecture will highlight their role as indicators of wider Earth-system changes. It will also focus on how interdisciplinary research can support practical, scalable solutions that promote sustainability and enable society to stay within planetary boundaries.

Keywords: Coastal ecosystems, climate change, plastic pollution, microplastics, coastal resilience

CURRENT CHALLENGES IN DRINKING WATER SYSTEMS: BIOFILMS, MICROORGANISMS AND WATER SAFETY

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Ensuring safe and high quality drinking water remains one of the major challenges of modern water supply systems. In addition to chemical pollutants, increasing attention is being directed toward microbial contamination and biological processes occurring within drinking water distribution networks. Among these, biofilm formation represents a significant issue due to its impact on water quality, disinfection efficiency, infrastructure integrity, and the persistence of opportunistic microorganisms.

This lecture will provide an overview of current challenges related to microorganisms in drinking water systems, with particular emphasis on biofilm development and its role in water safety. Factors influencing microbial growth and biofilm formation, as well as their implications for public health and water management, will be discussed. The lecture will also highlight modern approaches for monitoring and improving water quality through advanced technologies and interdisciplinary research aimed at ensuring safer and more resilient drinking water systems.

Keywords: drinking water systems, biofilms, microbial contamination, water safety, water quality

Acknowledgment: This work was carried out within the project AquaGuardian (DIGIT.2.1.02.001), funded through the World Bank Loan No. 9558-HR for the project "Digital, Innovative and Green Technologies" (DIGIT Project).

UTJECAJ VRSTE MATERIJALA NA PONAŠANJE I TRAJNOST PASIVNO SIGURNIH STUPOVA UZ CESTE
THE INFLUENCE OF MATERIAL TYPE ON THE BEHAVIOR AND DURABILITY OF PASSIVELY SAFE ROADSIDE POLES

Višnja Tkalčević Lakušić
Sveučilište u Zagrebu Građevinski fakultet, Kačićeva 26, 10000 Zagreb, Hrvatska

Sigurnost u cestovnom prometu jedan je od ključnih prioriteta suvremenih prometnih sustava. U tom kontekstu značajnu ulogu imaju stupovi uz ceste koji služe za rasvjetu, prometnu signalizaciju, nadzorne sustave i zaštitu. Sudari vozila s takvim stupovima mogu uzrokovati teške ozljede putnika i oštećenja vozila. Jedan od načina ublažavanja posljedica takvih prometnih nesreća je ugradnja pasivno sigurnih stupova koji se prilikom udara vozila drugačije ponašaju u odnosu na tradicionalne krute stupove. Na ponašanje stupova kod udarnog opterećenja i trajnost tijekom uporabe značajno utječe vrsta materijala od kojeg su izrađeni. U radu se analizira utjecaj različitih vrsta materijala, prvenstveno čelika, aluminija i kompozitnih materijala, na ponašanje stupova i mogućnost apsorpcije energije pri udaru vozila. Posebno se razmatra utjecaj korozije i okolišnih uvjeta na očuvanje projektiranog ponašanja tijekom vijeka trajanja stupova. Usporedbom karakteristika pojedinih materijala ukazuje se na potrebu istodobnog razmatranja sigurnosti pri sudaru, trajnosti, održavanja i troškova životnog ciklusa. Cilj rada je istaknuti važnost pravilnog odabira vrste stupa i materijala za povećanje sigurnosti, trajnosti i učinkovitosti prometne infrastrukture.

Ključne riječi: stupovi uz ceste, udar vozila, pasivna sigurnost, materijali, apsorpcija energije, korozija

INSECT AS GREEN ENGINEERS OF WASTE MANAGEMENT

Neven Voća[1], Karla Gašparić[1], Matija Harcet[2]
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Insects are increasingly recognised as efficient biological agents for sustainable waste management and resource recovery. Selected species, including black soldier fly larvae (*Hermetia illucens*), cockroaches (*Blaptica dubia* and *Blatta lateralis*), mealworms (*Tenebrio molitor*) and superworms (*Zophobas morio*), show considerable potential for treating organic waste, agro-industrial by-products and, to a limited extent, plastic waste. Black soldier fly larvae are among the most advanced models of insect-based bioconversion, rapidly transforming biowaste into protein-rich biomass, larval oil and nutrient-rich frass. The use of brewery spent grain as a substrate demonstrates the potential to convert agro-industrial residues into valuable products within circular bioeconomy systems. Blatticomposting with selected cockroach species offers an additional route for converting food waste into nutrient-rich and hygienically safe organic material, although it requires strict control of rearing conditions, containment and public acceptance. Mealworms and superworms are suitable for processing dry organic substrates and are also used as experimental models for studying partial polystyrene degradation. Although insect-based plastic bioconversion is still at an early stage, it raises important questions related to polymer transformation, microplastics in frass and environmental safety. Overall, insects can be considered small but efficient "green engineers" linking waste reduction, biomass production, nutrient recovery and circular economy principles.

Keywords: bioconversion, biowaste, waste streams, waste reduction

Usmena priopćenja
Oral Presentations

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Kemija u poljoprivredi i šumarstvu

Chemistry in Agriculture & Forestry

OKRATOKSIN A KAO KONTAMINANT HRANE: PROCJENA RIZIKA ZA ODRASLU POPULACIJU U REPUBLICI HRVATSKOJ
OCHRATOXIN A AS FOOD CONTAMINANT: RISK ASSESSMENT OF ADULT POPULATION IN THE REPUBLIC OF CROATIA

Sanja Miloš[1], Dražen Knežević[1], Jelka Pleadin[2], Irena Jug[3], Maja Šegvić Klarić[4]

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Okratoksin A (OTA) je najtoksičniji predstavnik skupine nefrotoksičnih mikotoksina. Sintetiziraju ga sveprisutne plijesni rodova *Aspergillus* i *Penicillium*. U svrhu zaštite zdravlja potrošača, Hrvatska agencija za poljoprivredu i hranu (HAPIH) je izradila procjenu rizika za odraslu populaciju Republike Hrvatske OTA iz različitih vrsta hrane [1]. Za procjenu su korišteni rezultati službenog monitoringa hrane na tržištu RH, rezultati znanstveno istraživačkog projekta o mikotoksinima u hrvatskim tradicionalnim mesnim proizvodima Hrvatskog veterinarskog instituta (HVI), te prehrambene navike odrasle populacije RH. Rezultati procjene izloženosti ukazuju na moguću zabrinutost za zdravlje odrasle populacije zbog unosa OTA putem analiziranih grupa hrane koja se temelji na kritičnom učinku pojave tumora bubrega. Najveći doprinos izloženosti OTA za konzumente predstavljaju proizvodi iz kategorije „Žitarica i proizvoda na bazi žitarica“.

Ključne riječi: okratoksin A, nefrotoksičnost, procjena rizika

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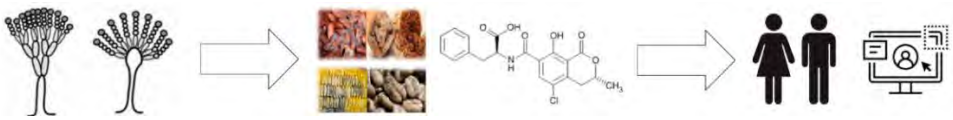

MIKROBNE BIOPOLIMERNE FORMULACIJE NOVE GENERACIJE: INKAPSULACIJA I KOINKAPSULACIJA KORISNIH MIKROORGANIZAMA U ALGINATNE MIKROČESTICE
MICROBIAL BIOPOLYMER FORMULATIONS OF THE NEW GENERATION: ENCAPSULATION AND CO-ENCAPSULATION OF BENEFICIAL MICROORGANISMS IN ALGINATE MICROPARTICLES

Marko Vinceković, Kristina Vlahoviček Kahlina, Karla Gašparić, Nenad Jalšenjak, Nataša Hulak

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Korisni mikroorganizmi imaju ključnu ulogu u razvoju održivih poljoprivrednih sustava jer doprinose poboljšanoj dostupnosti hraniva potiču rast i razvoj biljaka te povećavaju njihovu otpornost na biotske i abiotske stresove. Među najznačajnijim mikroorganizmima koji se koriste u tu svrhu ističu se bakterije *Azospirillum brasilense*, *Azotobacter chroococcum* i *Pseudomonas brassicacearum* te gljiva *Trichoderma harzianum* T1. Njihovo djelovanje temelji se na biološkoj fiksaciji dušika, proizvodnji biljnih regulatora rasta, mobilizaciji hranjiva iz tla i biološkoj zaštiti biljaka od fitopatogena. Međutim, primjena ovih mikroorganizama u obliku slobodnih stanica često je ograničena njihovom smanjenom stabilnošću, osjetljivošću na nepovoljne okolišne uvjete i slabijim preživljavanjem nakon primjene. U ovom radu istražen je razvoj alginatnih kompozitnih biopolimernih mikročestica kao nosača za inkapsulaciju i koinkapsulaciju korisnih mikroorganizama. Pojedinačna inkapsulacija bakterijskih i gljivičnih kultura te njihova zajednička koinkapsulacija provedene su metodom ionskog geliranja. Dobivene mikročestice karakterizirane su analizom morfoloških i fizikalno-kemijskih svojstava, učinkovitošću inkapsulacije, kapacitetom inkapsulacije, preživljavanjem mikroorganizama tijekom skladištenja te mogućnošću njihova kontroliranog otpuštanja.

Predstavljeni rezultati potvrđuju uspješnu inkapsulaciju svih ispitivanih mikroorganizama uz očuvanje njihove vijabilnosti i funkcionalne stabilnosti. Posebna pozornost je bila posvećena prednostima koinkapsulacije, koja omogućuje istodobno očuvanje više funkcionalno komplementarnih mikroorganizama u jedinstvenom biopolimernom sustavu. Takav pristup otvara mogućnosti razvoja novih generacija višekomponentnih mikrobnih biopreparata s povećanom učinkovitošću, stabilnošću i potencijalom primjene u održivoj poljoprivredi.

Ključne riječi: Azospirillum brasilense, Azotobacter chroococcum, Pseudomonas brassicacearum, Trichoderma harzianum T1, koinkapsulacija, kompozitne mikročestice, PGPR

Kemijska analiza i sinteza
Chemical Analysis & Synthesis

SYNTHESIS, CHARACTERIZATION, STRUCTURAL OPTIMIZATION, AND EVALUATION OF THE BIOLOGICAL ACTIVITY OF INDOLE SCHIFF BASES

Valerija Čolig[1], Dragana Vuk[1], Vilma Lovrinčević[1], Marija Vuković Domanovac[1], Ines Despotović[2]

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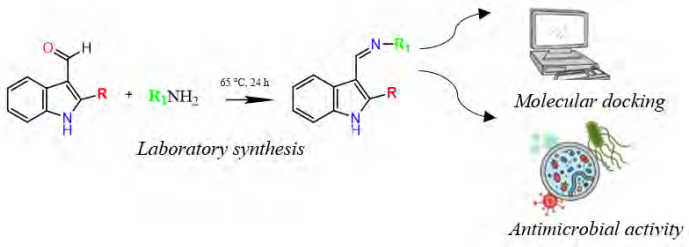
Schiff bases, also known as imines, represent an important class of organic compounds containing an azomethine group and are formed through the condensation reaction of primary amines with aldehydes or ketones. Owing to their structural diversity, straightforward synthesis, and broad spectrum of biological activities, they are considered one of the most significant classes of compounds in the development of new bioactive molecules.[1],[2] The aim of this study was to synthesize novel differently substituted Schiff bases using indole-3-carboxaldehyde and methyl-indole-3-carboxaldehyde as starting materials and various amines in condensation reactions. The obtained compounds were structurally characterized by NMR spectroscopy, confirming their successful synthesis. The synthesized compounds were evaluated for antimicrobial activity against selected microorganisms, and their biological activity was additionally assessed using computational methods, providing further insight into their potential biological effects and structure–activity relationships. The results indicate that structural modifications of indole-based Schiff bases significantly influence their antimicrobial and antifungal activity, with certain derivatives exhibiting promising biological properties.

Keywords: Schiff bases, structural characterization, antimicrobial activity, computational methods

Acknowledgment: This research was conducted within the project OSKomLiMe (112104) financed by the European Union's- NextGenerationEU fund from the source 581 – The recovery and resilience mechanism, in the frame of Programme financing of public higher education institutions and public scientific institutes.



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[2] D. Chaturvedi, M. Kamboj, *Chem.Sci.J.*, 2016, 7(2),e114.

ENHANCING THE STABILITY OF PLATINUM FOR THE HYDROGEN OXIDATION REACTION AS THE COUNTERREACTION IN LITHIUM-MEDIATED ELECTROCHEMICAL AMMONIA SYNTHESIS

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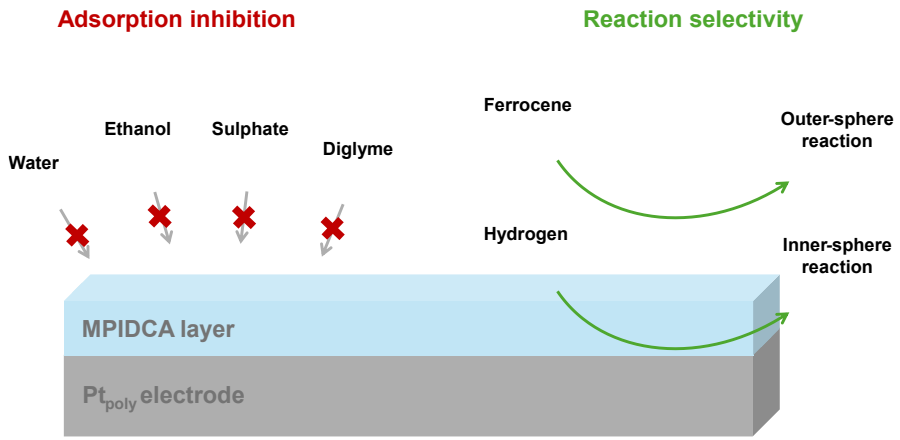
Ammonia is indispensable to global food production, yet its manufacture still relies on the centralized, energy-intensive Haber–Bosch process, which contributes substantially to greenhouse-gas emissions. Lithium-mediated nitrogen reduction (Li-NRR) is a promising alternative for decentralized ammonia synthesis under ambient conditions. In non-aqueous Li-NRR systems, the hydrogen oxidation reaction (HOR) is particularly attractive as the anode reaction because it supplies protons for ammonia formation while lowering the overall cell voltage. However, platinum, the benchmark HOR catalyst, deactivates rapidly in these electrolytes because electrolyte-derived decomposition products block its surface. Here, we investigate 1-methyl-3-propylimidazolium dicyanamide (MPIDCA) as an interfacial modifier for platinum electrodes in non-aqueous HOR. We characterized the MPIDCA-modified interface and compared its electrochemical behavior with that of polycrystalline platinum. The MPIDCA layer preserved high HOR activity while suppressing electrolyte decomposition and surface poisoning, demonstrating that it forms a selective protective interface that maintains reactant access to platinum active sites. This strategy improves platinum durability and enables lower-overpotential hydrogen oxidation in HOR-coupled Li-NRR systems.

Ključne riječi: oksidacija vodika, modifikacija površine elektrode, stabilnost



Kemijsko i biokemijsko inženjerstvo
Chemical & Biochemical Engineering

BIORAZGRADNJA ANTIVIROTIKA PRIMJENOM AKTIVNOG MULJA
BIODEGRADATION OF ANTIVIRALS USING ACTIVATED SLUDGE

Dora Lastovčić, Ivona Zirn, Tijana Jezerčić, Luka Večenaj, Kristina Bule Možar, Matija Cvetnić, Marinko Markić, Tomislav Bolanča, Dajana Kučić Grgić, Šime Ukić†

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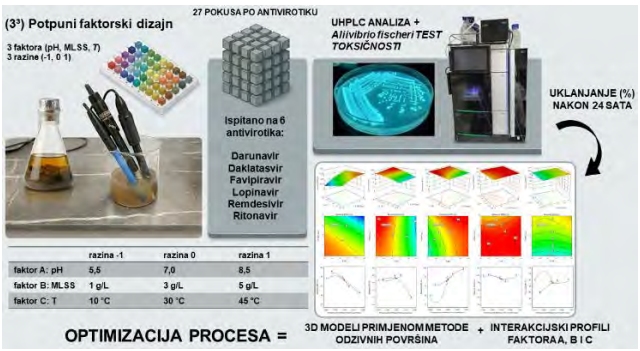
Biološko pročišćavanje otpadnih voda ključan je korak za uklanjanje mikroonečišćivala, uključujući zakonski neregulirane i nedovoljno istražene SARS-CoV-2 antivirotike koji predstavljaju rastući ekološki rizik. Cilj ovog istraživanja bio je optimizirati biorazgradnju aktivnim muljem pomoću potpunog faktorskog dizajna za šest antivirotika: daklatasvir, darunavir, favipiravir, lopinavir, remdesivir i ritonavir. Ispitivanja su provedena tijekom 24 sata, prateći interakcije triju faktora na trima razinama: pH-vrijednosti (5,5, 7,0 i 8,5), koncentracije biomase (1, 3 i 5 g/L) i temperature (10, 30 i 45 °C). Koncentracije antivirotika određivane su tekućinskom kromatografijom ultravisoke djelotvornosti s UV detektorom, dok je ekotoksičnost ispitivana na bakteriji *Aliivibrio fischeri*. Optimalni uvjeti uklanjanja za sve antivirotike postignuti su metodom odzivnih površina uz poželjnost od 0.739 pri pH 5,9, koncentraciji biomase 3,9 g/L i temperaturi 44,7 °C. Postotak uklanjanja iznosio je >99 % za daklatasvir, 97,4–98,2 % za favipiravir, lopinavir i remdesivir, 93,3 % za ritonavir te 74,7 % za darunavir. Dobiveni rezultati pružaju nužne informacije o učinkovitosti biološke obrade antivirotika, čime se doprinosi boljoj zaštiti okoliša i pročišćavanju otpadnih voda.

Ključne riječi: SARS-CoV-2, antivirotici, biorazgradnja, aktivni mulj, optimizacija



Zahvala: Istraživanje je provedeno u sklopu projekta Hrvatske zaklade za znanost „Okolišni aspekti SARS-CoV-2 antivirotika" (EnA-SARS, IP-2022-10-2822; voditelj projekta prof. dr. sc. Šime Ukić†).

BIOMASS COMPOUND HYDROGENATION ELECTRIFICATION USING MAGNETIC CATALYSIS

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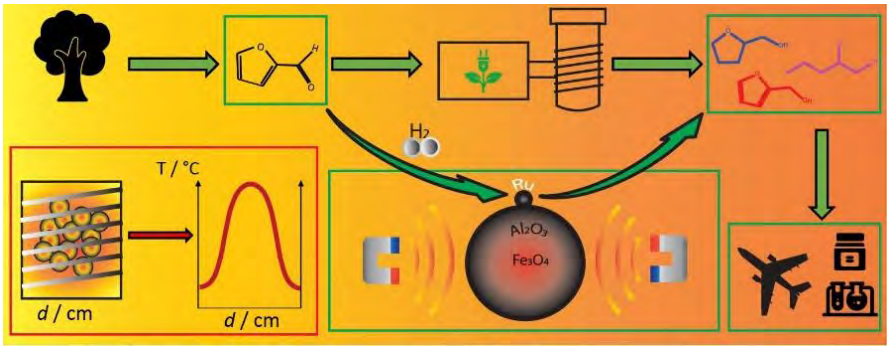
The mitigation of fossil fuel use is certainly one of the hot topics in chemical engineering and science in general. Woody biomass is a highly promising renewable source of different chemicals that can be used in various industrial branches, such as pharmacy, fuel industry, solvent industry etc. Due to its wide range of utilizaiton possibilities after hydrogenation, furfural was chosen as a model compound.[1] Magnetic heating is a promising heating technique based on the heat delivery directly to the catalyst surface using an alternating magnetic field (AMF).[2] For this purpose, a nanocomposite magnetic catalyst was synthesized in a multi-step synthesis method. The nanocomposite catalyst consists of iron oxide nanoparticles (approx. 20 nm in diameter), which act as a localized heater when interacting with AMF, γ-Al_2O_3 as a catalyst support, and ruthenium nanoparticles as a catalytically active material.[3] When exposed to the external magnetic field, ferrimagnetic magnetite nanoparticles exhibit a magnetic hysteresis loop, the area of which is proportional to the amount of produced heat. The nanoparticles were synthesized using a combination of co-precipitation and hydrothermal growth methods.[4] Magnetically heated hydrogenation reactions were performed under both magnetic and conventional heating and the yield/selectivity comparisons have been studied and showed in this work.

Ključne riječi: biomass, magnetic catalysis, nanocomposite catalyst



[1] R. Šivec *et al.*, *Chem. Eng. J.* (2022) 436.
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DEVELOPMENT OF A METHOD FOR QUANTIFYING CAR DETERGENT CLEANING POWER

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Following the evolution of the modern industry that follows green chemistry principles, EU standards for biodegradable detergents have scaled proportionally to the capabilities of detergent manufacturers. Stricter rules now apply for what is considered an eco-friendly efficient detergent as is determined by the new EU Ecolabel (concluded in May, 2026). However, car care cleaning products are excluded from the list of cleaning agents which can obtain the EU Ecolabel, partially due to the fact that no standardized test exists which can prove the cleaning efficiency of car detergents. To remedy the issue, we have developed a simple method capable of quantifying detergent cleaning power by developing a standardized dispersion of impurities which is cast onto a coated metal substrate and aged under solar irradiation and mildly increased temperature. Impurity removal is then characterized optically and gravimetrically by taking into account multiple passes until a certain percentage of the original dispersion is removed. Final examination steps include the examination of impurity thin film and fine particle removal, which is quantified optically via fluorescence. We show that by optimizing the procedure and varying the procedural steps, a method which is capable of generally and repeatedly quantify the washed impurity mass per amount of active ingredients used can be developed.

Keywords: Ecolabel, cleaning power, detergent

Medicinska kemija i farmacija
Medical Chemistry & Pharmacy

A PARAMETRIC MODEL FOR PREDICTING THE FORMATION OF THE "COFFEE RING" EFFECT IN ACTIVE PHARMACEUTICAL INGREDIENT RESEARCH

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The final morphology of a dried droplet is hard to anticipate from intuition alone. We introduce a fast, reduced-order parametric model that predicts coffee-ring deposition patterns directly from solubility and evaporation parameters. The generator blends four canonical morphological primitives (edge-ring formation, uniform deposition, central accumulation and multiphase/multi-ring structures), governed by physical parameters — solubility S, evaporation strength J_0 and initial concentration c_0 — mapped onto two dimensionless indicators: the saturation tendency $\Sigma = c_0/S$ and a proxy Péclet number (Pe). Blending weights follow logistic functions on a $\log_{10}$ scale, ensuring physically plausible transitions between regimes. The framework was validated through controlled evaporation experiments on three pharmaceutical actives spanning a wide solubility range (pantoprazole sodium, erythromycin and sulfasalazine), characterised by bright-field optical microscopy. Each active samples a distinct region of the (Σ, Pe) space, and the model correctly predicts the dominant primitive in every case: a multi-ring deposit for pantoprazole, (Figure 1) the textbook dense-rim/empty-centre ring for erythromycin and a combined edge-ring/multi-ring morphology for sulfasalazine. The framework bridges transport phenomena and empirical morphology descriptors, enabling rapid generation of high-fidelity labelled datasets for machine-learning and computer-vision applications in pharmaceutical formulation screening [1].

Keywords: coffee-ring effect, droplet evaporation, reduced-order model, pharmaceutical formulation screening, pantoprazole, erythromycin, sulfasalazine

Acknowledgments: This paper was funded by the Croatian Science Foundation through the project IP-2024-05-4339 entitled "'Coffee ring' effect in 'Lab on a Chip' environments in the development of new drug formulations".

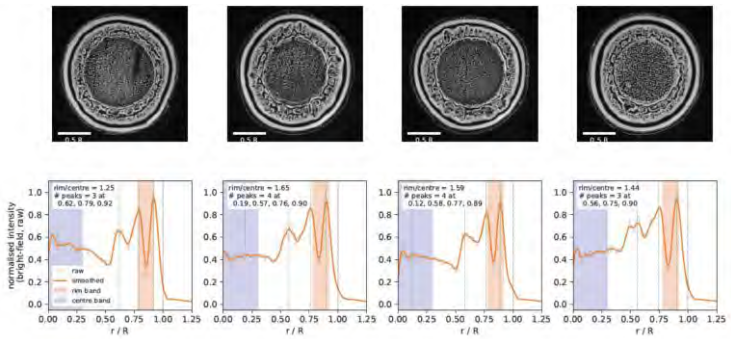

Figure 1. Cofee-ring deposition of pantoprazol sodium

[1] A. Danilovski, E. Meštrović, *Croat. Chem. Acta* 97 (2024) 243–259.

INVASIVE ALIEN PLANTS: FROM ECOLOGICAL THREAT TO PHARMACEUTICAL OPPORTUNITY

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Invasive alien plant species are among the major threats to biodiversity, yet they represent an abundant and largely unexplored source of bioactive natural compounds. Recent research on the sustainable valorisation of invasive alien plant species has shifted the focus from their ecological impacts towards their potential as renewable sources of bioactive natural products. Leaf and flower extracts of widespread invasive species collected in the Istria region (Croatia) were comprehensively investigated. Their phenolic profiles were characterised by LC-MS, antioxidant capacity was evaluated using in vitro assays, while antimicrobial, cytotoxic and genotoxic activities were assessed in human cell models to estimate their pharmaceutical potential. All investigated species proved to be rich sources of phenolic compounds with pronounced antioxidant activity. The extracts contained numerous species-specific specialized metabolites, providing characteristic phytochemical fingerprints and highlighting their potential as natural sources of bioactive molecules. Biological assays demonstrated diverse activities, including antimicrobial effects and concentration-dependent cytotoxic and genotoxic responses. Among the investigated species, *Ailanthus altissima* showed the most promising indications of selective activity toward tumor cells, making it an attractive candidate for further pharmacological investigation. The results demonstrate that invasive alien plants should not be viewed solely as an environmental problem, but also as a promising source of natural compounds with potential pharmaceutical applications. Their sustainable valorisation could simultaneously support invasive species management and the discovery of novel natural product-based candidates.

Keywords: antioxidant activity, cytotoxicity, genotoxicity, invasive alien plants, phenolic compounds, phytopharmaceuticals

SUKROSOMALNO I LIPOSOMALNO ŽELJEZO U PREVENCIJI I LIJEČENJU ANEMIJE KOD STARIJIH OSOBA: PREGLEDNI RAD
SUCROSOMAL AND LIPOSOMAL IRON IN THE PREVENTION AND TREATMENT OF ANEMIA IN ELDERLY: NARRATIVE REVIEW

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Prehrambeno-tehnološki fakultet Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Franje Kuhača 18, Osijek, Hrvatska
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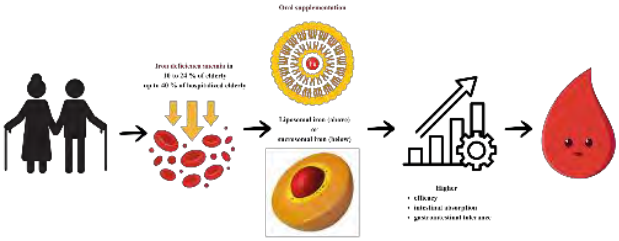
Cilj ovog pregleda je prikazati potencijal sukrosomalnog željeza (SFe) i liposomalnog željeza (LFe) u prevenciji i liječenju anemije (IDA) kod starijih osoba. Proveden je pregled dostupne literature, uključujući međunarodne smjernice, sustavne preglede i kliničke studije. Prevalencija IDAe u osoba starijih od 65 godina procjenjuje se na 10-24 %, dok u hospitaliziranih starijih bolesnika doseže i do 40 % [1]. Klasična oralna terapija željezom često je ograničena slabom apsorpcijom i gastrointestinalnim nuspojavama, što dovodi i do slabe adherencije, osobito u gerijatrijskoj populaciji [2]. SFe i LFe razvijeno je kao inovativni oralni oblik željeza s ciljem poboljšanja apsorpcije i podnošljivosti [2,3]. Kod SFe željezo pirofosfat okružen je fosfolipidnim membranama i sukroesterskom matricom [3], dok je kod LFe željezo pirofosfat inkapsuliran u liposome [4]. Klinička istraživanja pokazala su bolju bioraspoloživost i superiornu učinkovitost u korekciji IDAe u odnosu na konvencionalne oralne soli željeza, gastrointestinalne nuspojave javljaju se znatno rjeđe i adherencija bolesnika je viša [2,5,6].

Ključne riječi: sukrosomalno i liposomalno željezo, anemija, stariji, oralna suplementacija



[1] J. C. Alvarez-Paayares et al., *Cureus* 13(11) (2021) e19971.
[2] S. Gómez-Ramírez et al., *Pharmaceuticals* 16(6) (2023) 847.
[3] S. Gómez-Ramírez et al., *Pharmaceuticals* 11(4) (2018) 97.
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Prehrambena tehnologija i biotehnologija
Food Technology & Biotechnology

ROSEMARY EXTRACT IN NaDES-IMPACT ON *in vitro* CELL MIGRATION

Kristina Radošević, Višnja Gaurina Srček, Paula Čupić, Magdalena Maltar, Ana Sophia Prgomet, Tomislav Vladušić, Martina Železnjak, Ivana Radojčić Redovniković

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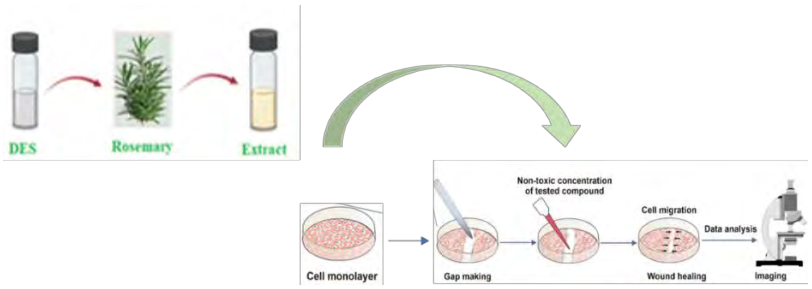
Wound healing is a complex biological process involving coordinated cellular events, including proliferation, migration, and tissue remodeling. Natural plant-derived compounds and extracts have gained increasing attention as wound healing agents due to their bioactive properties. Among these, rosemary (*Rosmarinus officinalis* L.) is rich in phenolic compounds that exhibit antioxidant and anti-inflammatory activities, which may contribute to tissue repair. Due to the various drawbacks associated with the use of organic solvents for the extraction of plant bioactive compounds, Natural Deep Eutectic Solvents (NaDES) have emerged as a sustainable and green extraction alternative. This study aimed to evaluate the effects of rosemary extract obtained by betain:sucrose NaDES on wound healing-related cellular responses using normal and tumor cell systems. The obtained results demonstrated dose-dependent cytotoxic effects in both cell lines, along with negative effect on cell migration and impaired wound-healing capacity.

Keywords: NaDES, rosemary extract, cytotoxicity, wound healing



Acknowledgement: This research was funded by the European Union (NextGenerationEU) under the National Recovery and Resilience Plan 2021–2026 (NRRP), through the UNIZG FFTB institutional project "Cell Migration Under the Effect of Plant Extracts in Natural Deep Eutectic Solvents", approved by the Ministry of Science, Education and Youth of the Republic of Croatia (component C3.2, source 581).

VALORIZATION POTENTIAL OF REED CANARYGRASS AS A SOURCE OF PHENOLIC ACIDS

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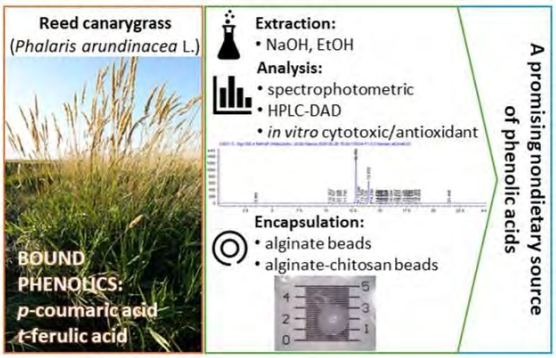
Reed canarygrass (*Phalaris arundinacea* L.) (RCG) is a perennial plant species from the Poaceae family, which is generally known to be abundant in bound phenolic acids. Among them, *p*-coumaric acid exhibits antioxidant, anti-inflammatory, antimicrobial, and other health-promoting properties. The recovery and further valorization of phenolics from RCG could be integrated with its prospective use as a second-generation bioenergy crop, presenting RCG as a novel and promising nondietary source of phenolics. This work aimed to investigate the content and extractability of phenolics from RCG, to establish encapsulation delivery systems of RCG phenolic extract as well as to evaluate its potential cytotoxic and antioxidant effects on liver, stomach, and oral cavity epithelial cells. Extracts of free phenolics were prepared by varying ethanol concentration in conventional extraction, while bound phenolics were deesterified using alkali while varying extraction time. The obtained extracts were evaluated for total phenolic content, antioxidant capacity, and individual phenolic profile (HPLC-DAD). Encapsulation of RCG phenolic extract was performed by ionic gelation using alginate and chitosan, while the obtained encapsulates were evaluated for encapsulation efficiency and release profile in simulated digestion fluids. RCG was shown to be abundant in *p*-coumaric acid, up to 0.8% of the dry weight. Alginate and alginate-chitosan systems enabled approximately 36% and 46% encapsulation efficiency, respectively, of RCG phenolics. The examined extracts did not show a cytotoxic effect. Ethanolic extract effectively inhibited hydroxyl radicals at the highest examined concentration, whereas the lowest concentration caused significant peroxidation of stomach and oral epithelial cells membranes.

Keywords: reed canarygrass, *p*-coumaric acid, extraction, encapsulation, bioenergy crop



Acknowledgement: This work has been supported by the Croatian Science Foundation project IP-2022-10-3075.

Zaštita okoliša
Environmental Protection

TESTING THE ANTIMICROBIC PROPERTIES OF SONOCHEMICALLY PREPARED MIXED Ag/Cu MOLYBDATES

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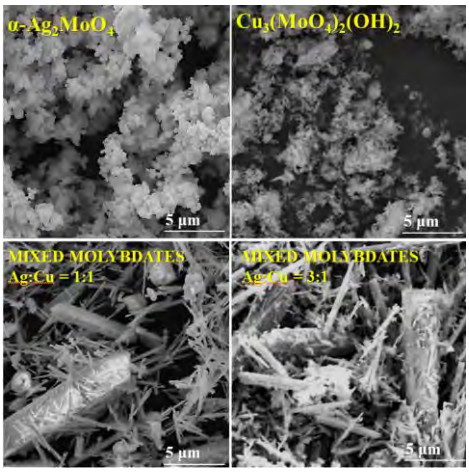
The rise of microbial resistance to classical antimicrobial agents drives the search for novel inorganic materials with intrinsic antimicrobial activity. In this work, the synthesis, structural and morphological characterization, and antimicrobial activity of pure and mixed silver and copper molybdates were investigated. X-ray diffraction analysis showed that pure Ag and Cu precursors formed silver molybdate (α-Ag_2MoO_4) and hydrated copper molybdate ($Cu_3(MoO_4)_2(OH)_2$). However, syntheses with the molar ratio of Ag:Cu = 1:1 and 3:1 resulted in a multiphase system of different mixed and pure Ag and Cu molybdates. Scanning electron microscopy provided insight into the morphology of the prepared samples. Silver molybdate formed spherical particles, copper molybdate formed platelet-like particles and mixed molybdates formed two distinct needle-like structures. Energy dispersive X-ray spectroscopy showed inhomogenous distribution of Ag and Cu in the two types of needle-like crystals present in the mixed samples. The antimicrobial activity was tested out against bacteria *Pseudomonas aeruginosa* and *Bacillus subtilis* and fungi *Candida albicans* and *Aspergillus niger*. Pure monophasic molybdates showed lower antimicrobial activity compared to the mixed molybdates, especially copper molybdate. Mixed molybdates performed better overall, showing potent antifungal activity even at lower concentrations compared to their antibacterial activity.

Keywords: silver molybdate, copper molybdate, mixed molybdates, antimicrobial activity



AIR POLLUTANTS AS CANDIDATE PREDICTORS IN RAGWEED POLLEN DYNAMICS: AN EXPLORATORY CORRELATION ANALYSIS

Alen Čuljak[1], Ivana Ćosić[2], Barbara Stjepanović[3]

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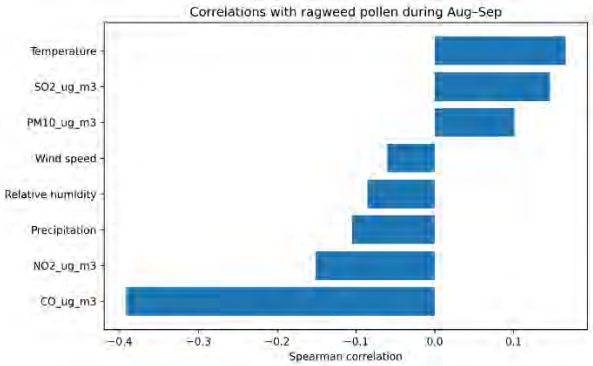
Ragweed (*Ambrosia artemisiifolia* L.) pollen is one of the most important aeroallergens in Central and Eastern Europe, with well-established sensitivity to meteorological conditions [1]. However, the influence of air pollutants on airborne pollen concentrations remains insufficiently understood. This study explored the relationships between daily ragweed pollen concentrations, meteorological variables, and selected air pollutants in Zagreb, Croatia. Daily pollen concentrations were analysed together with meteorological variables and air-quality indicators (SO_2, NO_2, CO, and PM10). Spearman rank correlation coefficinents were calculated for the complete dataset and separately for the main pollen season (August-September) to distinguish annual co-variation from within-season relationships [2]. Temperature showed the strongest positive association with ragweed pollen concentrations in both analyses (ρ = 0.31 full-year; ρ = 0.17 seasonal), while precipitation, relative humidity, and wind speed exhibited weak negative correlations. Among air pollutants, SO_2 and PM10 showed weak and unstable associations, NO_2 exhibited consistently weak negative correlations, and CO showed the strongest negative relationship, particularly during the pollen season ($\rho \approx -0.39$). Correlation patterns differed between the full-year and seasonal analyses, suggesting that some pollen-pollutant relationships may largely reflect common seasonal dynamics rather than direct environmental effects. These findings confirm that meteorological variables remain the primary drivers of ragweed pollen variability, while air pollutants should be considered as secondary predictors whose role requires further investigation using multivariable statistical and predictive modelling approaches [3,4].

Keywords: ragweed pollen, air pollutants, meteorological variables, Spearman correlation, seasonality.



Spearman correlation coefficients between ragweed pollen concentrations and environmental variables during the main pollen season (August–September)

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RAZVOJ METODE ZA ANALIZU OMJERA STABILNIH IZOTOPA ^{15}N I ^{13}C U OKOLIŠNIM UZORCIMA
METHOD DEVELOPMENT FOR THE ANALYSIS OF STABLE ISOTOPE RATIOS ^{15}N AND ^{13}C IN ENVIRONMENTAL SAMPLES

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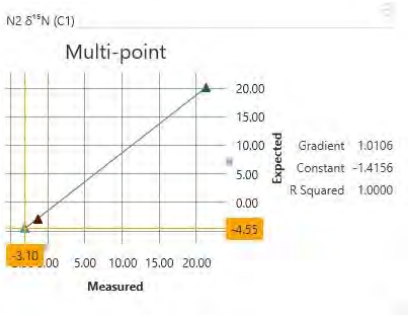
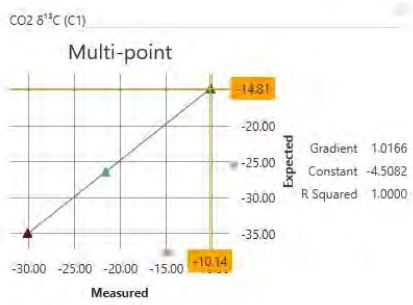
Elementna analiza – masena spektrometrija izotopnih omjera, engl. EA-IRMS vrlo je osjetljiva, moćna i široko primjenjiva tehnika koja se koristi za istovremeno određivanje koncentracija ukupnog dušika (N) i ugljika (C) (*bulk*) te omjera stabilnih izotopa $\delta^{15}N$ i $\delta^{13}C$ u različitim uzorcima iz okoliša s primarnom svrhom određivanja porijekla prisutnog materijala, kao i praćenja biogeokemijskih procesa u okolišu. Detaljna validacija metode provedena je na standardima certificiranima za koncentraciju i za izotopne omjere kao i na realnim uzorcima. LOD i LOQ određeni su za analizu oba elementa. Najveći izazov kod analiza uzoraka iz morskog okoliša je prisutnost kloridnih iona kao i promjenjive koncentracije N i C. Testirani su različiti pristupi kako bi se optimirao signal u uvjetima niskog sadržaja N te visokog sadržaja C. Metoda je u okviru validacije preliminarno testirana na uzorcima iz različitog morskog okoliša (čisto more, prijelazne vode, priobalne vode, eutrofni uzorci) što je poslužilo za definiranje protokola za pripremu i analizu uzoraka u svrhu pouzdanog određivanja koncentracija N i C te izotopnih omjera $\delta^{15}N$ i $\delta^{13}C$ u složenim uzorcima iz okoliša.

Ključne riječi: elementna analiza, masena spektrometrija izotopnih omjera, validacija metode, morski uzorci





ACQUISITION OF GEOENVIRONMENTAL NUMERICAL DATA

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University of Zagreb Faculty of Geotechnical Engineering,
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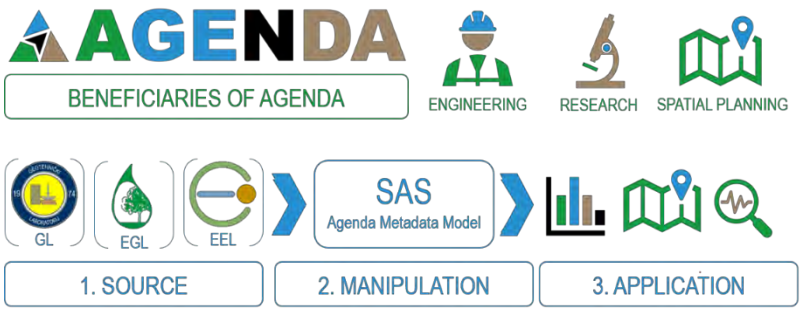
The Acquisition of Geoenvironmental Numerical Data (AGENDA) project establishes an institutional system for collecting, digitising, and standardising geoenvironmental numerical data generated across three laboratories of the Faculty of Geotechnical Engineering (Geotechnical – GL, Environmental Geochemistry – EGL, and Environmental Engineering – EEL). GL will provide mechanical parameters of soil (such as classification, particle size analysis, permeability, strength, deformability etc.). EGL will provide chemical parameters of soil and water (heavy and toxic metals, TOC, total N and P etc.). EEL will provide chemical data regarding qualitative and quantitative analysis of organic contaminants (pesticides, pharmaceuticals, industrial chemicals etc.). Therefore, the aim of the project is to develop open access, digitalised and interactive web application which will provide insight into a wider set of geolocalised geoenvironmental numerical data. The work includes digitising historical archives, structuring recent datasets, and developing a unified metadata model based on the SAS (Storage, Access, Search) approach which will enable data entry, validation, querying, and cartographic visualisation. Its modular architecture ensures interoperability, quality control, and long-term data sustainability.
The application will support scientific research, engineering practice, and spatial planning, where AGENDA serves as a strategic spatial resource. Integrated datasets enable the development of analytical tools and environmental indicators and form the basis for future geoenvironmental infrastructure.

Keywords: geoenvironmental data, digitalisation, interoperable and georeferenced data sets



Funded through National Recovery and Resilience Plan
Financira Europska unija NextGenerationEU

CHEMICAL OXYGEN DEMAND (COD) AS AN INITIAL INDICATOR OF WATER QUALITY IN CROATIAN AND HUNGARIAN FISH PONDS

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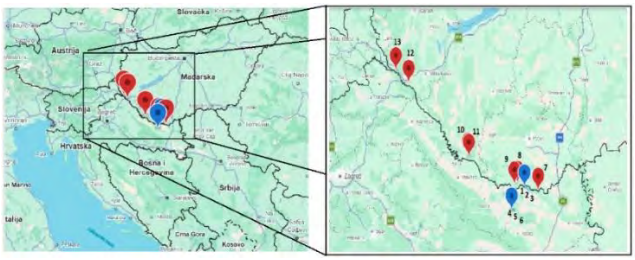
The PondSustain project aims to enhance the sustainability and climate resilience of fish pond aquaculture through cross-border cooperation between Croatia and Hungary. As part of the project activities, systematic water quality monitoring is being conducted to assess the ecological status of fish ponds and provide a scientific basis for sustainable management practices. Water quality is one of the key factors influencing fish production, biodiversity conservation, and the overall functioning of pond ecosystems. During the first sampling campaign, chemical oxygen demand (COD) was determined as an indicator of the amount of oxidizable organic matter present in the water. Water samples were collected simultaneously from selected fish ponds in Croatia and Hungary according to the project monitoring plan, and laboratory analyses were performed using standardized analytical methods. The preliminary results revealed considerable spatial variability in COD values among the investigated ponds, indicating differences in organic load and environmental conditions. Such variability may reflect differences in production intensity, management practices, hydrological characteristics, and natural ecological processes. These initial findings provide a valuable baseline for future seasonal monitoring of physicochemical water quality parameters within the PondSustain project. The collected data will contribute to a better understanding of the ecological status of transboundary fish ponds and support the development of sustainable aquaculture management strategies while promoting biodiversity conservation in the cross-border region.

Keywords: chemical oxygen demand (COD), water quality, fish ponds, sustainable aquaculture, PondSustain project

Acknowledgement: This work was supported by the Interreg Project "Assessing the Ecological and Economic Impact of Fish Ponds in Croatia and Hungary towards more sustainable and climate resilient aquaculture – PondSustain" (ID: HUHR/2401/2.4/083) under the Interreg VI-A Hungary-Croatia Programme 2021-2027.



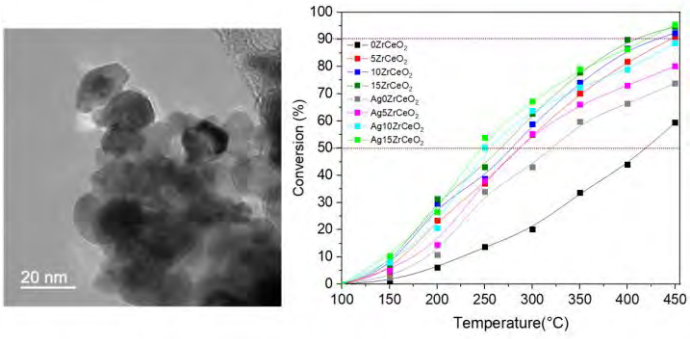
MESOPOROUS Ag/CeO_2-ZrO_2 SOLID SOLUTIONS FOR CATALYTIC OXIDATION OF VOLATILE ORGANIC COMPOUNDS

Katarina Mužina, Emma Berisha, Lora Šoljak, Filip Brleković, Filip Car, Gordana Matijašić, Stanislav Kurajica

University of Zagreb Faculty of Chemical Engineering and Technology, Trg Marka Marulića 19, 10000 Zagreb, Croatia

Mesoporous CeO_2-ZrO_2 solid solutions are attractive catalytic materials due to their high specific surface area, tuneable pore structure, enhanced oxygen storage capacity and favourable redox properties. In this work, pure CeO_2 and Zr-doped CeO_2 samples containing 5, 10 and 15 mol.% Zr were prepared by soft template method, decorated with silver nanoparticles by wet impregnation, and characterized using various techniques to investigate their structural, textural and catalytic properties. X-ray diffraction results confirmed the formation of CeO_2-ZrO_2 solid solutions accompanied by a minor secondary ZrO_2 phase. All samples exhibited a mesoporous structure, confirmed by type IV isotherms with H3 hysteresis loops, and average pore diameters ranging from 11.7 to 14.1 nm. The presence of silver was confirmed by energy dispersive X-ray spectroscopy analysis. Catalytic testing in oxidation of toluene as model volatile organic compound (VOC) showed that the addition of zirconium significantly enhanced the activity of CeO_2, while further improvement was achieved by silver nanoparticle decoration. The Ag15Zr:CeO_2 sample exhibited the lowest temperature required for 50% toluene conversion, demonstrating the potential of mesoporous Ag-decorated CeO_2-ZrO_2 catalysts for VOCs oxidation.

Keywords: ceria, soft template method, catalysis, volatile organic compounds

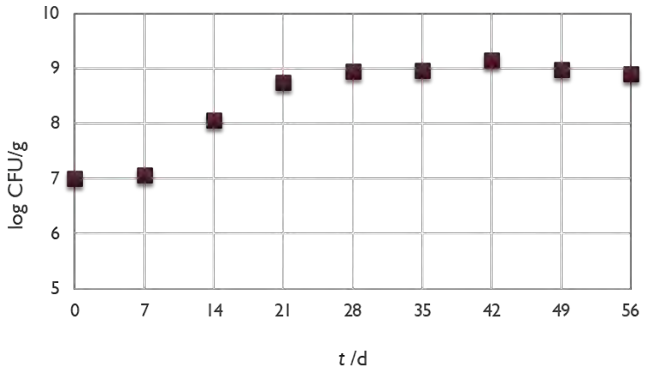


BIOLOGICAL ACTIVITY OF THE AUTOCHTHONOUS BACTERIAL COMMUNITY IN OIL-POLLUTED SOIL

Josip Tutić, Barbara Bertović, Monika Šabić Runjavec, Marija Vuković Domanovac
University of Zagreb Faculty of Chemical Engineering and Technology, Trg Marka Marulića 19, 10000 Zagreb, Croatia

Soil pollution by crude oil presents a significant environmental challenge due to its long-term impacts on soil quality, groundwater, and biodiversity. Bioremediation, which relies on the activity of microorganisms capable of degrading xenobiotics, has proved to be an effective method for remediating oil-contaminated soils. This study evaluated the potential of autochthonous bacterial strains to degrade petroleum hydrocarbons during natural attenuation. Physicochemical soil parameters were monitored throughout the experiment to assess process conditions and their influence on microbial activity. The pH ranged from 5.5 to 6.5, while the average temperature and moisture content were 24.9 ± 0.2 °C and 17.1 ± 0.4%, respectively, ensuring stable mesophilic conditions and adequate water availability for microbial degradation. Under these conditions, a marked increase in colony-forming units (CFU) was observed, reaching a maximum of 9.15 log CFU/g on day 42, indicating a strong intrinsic response of the autochthonous microbial community to the presence of petroleum hydrocarbons.

Keywords: autochthonous microorganisms, bioremediation, oil-polluted soil



ELECTROCHEMICAL AND EA-IRMS CHARACTERIZATION OF ORGANIC MATTER IN ROGOZNICA LAKE (DRAGON'S EYE)

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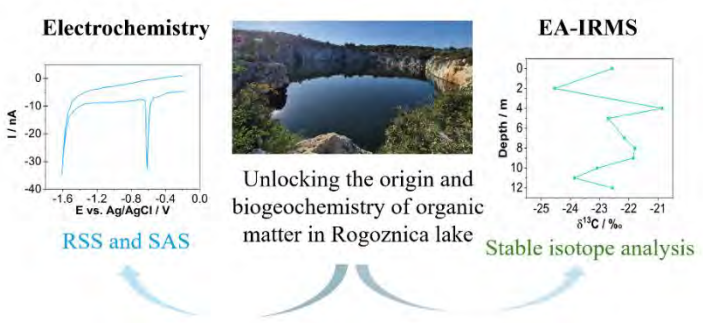
Rogoznica Lake (Dragon's Eye) is an eutrophic marine lake characterized by strong seasonal stratification and the development of a distinct chemocline separating oxic surface waters from anoxic deeper layers. Due to its pronounced sensitivity to environmental and climatic variations, lake represents a valuable natural laboratory for studying biogeochemical processes and organic matter (OM) dynamics. In this study, electrochemical techniques were applied during investigations conducted in 2026 to characterize reduced sulfur species (RSS) and surface-active substances (SAS) within the water column, with a particular focus on the chemocline region located at depths of 6-7 m. Electrochemical measurements confirmed the presence of RSS associated with anoxic conditions and active sulfur cycling. In addition, voltammetric measurements of SAS revealed the widespread occurrence of adsorbed organic surface-active material throughout the upper water column (oxic layer). A pronounced desorption peak at approximately −1.75 V vs. Ag/AgCl was noticed which could be associated with fresh production of organic matter with higher nitrogen content. To further investigate the origin and transformation of organic matter, elemental analyzer–isotope ratio mass spectrometry (EA-IRMS) was employed. Carbon isotope analysis showed $\delta^{13}C$ values raging from −20.86‰ to -24.54‰ at all investigated depths (0-12 m). These isotopic signatures suggest active primary production and the accumulation of fresh organic carbon. The combined application of electrochemical methods and EA-IRMS provided complementary information on the chemical functioning of Rogoznica Lake. While electrochemical techniques enabled sensitive detection of RSS and SAS, stable isotope analysis offered insight into the origin and biogeochemistry of OM.

Keywords: Rogoznica Lake, reduced sulfur species, surface-active substances, EA-IRMS, $\delta^{13}C$, sulfur cycle, organic matter, chemocline



Posterska priopćenja
Poster Presentations

FROM SPICE TO SHELF LIFE: TURMERIC AS A NATURAL PROTECTOR OF STRAWBERRIES

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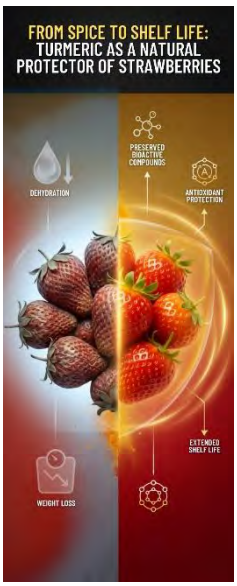
Strawberries are highly perishable fruits that undergo rapid quality deterioration during postharvest storage due to water loss, physiological changes, and oxidative processes. The aim of this study was to evaluate the effect of edible coatings based on carboxymethyl cellulose (CMC) and turmeric extract on the preservation of strawberry quality during storage. Fruits of the 'Albion' cultivar were treated with CMC coating or a combination of CMC and turmeric extract and monitored throughout the storage period. Weight loss, total phenolic content, and total flavonoid content were determined using spectrophotometric methods. The application of edible coatings significantly reduced weight loss compared to untreated fruits, indicating their effectiveness in limiting water vapor transfer and slowing transpiration processes. In addition, coated strawberries showed enhanced retention of phenolic compounds and flavonoids during storage, with the turmeric-enriched coating exhibiting the most pronounced effect. The improved preservation of bioactive compounds can be attributed to the antioxidant properties of turmeric and the protective barrier formed by the coating matrix. The results demonstrate that edible coatings, particularly those enriched with turmeric extract, represent a promising natural strategy for extending the shelf life and maintaining the physicochemical quality of strawberries. Their application may contribute to reducing postharvest losses while preserving the nutritional and functional value of fresh fruit.

Keywords: strawberry, edible coating, turmeric, postharvest storage, bioactive compounds

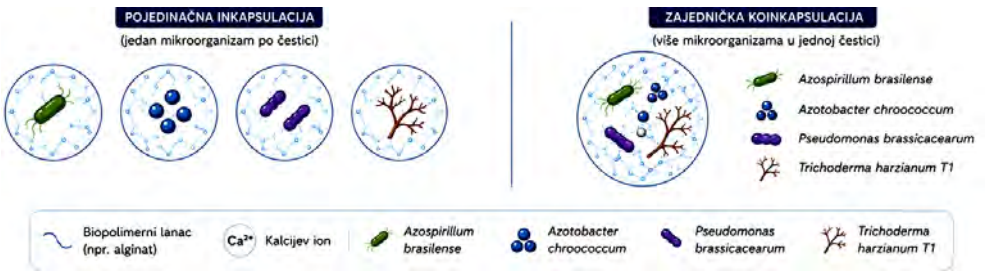


INKAPSULACIJA I KOINKAPSULACIJA KORISNIH MIKROORGANIZAMA U KOMPOZITNE BIOPOLIMERNE MIKROČESTICE
ENCAPSULATION AND CO-ENCAPSULATION OF BENEFICIAL MICROORGANISMS IN COMPOSITE BIOPOLYMER MICROPARTICLES

Karla Gašparić, Nataša Hulak, Lucija Božić, Kristina Vlahoviček Kahlina, Danijel Čičak, Nenad Jalšenjak, Marko Vinceković
Sveučilište u Zagrebu Agronomski fakultet, Svetošimunska cesta 25, 10000 Zagreb, Hrvatska

U ovom radu uspješno je provedena pojedinačna inkapsulacija bakterija *A. brasilense*, *A. chroococcum* i *P. brassicacearum* te gljive *T. harzianum T1*, kao i njihova zajednička koinkapsulacija u kompozitne biopolimerne mikročestice primjenom metode ionskog geliranja. Dobivene mikročestice karakterizirane su određivanjem morfoloških i fizikalno-kemijskih svojstava, učinkovitosti inkapsulacije, kapaciteta inkapuslacije, preživljavanja mikroorganizama te mogućnosti njihovog kontroliranog otpuštanja iz biopolimernog nosača. Rezultati istraživanja pokazali su uspješnu inkapsulaciju svih ispitivanih mikroorganizama unutar kompozitnog biopolimernog matriksa, pri čemu je očuvana njihova vijabilnost i funkcionalna stabilnost. Koinkapsulirane mikročestice omogućile su istodobno očuvanje različitih skupina korisnih mikroorganizama te predstavljaju potencijalni pristup za razvoj višekomponentnih mikrobnih pripravaka poboljšane učinkovitosti. Dobiveni rezultati potvrđuju potencijal primjene inkapsulacije selektiranih mikroorgnaizama u kompozitne biopolimerne mikročestice kao tehnologije za zaštitu i dostavu korisnih mikroroganizama, čime se doprinosi razvoju inovativnih bioformulacija i smanjenju ovisnosti o konvencionalnim agrokemijskim sredstvima u održivoj poljoprivrednoj proizvodnji.

Ključne riječi: korisni mikroorganizmi, koinkapsulacija, kompozitne mikročestice



UTJECAJ PODRIJETLA GROŽĐA I KVASACA NA KARAKTERISTIKE VINA GRAŠEVINE
INFLUENCE OF GRAPE ORIGIN AND YEAST STRAINS ON THE CHARACTERISTICS OF GRAŠEVINA WINES

Josip Mesić[1], Lovro Hoborka[1], Valentina Obradović[1], Anita Pichler[2], Ivana Ivić[2], Helena Marčetić[1], Veronika Brišić[1], Brankica Svitlica[3]

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Cilj istraživanja bio je utvrditi utjecaj podrijetla grožđa i različitih sojeva kvasaca na fizikalno-kemijska i senzorna svojstva vina sorte graševina. Korišteni su moštevi graševine iz vinogorja Kutjevo i Nova Gradiška, fermentirani primjenom rezličitih kvasaca *S. cerevisiae* SIHA Aktiv 7 i ESOTICFERM, *L. thermotolerans* Vinflora OCTAVE te autohtonih kvasaci. Analizirano je ukupno šest uzoraka vina proizvedenih različitim kombinacijama podrijetla grožđa i kvasaca u vinskom podrumu Hoborka. Senzorska analiza provedena je metodom 100 bodova, Najvišu ukupnu ocjenu ostvario je uzorak kombinacije grožđa iz oba vinogorja s kvasccem SIHA Aktiv7 (87 bodova). Fizikalno-kemijska analiza provedena je uređajem WineScan, pri čemu su određeni sadržaj alkohola, ukupne i hlapive kiseline, reducirajući šećeri, pH vrijednost, organske kiseline, te sadržaj slobodnog i ukupnog sumporovog dioksida. Alkohola kretao se od 11,7 do 13,9 vol %. Sva vina pripadaju kategoriji suhih vina, a ukupna kiselost je u rasponu od 5,3 do 6,8 g/L. Istraživanje je pokazalo da podrijetlo grožđa i odabrani kvasci značajno utječu na senzorska svojstva i kvalitetu vina Graševina. Najbolji rezultat postignut je kombinacijom moštova iz oba vinogorja i fermentacijom kvascem SIHA Aktiv 7.

Ključne riječi: graševina, vino, vinogorje Kutjevo, vinogorje Nova Gradiška, kvasci

VOLATILE PROFILE CHARACTERIZATION BY HS-SPME-GC-MS OF *Eucalyptus cinerea* SUPERCRITICAL FLUID EXTRACT

Vedran Poljak[1], Marijana Franičević[2], Vlatka Paštar[2], Ivana Kavain[2], Marko Šuste[1]

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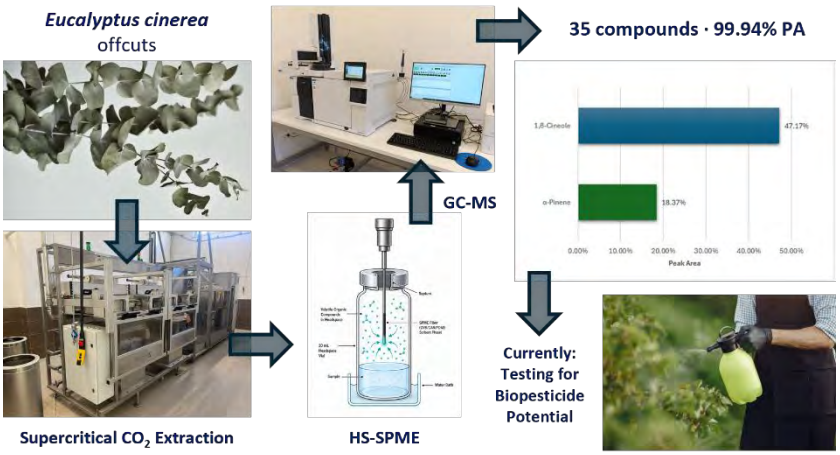
Eucalyptus cinerea cultivation for use in floristry and garden design generates substantial pruning offcuts. This study reports the extraction of air-dried and milled *E. cinerea* leaves and thin branches using supercritical CO_2 on a pilot-scale extractor. Volatile organic compound composition of the resulting extract was characterized by headspace solid-phase microextraction coupled with gas chromatography-mass spectrometry (HS-SPME-GC-MS). A total of 35 compounds were identified, accounting for 99.94% of total peak area. The identified compounds were dominated by 1,8-cineole (47.17%) and α-pinene (18.37%), alongside minor terpenoid constituents. The volatile fraction is rich in monoterpenes, compounds with documented insecticidal and repellent bioactivities. This composition supports the extract's potential application as a botanical biopesticide. The water condensate fraction collected during the extraction process is currently being evaluated for insect repellent activity against both larval and adult stages.

Keywords: Eucalyptus cinerea, volatile compounds, supercritical fluid extraction, HS-SPME-GC-MS



IS WASTE WORTH MORE? POLYPHENOL RECOVERY FROM APPLE POMACE

Sandra Voća, Vanja Jurišić, Ana Matin, Neven Voća, Ante Galić, Ivan Brandić, Anamarija Peter, Jona Šurić, Mia Dujmović, Ivana Tomić, Karlo Špelić, Jana Šic Žlabur
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Recovery of polyphenols from agro-industrial waste represents an important approach to valorizing plant-derived by-products within the circular bioeconomy framework. Polyphenols are bioactive compounds with strong antioxidant capacity and significant potential for applications in the food, pharmaceutical, and cosmetic industries. The aim of this study was to determine the content of bioactive compounds and the antioxidant capacity of apple pomace generated after juice production, in order to assess its potential as a raw material for further valorisation. The obtained results show that apple pomace is a significant source of polyphenols (approximately 140 mg GAE/100 g fresh weight) and other bioactive compounds with pronounced antioxidant activity. This confirms its value as a secondary raw material rather than waste, with potential for further utilisation and the development of high value-added products. Particular emphasis is placed on the possibility of polyphenol extraction and their application in the development of functional extracts and cosmetic formulations with antioxidant activity, thereby contributing to the development of sustainable and circular bioprocesses..

Keywords: apple pomace, recovery, polyphenolics, antioxidant capacity, circular bioeconomy

INVESTIGATING THE INFLUENCE OF PR CONCENTRATION ON THE STRUCTURAL EVOLUTION OF CERIA-BASED HIGH-ENTROPY OXIDES

Jakov Babić, Stjepan Šarić, Dalibor Tatar, Jelena Kojčinović, Petra Šušak, Igor Djerdj

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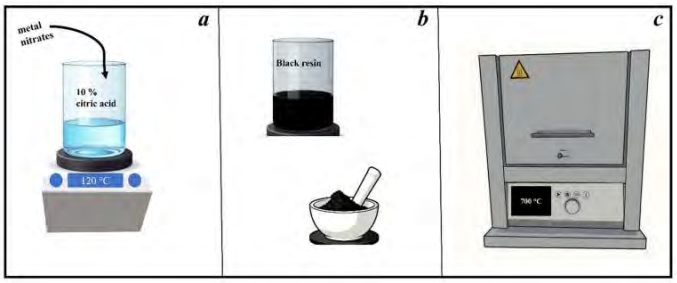
A family of materials known as high-entropy oxides (HEOs) is associated with a wide range of potential applications due to their unique compositions and crystal structures. Exceptional stability is exhibited by these single-phase solid solutions containing five or more principal metal cations in equiatomic proportions, owing to the random distribution of cations within the crystal lattice [1]. In the present study, Ce–Zr–Pr–Sm–Eu-based high-entropy oxides with systematically varied Pr content were synthesized via a modified sol-gel citrate method to investigate the influence of Pr incorporation on the lattice structure, defect formation, and photocatalytic performance [2]. A single-phase cubic fluorite structure was maintained across all synthesized compositions, while gradual lattice expansion and increased microstrain were detected with increasing Pr concentration as a result of substitution by larger Pr^{3+} ions. Morphological and surface characterization revealed the formation of porous nanostructures at intermediate Pr levels, whereas excessive Pr incorporation led to densification and reduced surface accessibility. The presence of Pr^{3+}/Pr^{4+} and Ce^{3+}/Ce^{4+} redox pairs, pronounced $4f$–$2p$ orbital hybridization, and enhanced defect-related electronic states, contributing to bandgap reduction, were confirmed through spectroscopic analysis. Under UV irradiation, the optimized Pr-containing composition achieved almost complete degradation of methylene blue within 30 minutes. This behavior is attributed to enhanced charge separation efficiency, together with redox cycling between Ce and Pr centers, facilitated by the narrowed bandgap.

Keywords: high-entropy oxides, fluorite structure, praseodymium, photocatalysis



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[2] D. Tatar, J. Babić, S. Šarić, J. Kojčinović, P. Šušak, A. Stanković, L. Milišić, A. Mavrić, C. Deák, G. Ballai, I. Szenti, Á. Kukovecz, I. Djerdj, Molecules 31 (2026) 598.

SYNTHESIS AND DYEING PROPERTIES OF NOVEL BENZOTHIAZOLE-BASED AZO NAPHTHOLSULFONIC DYES

Anja Beč[1], Petra Meštrović[1], Ana Sutlović[2], Iva Brlek[2], Livio Racané[1]
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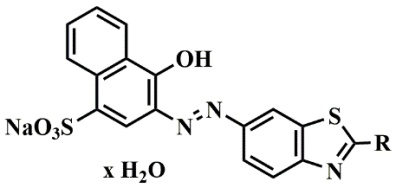
Aromatic and heteroaromatic azo compounds represent the largest and most diverse group of synthetic colorants with application not only in the textile industry but also in many other technological fields. Azo dyes prepared from heterocyclic diazo components show good colorimetric parameters, such as are hue and brightness. Among azo dyes, anionic dyes represent an important class of water soluble colorants widely used for dyeing protein and polyamide fibers due to their good affinity, bright shades, and ease of application [1]. Within this work, as a continuation of our research on azo dyes [2], novel benzothiazole azo derivatives of naphtolsulfonic acids were synthesized. 6-Aminobenzothiazole, 6-amino-2-methylbenzothiazole, and 6-amino-2-chlorobenzothiazole were first prepared, and the corresponding diazonium salts were obtained by diazotation. Using copulation reaction with commercially available sodium 4-hydroxynaphthalene-1-sulfonate afforded the following previously not described azo compounds. The synthesized compounds were structurally characterized using UV/Vis, ^{1}H and ^{13}C NMR spectroscopy, and elemental analysis. Prepared anionic dyes are water soluble and their dyeing properties were investigated on polyamide fiber. In addition, the wash fastness of the dyed polyamide materials was investigated.

Ključne riječi: azo dyes, benzothiazole, synthesis, dyeing, fastness properties



R = H, CH_3, Cl

Fig. 1. Prepared benzothiazole azo naphtholsulfonic dyes

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EVALUATION OF HONEY QUALITY AND SAFETY USING PHYSICOCHEMICAL ANALYSIS AND ICP-MS ELEMENTAL PROFILING

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Honey is a natural product valued for its nutritional composition and health benefits, although environmental pollution and adulteration may compromise its quality and safety. This study investigated the physicochemical properties and elemental composition of 33 honey samples of different botanical and geographical origins, including adulterated products. Physicochemical parameters were determined, while macroelements and trace elements were quantified using inductively coupled plasma mass spectrometry (ICP-MS).

Significant differences were observed among samples depending on their origin and production characteristics. Several samples deviated from regulatory limits for electrical conductivity and water content, while elevated concentrations of toxic heavy metals were detected in some samples, indicating possible environmental contamination. One blossom honey sample exhibited particularly high concentrations of both essential minerals and potentially hazardous trace metals.

The results demonstrate that ICP-MS elemental profiling combined with physicochemical characterization is a valuable tool for honey quality assessment, authenticity evaluation, food safety control, and environmental monitoring.

Keywords: honey, ICP-MS, heavy metals, physicochemical characterization

Mineral and Contamination Profiles of Selected Honey Samples (mg/kg)

Honey Sample	K	Mg	P	Fe	Cu	Pb	Zn
8	1696.0	38.2	69.9	7.4	32.3	10.1	20.6
9	412.0	26.4	54.0	38.7	159.1	92.5	97.1
14	2942.0	122.0	160.4	6.3	0.9	0.1	1.1
25	1866.0	29.8	72.1	1.3	1.3	4.5	1.8
33	4094.0	88.4	268.4	3.8	4.4	0.1	1.0

MICROWAVE-ASSISTED SYNTHESIS OF A NOVEL IMIDAZOLE-TRIAZOLE DERIVATIVE FOR ANTIBACTERIAL EVALUATION

Andrea Dandić, Marija Paurević, Iva Funarić, Martina Šrajer Gajdošik
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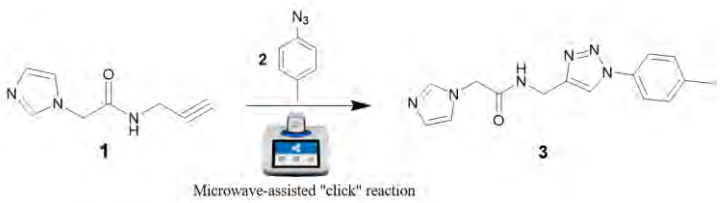
Nitrogen-containing heterocycles, particularly imidazole and 1,2,3-triazole derivatives, represent an important class of bioactive compounds exhibiting a broad spectrum of pharmacological activities, including antibacterial, antifungal, antiviral, and anticancer effects. The combination of these two heterocyclic scaffolds into a single molecular framework has attracted considerable interest as a promising strategy for the development of novel biologically active compounds with enhanced therapeutic potential. In this study, a new imidazole – 1,2,3-triazole derivative (3) was synthesized through a three-step synthetic route. Initially, the propargyl intermediate, 2-(1H-imidazol-1-yl)-*N*-(prop-2-yn-1-yl)acetamide (1), was prepared via Steglich esterification method. Separately, the corresponding aryl azide (2) was generated from the appropriate aniline derivative through diazotization followed by azidation. The target triazole derivative was then obtained by copper-catalyzed azide–alkyne cycloaddition (CuAAC) "click" reaction. This key step was performed in a microwave reactor at 80 °C for 30 minutes (150 W), serving as an efficient, rapid, and environmentally friendly "green chemistry" alternative to conventional heating methods. The use of microwave-assisted synthesis significantly reduced the reaction time while improving energy efficiency. The synthesized compound was purified by column chromatography and structurally characterized using nuclear magnetic resonance (^{1}H and ^{13}C NMR) spectroscopy and mass spectrometry (MS), confirming the successful formation of the desired imidazole–triazole derivative. Ongoing research is focused on evaluating its antibacterial activity against selected bacterial strains to assess its potential as a novel antimicrobial agent.

Keywords: 1,2,3-triazole, imidazole, click chemistry, microwave-assisted synthesis

Acknowledgment: This research was funded by the European Union—Next Generation EU, project number 581-UNIOS-105.



NATURAL REPELLENTS: EXTRACTIONS AND GC-MS ANALYSES OF VOLATILE COMPONENTS OF CLOVE, LAVENDER AND THYME

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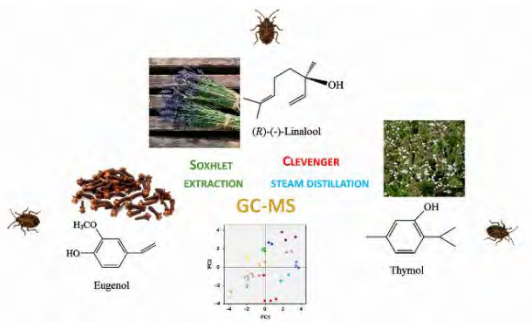
Volatile organic compounds (VOCs) are low molecular weight chemicals that readily evaporate. In plants, they form the basis of what we recognise as essential oils. Their effects in plants encompass a wide range of biological, ecological, and biochemical processes. Because VOCs readily evaporate and disperse through the air, they serve as a primary medium through which plants communicate with their environment, influence other organisms and defend themselves against threats such as insects [1-2].

In this work, we selected three plants with known repellent activity - clove (flower buds), lavender and thyme (flowering aerial parts) and applied different methods of VOC extraction including hydrodistillation using a Clevenger apparatus, steam distillation and Soxhlet extraction. The aim is to compare the volatile profiles of extracts with potential repellent activity. The extracts obtained are analysed by proper GC-MS techniques. The results will provide a better understanding of the influence of the extraction method on the chemical composition of the extracts and their potential for use as natural repellent agents.

Keywords: volatile organic compounds (VOCs), essential oils, extraction methods, GC-MS

Acknowledgment: This work is funded by the Croatian Science Foundation project IP-2025-02-7105 and the ERDF – Competitiveness and Cohesion Operational Programme project KK.1.1.10.0001.



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MECHANISM OF THE ELECTROCHEMICAL RESPONSE OF GALLIC ACID AT A POROUS ELECTRODE: THE (IR)REVERSIBILITY PARADOX

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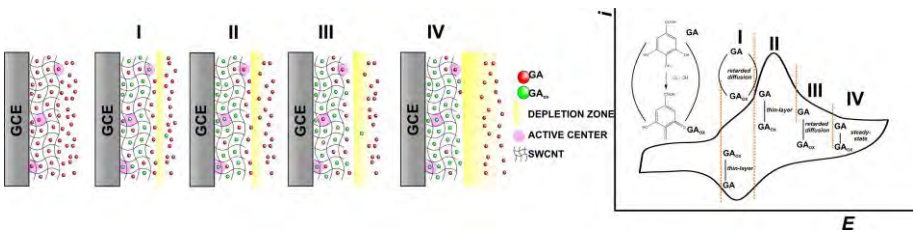
Gallic acid (GA) is a polyphenolic compound with strong antioxidant properties whose oxidation mechanism remains insufficiently understood. Although its electrochemistry is commonly described as electrochemically irreversible, we show that the voltammetric response can be varied from electrochemically irreversible to reversible depending on experimental conditions. Building on our previous results regarding the diffusion domains in the porous SWCNT layer [1], this work focuses on explaining the mechanism of the voltammetric behavior of the SWCNT-modified glassy carbon electrode (GCE) at different concentrations of the supporting electrolyte. Under certain experimental conditions, counter-intuitive behavior can be observed, where a significantly improved voltammetric signal is obtained with low supporting electrolyte concentration. Detailed analysis of results from cyclic voltammetry, reverse pulse voltammetry, and double potential step chronoamperometry reveals that the electrochemical behavior is governed by a complex interplay between different mass transport phenomena occurring within the porous SWCNT layer, with emphasis on those near the GCE. Presented results are important for understanding "apparent" electrochemical catalysis at nanostructured and porous electrodes used in sensing, polyphenol analysis, and energy storage systems.

Keywords: gallic acid, porous, mass transport, (ir)reversibility paradox, electrochemistry



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MALTOL AND KOJIC ACID AS VERSATILE *O*-DONOR LIGANDS IN TRANSITION METAL COMPLEXES

Nikolina Filipović, Iva Jozinović, Stjepan Šarić, Martina Šrajer Gajdošik, Tomislav Balić, Elvira Kovač-Andrić

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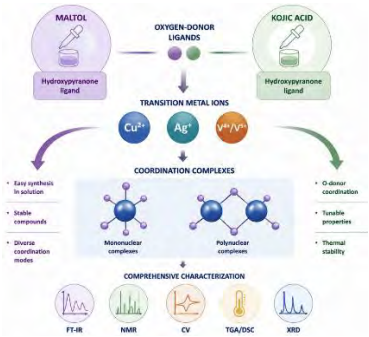
Hydroxypyranones are an important class of oxygen-donor ligands capable of forming stable complexes with transition metal ions through hydroxyl and carbonyl functional groups [1]. In this work, novel transition metal complexes containing maltol and kojic acid were synthesized and structurally characterized in order to investigate their coordination behavior and physicochemical properties. Complexes of transition metal ions were prepared by solution synthesis under mild reaction conditions. The obtained compounds were characterized using Fourier-transform infrared spectroscopy (FT-IR), nuclear magnetic resonance spectroscopy (NMR), thermogravimetric analysis (TGA/DSC), cyclic voltammetry (CV), elemental analysis, and X-ray diffraction techniques. The combination of complementary analytical methods enabled the determination of coordination modes, oxidation states, and thermal stability of the synthesized compounds. The results indicate that hydroxypyranone ligands efficiently coordinate metal ions through oxygen donor atoms, forming structurally stable complexes with diverse coordination environments. Maltol predominantly acts as a bidentate *O,O*-donor ligand, generating stable chelate structures, while kojic acid exhibits versatile coordination behavior depending on the metal center and reaction conditions. Significant differences in thermal and electrochemical properties were observed among the investigated complexes, highlighting the influence of ligand structure on complex stability and coordination geometry. The presented results contribute to a better understanding of metal–ligand interactions in hydroxypyranone-based systems and demonstrate the potential of maltol and kojic acid as versatile building blocks for the design of new coordination compounds with tailored physicochemical properties.

Keywords: hydroxypyranone ligands, maltol, kojic acid, transition metal complexes, coordination chemistry



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NEW PYRIDINE DERIVED HYDRAZONES AS OPTICAL SENSORS FOR METAL CATIONS

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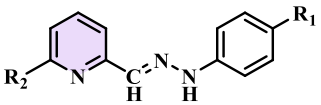
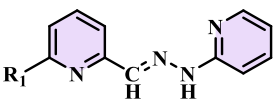
Hydrazone derivatives and their metal complexes, possesing the azomethine bond, have attracted considerable attention as biologically active agents and efficient chelating agents. Hydrazone-metal complexes have proven to be a chromogenic and fluorogenic reagents for the spectrophotometric detection and quantification of trace metals. The possible application of hydrazone complexes can be found in many fields, usually in medicinal and pharmaceutical chemistry, in environmental and analytical chemistry and in targeted drug delivery. [1, 2]
Within this work, we report the synthesis and spectroscopic characterization of pyridine derived hydrazones which were prepared via condensation between chosen hydrazines and aromatic aldehydes. The structures of the prepared compounds were confirmed using ^{1}H and ^{13}C NMR spectroscopy and MS spectrometry. UV-Vis titrations with aqueous solutions of chosen metal cations were performed to evaluate the potential applicability of the synthesized hydrazones for metal ion sensing purposes. [3]

Keywords: hydrazones, metal cations, pyridines, spectroscopy

Acknowledgement: This research was conducted within the project OsKomLiMe (112104) financed by the European Union's- NextGenerationEU fund from the source 581 – The recovery and resilience mechanism, in the frame of Programme financing of public higher education institutions and public scientific institutes.



R_1 = H, NO_2, I, CF_3
R_2 = H, Br, CF_3, NO_2, OCH_3



R_1 = H, Br, CF_3, NO_2, OCH_3

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VOLTAMETRIC CHARACTERIZATION OF HYDRAZIDE MACROCYCLIC COMPOUNDS

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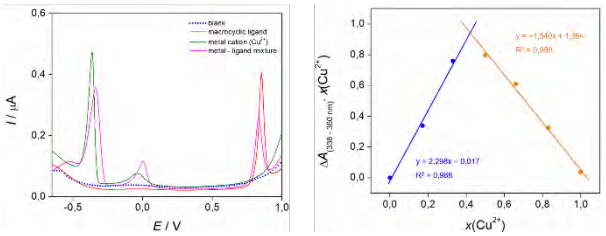
Hydrazide macrocyclic compounds represent an important class of organic and coordination compounds that combine the structural characteristics of hydrazides with the unique geometry of macrocyclic systems. These compounds have attracted considerable interest in medicinal chemistry, supramolecular chemistry, catalysis, and materials science due to their strong binding affinity, structural versatility, and diverse biological activities [1]. The main objective of this study was to investigate the electrochemical properties of two hydrazide macrocyclic compounds and their interactions with metal cations (Ag^{+}, Eu^{3+}, and Cu^{2+}) using voltammetric techniques and Job's method of continuous variations [2]. The cyclic voltammetry results showed that copper nitrate and silver nitrate were electroactive, whereas europium nitrate exhibited no electrochemical activity under the experimental conditions investigated. Both macrocyclic ligands were electroactive, and a single irreversible oxidation peak at approximately 0.9 V was observed for each compound. Interactions between the investigated metal cations and the macrocyclic ligands were confirmed by shifts in the oxidation peaks of the cations in solutions containing both the metal ions and the macrocyclic ligands. The metal-to-ligand stoichiometric ratio was estimated using Job's method of continuous variations, revealing a 1:1 stoichiometry for all investigated metal-ligand interactions.

Keywords: voltammetry, hydrazide compounds, metal ions, Job plot



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POLYPHENOLS FROM THE PEEL OF TRADITIONAL APPLE VARIETIES AS α-GLUCOSIDASE INHIBITORS

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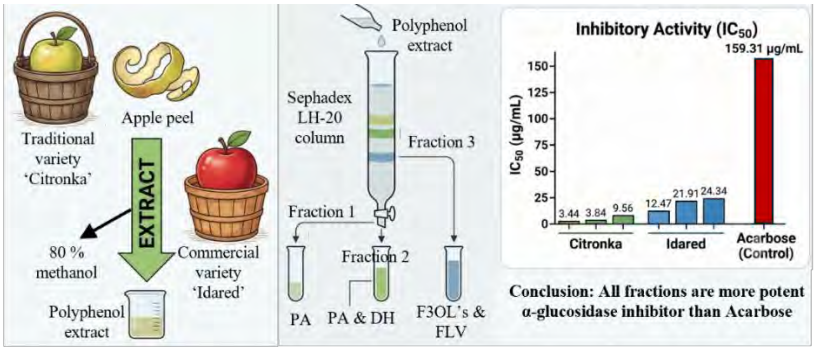
Apples are an important dietary source of polyphenols, and apple peel is particularly rich in these bioactive compounds. Traditional cultivars remain an underexplored source of polyphenols with potential health benefits. Apple polyphenols exhibit several biological activities, including inhibition of digestive enzymes such as alpha-glucosidase, which is relevant for postprandial glycemic control. This study evaluated the alpha-glucosidase inhibitory activity of polyphenols from the peel of one traditional apple cultivar (Citronka) and one commercial cultivar (Idared). Samples were extracted with 80% methanol, and peel polyphenols were separated into three fractions by Sephadex LH-20 column chromatography, with fraction 2 enriched in phenolic acids and dihydrochalcones and fraction 3 enriched in flavonols and flavan-3-ols. Inhibition was measured spectrophotometrically using *p*-nitrophenyl-α-D-glucopyranoside as substrate, and IC_{50} values were determined from logarithmic curves. All tested fractions exhibited significantly lower IC_{50} values than acarbose (159,31 µg/mL), indicating stronger alpha-glucosidase inhibition. In Citronka peel, IC_{50} values were 3.44, 3.84 and 9.56 µg/mL for fractions 1–3, respectively, while in Idared peel they were 12.47, 21.91 and 24.34 µg/mL. These results indicate that apple peel polyphenols, especially from the traditional cultivar, are strong alpha-glucosidase inhibitors and support the bioactive potential of traditional apple cultivars.

Keywords: apples, traditional varieties, α-glucosidase, inhibition



ROLE OF BISPHENOL A IN MODULATING CALCIUM OXALATE PRECIPITATION

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Calcium oxalate (CaOx) represents the predominant mineral phase in human kidney stones, and understanding its nucleation, growth, and phase behavior is essential for elucidating urolithiasis mechanisms [1,2]. Bisphenol A (BPA), a widely used industrial chemical present in plastics and epoxy resins, is continuously detected in the environment and biological systems, raising concerns about its potential interactions with biominerals [3]. In this study, CaOx precipitation was investigated in the presence and absence of BPA under physiologically relevant conditions. Crystal morphology and aggregation were evaluated by light microscopy, while phase composition was analyzed using powder X-ray diffraction (PXRD) and Fourier-transform infrared spectroscopy (FTIR). In addition, UV–Vis spectroscopy was employed to examine potential interactions between BPA and individual reactants, aiming to identify which component may preferentially interact with the additive. Without BPA, calcium oxalate (COT) crystals form on their own and spread evenly throughout the solution. When BPA is added, the crystals clump together tightly and change in size and shape, showing that BPA affects their growth. However, the crystal type itself does not change, meaning COT remains the only form under all conditions. UV–Vis results suggested weak or selective interactions between BPA and the ionic species. Overall, BPA influences CaOx crystallization primarily through surface-mediated and hydrophobic interactions, promoting aggregation without significantly altering phase stability. These findings highlight the potential role of environmental contaminants in modulating biomineralization processes, while further studies are needed to clarify the underlying molecular mechanisms.

Keywords: bisphenol A, calcium oxalate, precipitation, crystallization

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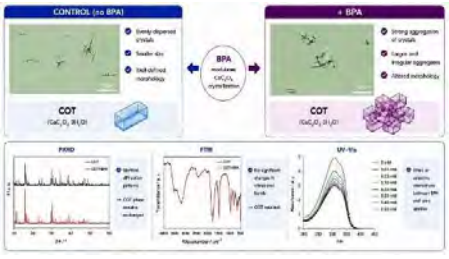

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UKLANJANJE PVC MIKROPLASTIKE IZ MORSKE VODE PRIMJENOM ISTOSMJERNE ELEKTRIČNE STRUJE
REMOVAL OF PVC MICROPLASTICS FROM SEAWATER USING DIRECT ELECTRIC CURRENT

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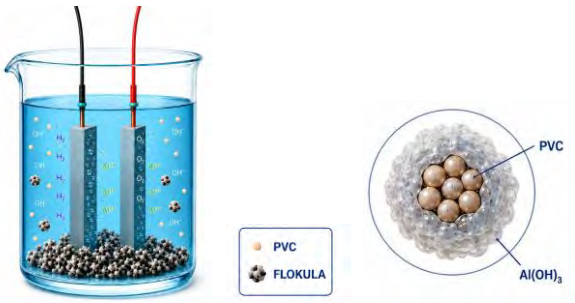
Intenzivna uporaba mikroplastike na bazi poli(vinil-klorida), PVC, dovodi do povećanog prisustva PVC mikroplastike u morima i oceanima što se prepoznaje sve više kao ozbiljan problem za okoliš i živi svijet. U morskoj vodi čestice mikroplastike mogu plutati, lebdjeti ili tonuti, ovisno o gustoći polimera, veličini čestica i sastavu morske vode. Pod utjecajem istosmjernog električnog polja čestice mikroplastike je moguće destabilizirati elektrokinetičkim i elektrokoagulacijskim procesima. Visoka ionska jakost morske vode smanjuje površinski naboj čestica mikroplastike i potiče njihovu agregaciju, dok elektrokemijski nastale metalne hidroksidne flokule mogu adsorbirati i zarobiti čestice mikroplastike uzrokujući njihovo taloženje. U cilju uklanjanja PVC mikroplastike provedena su ispitivanja u sintetičkoj morskoj vodi primjenom struje od 0,3 A u vremenu od 1 do 3 h pri sobnoj temperaturi 25±2 °C, salinitetu 10 i 30 ppt uz konstantno miješanje od 150 o min^{-1}. Ispitivana je učinkovitost uklanjanja PVC mikroplastike primjenom aluminijskih elektroda (AA6063) uz mjerenje parametara otopine (pH, TDS, salinitet i električna vodljivost). Nastali talog analiziran je SEM/EDS analizom i optičkom mikroskopijom dok je karakterizacija PVC mikroplastike prije i nakon procesa provedena primjenom infracrvene spektroskopije s Fourierovom transformacijom (FT-IR). Postignuta je učinkovitost uklanjanja do 94,05 % pri salinitetu od 10 ppt i 71,68 % pri salinitetu od 30 ppt. Veća učinkovitost uklanjanja pri nižem salinitetu povezuje se s intenzivnijom flokulacijom i nastankom veće količine taloga, što omogućuje bolje vezanje i taloženje PVC mikroplastike.

Ključne riječi: PVC mikroplastika, morska voda, elektrokoagulacija, istosmjerna struja



STATE OF CHARGE ANALYSIS IN A VANADIUM REDOX FLOW BATTERY USING AN UV-VIS-BASED CALIBRATION MODEL

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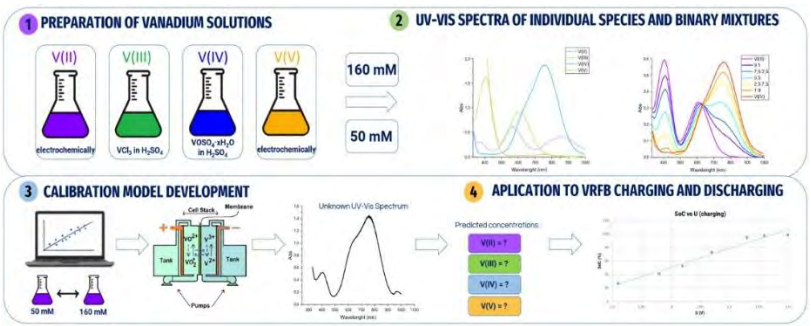
Climate change and the growing demand for sustainable energy solutions have accelerated the deployment of renewable energy sources such as solar, wind, hydropower and low-carbon energy from nuclear reactors. However, the intermittent and unpredictable nature of these energy sources requires efficient energy storage systems (ESSs) capable of balancing electricity generation and consumption. Consequently, vanadium redox flow batteries (VRFBs) have emerged as a promising option for large-scale energy storage due to their long cycle life and independent scaling of power and energy capacity. Reliable determination of the state of charge (SoC) is essential for understanding battery performance and optimising operating conditions. Since the SoC is directly related to the concentration of vanadium oxidation states in the electrolyte, spectroscopic methods offer an attractive approach for its determination.[1] In this study, UV-Vis spectroscopy was employed to monitor changes in vanadium species concentrations and evaluate the SoC of a laboratory-scale VRFB system during operation. A developed calibration model based on characteristic absorption spectra of vanadium redox couples was used to determine the concentrations of vanadium species in anolyte and catholyte collected at different stages of battery cycling. The obtained concentration data were subsequently correlated with the measured cell voltage to construct SoC–voltage profiles. Charging and discharging experiments were performed at different current densities and the resulting SoC–voltage relationships were compared over multiple cycles. The analysis provides insight into voltage response, charge utilisation and electrolyte composition changes under varying electrochemical regimes.

Keywords: vanadium redox flow battery, UV-Vis spectroscopy, calibration model, state of charge



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FERROCENOLATION OF CYTOSINE AND C5-SUBSTITUTED URACILS: REACTIVITY AND REGIOSELECTIVITY

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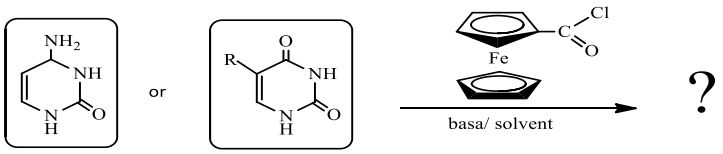
Pyrimidine nucleobases, such as uracil and cytosine, are essential structural components of nucleic acids and, owing to their biological significance and amenability to chemical modification, occupy a prominent position in synthetic and medicinal chemistry. [1] Owing to its chemical stability, unique redox properties, and good biocompatibility, ferrocene has become an important structural motif in the design of novel nucleobase derivatives with the potential to exhibit improved physicochemical and biological properties compared with their parent compounds. [2] Previous studies established efficient conditions for the *N*-ferrocenoylation of uracil and C5-substituted uracil derivatives and demonstrated that the electronic nature of the substituent at the C5 position significantly affects the reactivity and regioselectivity of the reaction. The results further indicated that, in addition to the choice of solvent and deprotonating base, the electronic properties of the substituents play a crucial role in determining the reaction outcome, providing the basis for extending these studies to other C5-substituted uracil derivatives. [3, 4] Building on these findings, the present study investigates the ferrocenoylation of cytosine and 5-substituted uracil derivatives under previously optimised reaction conditions to evaluate the influence of electron-donating (EDG) and electron-withdrawing (EWG) C5 substituents on the reaction outcome (Scheme 1). The structures of the products obtained, including the position of the ferrocenoyl group, were determined by spectroscopic methods.

Keywords: uracil derivatives, cytosine, ferrocenoylation, regioselectivity



R (EDG) = NH_2, CH_2OH
R (EWG) = NO_2, CN

Scheme 1. Ferrocenoylation of cytosine and C5-substituted uracil derivatives

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AROMATIC PROFILE OF *ISTRIAN MALVASIA* WINE LEES

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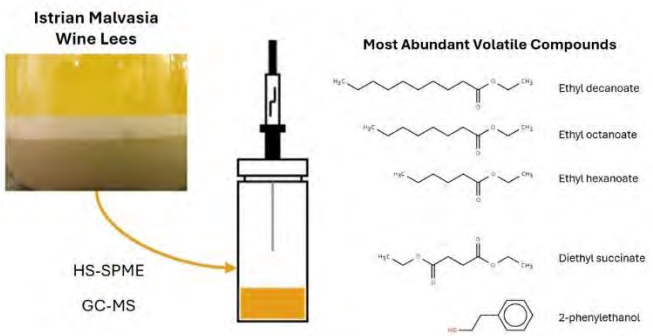
Wine production process generates large quantities of by-products such as grape pomace, skins, seeds, and wine lees [1]. During the vinification process, a series of chemical reactions take place, leading to the formation of aromatic compounds. In this study, the chemical composition of volatile compounds in the wine lees of Istrian Malvasia white wine was investigated. Four samples were analysed, with selected yeasts applied, along with gaining in stainless steel tanks and wooden barrels. Volatile compounds from the lees were isolated by headspace solid-phase microextraction (HS-SPME) using a grey fiber (DVB/CAR/PDMS) and the samples were analysed using a gas chromatography coupled with mass spectrometry (GC-MS) system. The method applied detected esters as the most abundant compounds in the samples: ethyl decanoate, ethyl octanoate, and ethyl hexanoate, contributing fruity notes to the lees. The next most abundant compounds were diethyl succinate and 2-phenylethanol. Diethyl succinate forms during esterification between carboxylic acids and alcohols, specifically succinic acid and ethanol in the presence of a dehydrating reagent [2]. The formation of 2-phenylethanol in the Istrian Malvasia wine lees samples may also be influenced by the yeast used for fermentation. The proportion of volatile compounds in the wine lees samples were observed to be both similar and, at the same time, different across the samples.

Keywords: wine lees, Istrian Malvasia, volatile compounds, HS-SPME, GC-MS



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A NOVEL SPECTROPHOTOMETRIC METHOD FOR NITRATE DETERMINATION: ASSESSMENT USING GREEN AND WHITE ANALYTICAL CHEMISTRY METRICS

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This work introduces a novel spectrophotometric method for the determination of nitrate in water, which is based on the reduction of nitrate to nitrite using zinc powder, followed by the Griess reaction that yields a vibrant pink azo compound that absorbs at 540 nm. Through the optimization of experimental conditions, the consumption of reagents, reduction time, sample volume were minimized and cadmium was replaced by less harmful zinc. Linearity was achieved in the concentration range from 3.0×10^{-7} to 8.0×10^{-5} mol L^{-1} ($R^2 = 0.999$, %RSD < 3%). The proposed method was successfully applied for the determination of nitrate in spiked samples of tap and surface water.

Additionally, the method was compared with the three most commonly used spectrophotometric methods for the determination of nitrates using metrics for evaluating greenness (AGREE, ComplexGAPI), analytical efficiency (RAPI) and applicability (BAGI).[1-4] Beyond a standard environmental assessment, the concurrent integration of blue and red metrics enabled a holistic evaluation that satisfies the comprehensive principles of both green and white analytical chemistry.

Keywords: nitrate, Griess reaction, green analytical chemistry, white analytical chemistry

Acknowledgement: This work has been fully supported by Federal Ministry of Education and Science, F B&H.

ComplexGAPI AGREE BAGI RAPI

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SYNTHESIS AND STRUCTURAL CHARACTERIZATION OF NOVEL ACYLHYDRAZONE DERIVATIVES

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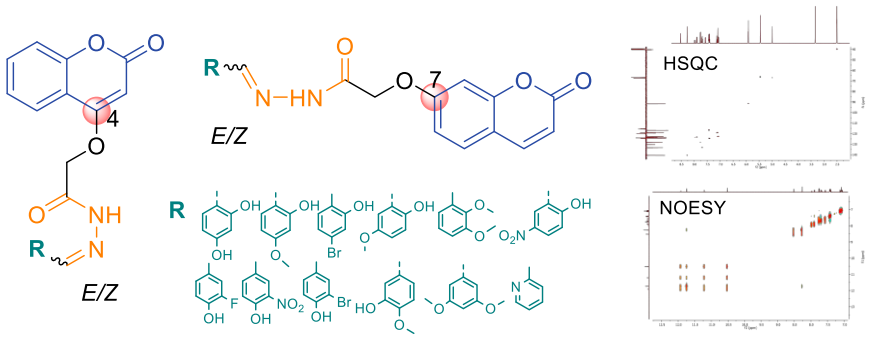
Coumarins represent an important class of heterocyclic compounds widely recognized for their diverse pharmacological properties, including antitumor, anti-inflammatory, antiviral, and antibacterial activities. Their structural versatility makes them attractive scaffolds for the development of novel biologically active molecules.[1,2]
In this study, a series of new coumarin-based *O*-acylhydrazone derivatives was synthesized to identify compounds with potential antitumor and antiviral activity, as well as to serve as ligands for the preparation of rhenium(I) coordination complexes. The synthetic route involved the preparation of 4-*O*- and 7-*O*-acylcoumarin intermediates, followed by conversion into the corresponding oxyacetohydrazides. Subsequent condensation of hydrazides with a series of substituted benzaldehydes afforded coumarin *O*-acylhydrazone derivatives as mixtures of E and Z isomers. With the aim of implementing green synthetic methodologies, the reaction conditions for both conventional and mechanochemical synthesis of selected coumarin acylhydrazone derivatives were optimized. Furthermore, complexation of ligands with rhenium(I) pentacarbonyl chloride resulted in the isolation of a novel rhenium(I) complex, expanding the structural diversity of the synthesized compounds. The structures of all synthesized compounds were confirmed by ^{1}H and ^{13}C NMR spectroscopy and were unambiguously established using two-dimensional NMR techniques including NOESY, HSQC and HMBC. The prepared coumarin derivatives constitute a valuable library of compounds for further biological evaluation as potential antitumor and antiviral agents, while the incorporation of a rhenium(I) center provides an additional opportunity to investigate the influence of metal coordination on biological activity.

Keywords: coumarin, acylhydrazone, rhenium(I) complex



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OPTIMIRANJE REAKCIJE KONDENZACIJE CINKOVIH BIS(2-AMINOTIOFENOLATA)
OPTIMISING CONDENSATION REACTIONS OF ZINC BIS(2-AMINOTHIOPHENOLATES)

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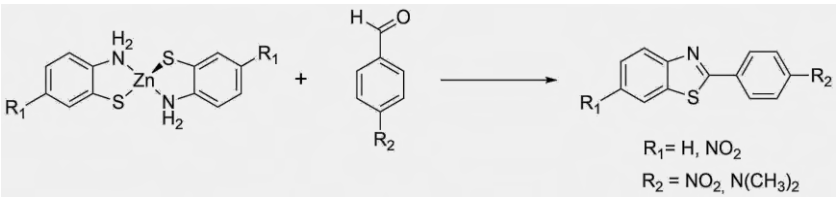
Benzotiazol i njegovi derivati imaju široku primjenu, pogotovo u medicini i molekularnoj biologiji zbog povoljnih bioloških svojstava. Najčešća metoda priprave 2-supstituiranih benzotiazolnih derivata je reakcija kondenzacije 2-aminotiofenoloa s aldehidima, karboksilnim kiselinama i njihovim derivatima. Nedostatak ove metode je nestabilnost 2-aminotiofenolnih derivata na zraku koji spontano na zraku oksidiraju u disulfidni oblik [1]. Pokazalo se da korištenje disulfida za kondenzaciju zahtijeva žestoke reakcijske uvijete što može rezultirati nastankom nusprodukata i manjim iskorištenjima na ciljanim spojevima. Cilj ovog rada bio je istražiti uvjete priprave stabilnih cinkovih 2-aminotiofenolata te ispitati mogućnost njihovih kondenzacijskih reakcija s aldehidima. Pronađeni su najpovoljniji reakcijski uvjeti za pripravu cinkovog 2-aminotiofenolata i cinkovog 5-nitro-2-aminotiofenolata kojemu je struktura potvrđena rendgenskom strukturnom analizom. Optimirane su reakcije kondenzacije priređenih cinkovih kompleksa s nitro i *N,N*-dimetilamino supstituiranim benzaldehidima u različitim otapalima pri različitim temperaturama.

Ključne riječi: benzotiazol, kondenzacija, cinkovi kompleksi



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PHYTO-MEDIATED SYNTHESIS OF AMORPHOUS SELENIUM NANOPARTICLES USING WALNUT (*Juglans regia* L.) SEPTUM EXTRACT

Valentina Pavić[1], Zorana Katanić[1], Liljana Krstin[1], Lovro Mihajlović[1], Anamarija Perić[2], Stjepan Šarić[2], Martina Šrajer Gajdošik[2], Elvira Kovač-Andrić[2], Vlatka Gvozdić[2]

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Walnut (*Juglans regia* L.) fruit septum is an agro-industrial by-product rich in phenolic compounds that can serve as natural reducing and stabilizing agents in nanoparticle synthesis. In this study, amorphous selenium nanoparticles (SeNPs) were synthesized using walnut fruit septum extract and sodium selenite (Na_2SeO_3) through a green synthesis approach. The formation of SeNPs was confirmed by UV–Vis spectrophotometry, Fourier-transform infrared spectroscopy (FT-IR), and powder X-ray diffraction (PXRD) analysis. UV–Vis spectroscopy revealed a characteristic absorption maximum at 259 nm, while PXRD analysis confirmed the amorphous nature of the synthesized nanoparticles. The preservation of the amorphous structure is particularly relevant due to its reported higher biological availability compared to crystalline selenium forms [1]. FT-IR analysis indicated the involvement of phenolic compounds and other functional groups in the reduction and stabilization of SeNPs. These findings highlight walnut fruit septum waste as a sustainable resource for the green synthesis of selenium nanoparticles with potential biomedical and environmental applications.

Keywords: selenium nanoparticles, green synthesis, agro-industrial waste, walnut fruit septum, amorphous nanomaterials

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IN-DEPTH ANALYSIS OF THE PHYTOCHEMICAL AND BIOACTIVE PROFILE OF ENDEMIC BROWN MACROALGA *Fucus virsoides*

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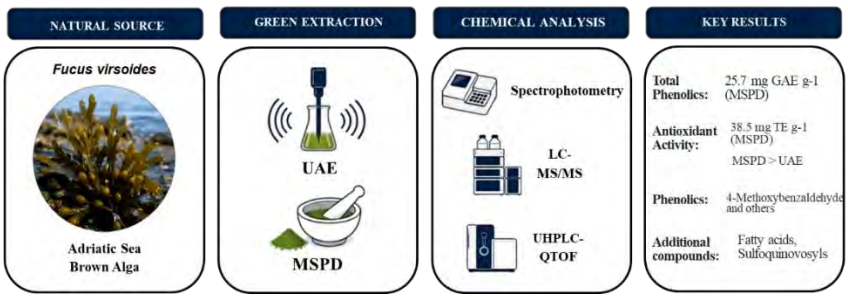
This study investigated *Fucus virsoides*, an endemic Adriatic brown macroalga that remains insufficiently explored despite its potential as a source of bioactive compounds. Bioactive compounds were extracted using an ethanol and water mixture in equal proportions and two environmentally friendly extraction techniques, ultrasound and matrix solid-phase dispersion. Total phenolic content and antioxidant activity were determined using spectrophotometric methods, while the phenolic profile and chemical composition were analysed using liquid chromatography coupled with tandem mass spectrometry and high-resolution liquid chromatography–mass spectrometry. The extract obtained by matrix solid-phase dispersion contained 25.7 mg gallic acid equivalents per gram of dry algae and exhibited an antioxidant activity of 38.5 mg Trolox equivalents per gram of dry algae, ranking among the highest values compared with eleven other Adriatic macroalgae. Although ultrasound-assisted extraction yielded a higher total phenolic content, matrix solid-phase dispersion proved more effective in extracting compounds with stronger antioxidant activity. The predominant phenolic compounds were 4-methoxybenzaldehyde, 4-hydroxybenzaldehyde and 2,4,6-trihydroxybenzoic acid. Chemical profiling additionally revealed sulfoquinovosyl monoacylglycerols, fatty acids, organic acids and other metabolites. These findings demonstrate that *Fucus virsoides* is a promising natural source of bioactive compounds with potential applications in functional foods, pharmaceuticals and cosmetics.

Keywords: Fucus virsoides, extraction, polyphenols, antioxidant activity



VOLATILE COMPOUNDS OF *Vitex agnus-castus* L.

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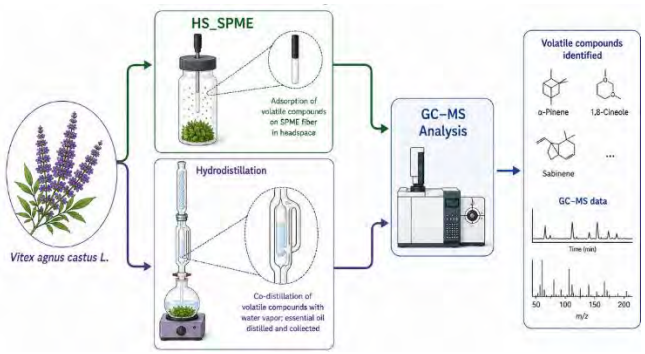
University of Split, Faculty of Chemistry and Technology, Ruđera Boškovića 35, 21000 Split, Croatia

Vitex agnus-castus L., Lamiaceae, is a small tree or shrub widely distributed in the Mediterranean region of Europe and Central Asia. Often used as a remedy for women's health issues and other reproductive ailments, *V. agnus-castus* is universally known as the chaste tree. The plant got its name from the notion that it may help treat infertility and reduce libido. The aim of this study was to isolate and identify the volatile compounds from various parts (leaves, flowers, and fruits) of *V. agnus-castus* collected in Mimice, Dalmatia, in August 2025. Freshly picked plant material was placed in paper bags, transferred to the laboratory, and frozen at -4 °C until analysis. Volatile compounds were isolated by solid phase microextraction coupled with gas chromatography-mass spectrometry (HS-SPME/GC-MS). Two SPME fibers were used: divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) and carboxen/polydimethylsiloxane (CAR/PDMS). GC-MS analyses were performed using a non-polar, HP-5MS column.

A higher number of compounds was identified in headspace volatiles using DVB/CAR/PDMS fiber than in headspace volatiles using CAR/PDMS fiber. All samples, regardless of the fiber used, were qualitatively similar. However, there were differences in the content of the main compounds identified in different plant parts. Regardless of differences in the content of individual compounds, mono- and sesquiterpenes were the most abundant compounds in all samples. Among the monoterpene compounds, the most abundant were the hydrocarbons *α*-pinene, sabinene, myrcene, limonene and *β*-ocimene, and the ether 1,8-cineole. Among the sesquiterpenes the most abundant were *trans*-*β*-farnesene, *trans*-caryophyllene and bicyclogermacrene.

Keywords: Vitex agnus castus L., headspace volatiles, GC-MS analysis

Acknowledgement: This research was partially funded by the project GREEN4MED (IP-UNIST-26) granted by the European Union - "NextGenerationEU".



SYNTHESIS AND ELECTROCHEMICAL PROPERTIES OF TWO SELECTED QUINAZOLINONES

Ivana Tomac[1], Mario Komar[1], Leonarda Marković[1], Maja Molnar[1], Martina Jakovljević Kovač[1], Dajana Gašo Sokač[1], Martin Kondža[1,2], Mirna Habuda-Stanić[1], Damir Magdić[1], Lahorka Budić[1], Mia Suknović[3], Valentina Bušić[1]

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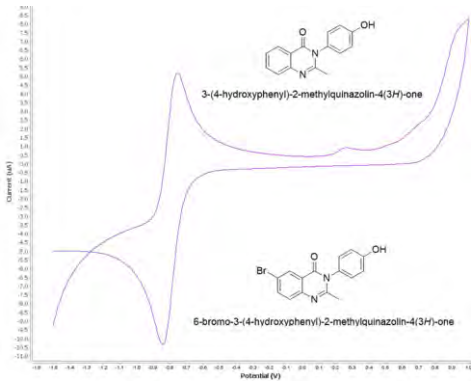
The two selected quinazolinone derivatives (3-(4-hydroxyphenyl)-2-methylquinazolin-4(3*H*)-one and 6-bromo-3-(4-hydroxyphenyl)-2-methylquinazolin-4(3*H*)-one) were synthesized using deep eutectic solvents, and their electrochemical properties are investigated. After synthesis, the electrochemical properties of the synthesized quinazolinone compounds are investigated using cyclic voltammetry in a non-aqueous medium, and the influence of scan rate, chemical structure, and concentration on the electrochemical response, as well as their influence on the response of the electrochemical DNA biosensor, are determined. The electrochemical results showed that the optimal scan rate was 50 mV s^{-1}. The influence of concentration on the electrochemical response of both quinazolinones showed linearity in the range between $1 \cdot 10^{-5}$ and $1.9 \cdot 10^{-4}$ mol L^{-1}. Further, the influence of the chemical structure of both quinazolinones showed two peaks, one at 0.3 V, which may be attributed to the oxidation of the aromatic ring of quinazolinone, and the other at 0.75 V to the carbonyl group of the quinazolinone ring. The response of the electrochemical DNA biosensor showed a relative portion of survived DNA of around 80% for both quinazolinone. Both synthesized quinazolinones showed good concentration linearity and diminished the degree of DNA damage.

Keywords: quinazolinone, synthesis, cyclic voltammetry, biosensor

Acknowledgement: This research was funded by the European Union – NextGenerationEU, Institutional Research Project "*Environmentally friendly methods for the synthesis and extraction of organic compounds with potential biological activity*" (581-UNIOS-92).



VOLATILE AROMA COMPOUNDS OF KAJMAK

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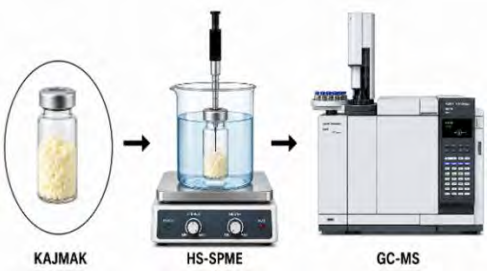
Kajmak is a traditional dairy product of the Balkan region, valued for its creamy texture, mildly acidic taste, and characteristic aroma of boiled milk. Beyond the Balkans, a closely related product, often called *kaymak*, is also manufactured in Turkey, while similar clotted cream-type products are found in the Middle East, Central Asia, Iran, Afghanistan, and India, where they are known as *kaymak*, *qeymak*, or *sarshir*, depending on the region and production method [1, 2]. Kajmak is classified as a full-fat fermented dairy product, positioned between butter and soft cheese in composition, with a high milk fat content and a layered microstructure that distinguishes it from other spreadable dairy products. National regulations in Serbia and Bosnia and Herzegovina distinguish fresh and mature kajmak based on ripening duration, specifying maximum moisture content and minimum fat levels. During ripening, the aroma of kajmak changes from butter-like to cheese-like, while the texture shifts in the opposite direction, becoming more butter-like and less cheese-like [1, 3, 4].
Studies on the volatile aroma compounds of kajmak are limited and mainly focus on Turkish kaymak [5, 6]. In this study, two commercial kajmak samples from Bosnia and Herzegovina, one fresh and one mature, both purchased in Croatia, were investigated. Volatile aroma compounds were isolated by headspace solid-phase microextraction (HS-SPME) using two fibers of different composition and analyzed by gas chromatography-mass spectrometry (GC-MS). A total of 36 compounds were identified in the kajmak samples: 11 carboxylic acids, 9 ketones, 7 esters, 6 alcohols, and 3 other compounds. In both fresh and mature kajmak samples, regardless of fibre type, carboxylic acids and ketones were the most abundant, followed by alcohols.

Keywords: kajmak, volatile aroma compounds, HS-SPME, GC-MS



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RAZGRADNJA BIOKOMPATIBILNOG POLIMERA PRIPREMLJENOG PRECIPITACIJOM U FIZIOLOŠKOM PUFERU
DEGRADATION OF A BIOCOMPATIBLE POLYMER PREPARED BY PRECIPITATION IN A PHYSIOLOGICAL BUFFER

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Poli(laktid-*ko*-glikolid) (PLGA) je biokompatibilan i biorazgradiv polimer koji se, zbog svojih povoljnih fizikalno-kemijskih svojstava, primjenjuje u medicini za izradu nosača za regeneraciju tkiva i sustava za kontrolirano oslobađanje lijekova. Hidrolitičkom razgradnjom PLGA nastaju mliječna i glikolna kiselina, pri čemu dolazi do promjena važnih fizikalno-kemijskih karakteristika materijala, posebice molarne mase. Poznavanje razgradnje polimera u fiziološkom okruženju od velike je važnosti jer je kontrolirano oslobađanje lijeka usko vezano uz proces razgradnje polimerne matrice. [1] U ovom radu PLGA čestice izrađene su metodom precipitacije. Polimerni uzorci otopljeni su u dimetilsulfoksidu pri masenom udjelu od 20 %, a nakon potpunog otapanja taloženi su u neotapalu, vodi. Nakon precipitacije, čestice su sušene liofilizacijom. Dobivene su kuglice promjera približno 0,2 cm. Korišteni su polimeri s molarnim udjelom laktida u rasponu od 50 do 100 mol. %, početnom molarnom masom od 15000 g mol^{-1} te s kiselinskom ili esterskom krajnjom skupinom. Pripremljenim česticama određena su svojstva kako bi se utvrdio utjecaj pripreme na svojstva – toplinska svojstva metodama DSC, TGA te molarna masa metodom GPC. Razgradnja čestica vršila se u vremenskom rasponu od 3 mjeseca u fosfatnom puferu (pH = 7,4) pri 37 °C, na tresilici brzine miješanja od 100 min^{-1}. Pratilo se bubrenje čestica gravimetrijski, a kao glavni parametar pratila se molarna masa u vremenu metodom GPC. Rezultati ukazuju da ispitivani polimeri imaju linearnu razgradnju u vremenu što ih čini pogodnima za kontrolirano oslobađanje lijeka, razgradnja je brža uz povećanje udjela glikolida te uz kiselinsku krajnju skupinu.

Ključne riječi: poli(laktid-*ko*-glikolid), precipitacija polimera, molarna masa, kontrolirano oslobađanje lijeka

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IMMOBILIZATION OF GLUCOSE DEHYDROGENASE IN HYDROGELS

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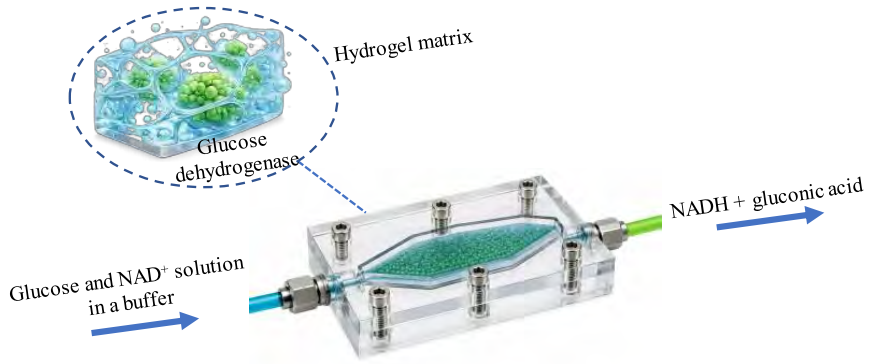
Although enzymes have significant potential for industrial applications, their practical use is often limited by insufficient stability and difficulty in reuse. Therefore, enzyme immobilization has become increasingly important for retaining enzymes within reactors, separating enzymes after use in batch reactors, and enabling possible reuse [1]. Immobilization can increase enzyme stability, allow repeated use, and facilitate separation of enzymes from the reaction mixture. Hydrogels are suitable materials for enzyme immobilization because they form a hydrated polymer network that can embed the enzyme, while smaller molecules, such as substrates and products, can pass through the gel matrix [2].
This study aimed to investigate the efficiency of immobilizing glucose dehydrogenase in different hydrogel matrices within a microreactor system and to identify the matrix that best preserves enzyme activity and stability while enabling efficient continuous glucose oxidation. Immobilization was performed in four hydrogels matrices: sodium alginate, gelatine, chitosan, and agar. The efficiency of each system was assessed at various flow rates in order to investigate the effects of residence time and hydrogel composition on glucose conversion.

Keywords: glucose, glucose dehydrogenase, hydrogels, immobilization, microreactor



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SINERGIZAM I ANTAGONIZAM: KOMPARATIVNA ANALIZA ANTIOKSIDACIJSKE AKTIVNOSTI SMJESA ODABRANIH ETERIČNIH ULJA
SYNERGISM AND ANTAGONISM: COMPARATIVE ANALYSIS OF ANTIOXIDANT ACTIVITY OF MIXTURES OF SELECTED ESSENTIAL OILS

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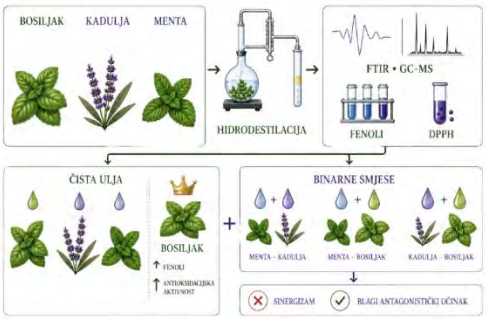
Zbog velikog interesa za prirodne alternative sintetskim antioksidansima u prehrambenoj, kozmetičkoj i farmaceutskoj primjeni, mnoga istraživanja usmjerena su prema eteričnim uljima. Premda pojedina eterična ulja pokazuju izraženu antioksidacijsku aktivnost, ostaje neistraženo kako njihovo međusobno kombiniranje utječe na antioksidacijsku aktivnost. Upravo se na toj pretpostavci temelji ovo istraživanje, s ciljem utvrđivanja mogu li binarne smjese eteričnih ulja pokazati sinergijski ili antagonistički učinak te kakav to značaj ima za razvoj prirodnih formulacija. U ovom radu istražen je odnos između kemijskog sastava, ukupnog sadržaja fenola i antioksidacijske aktivnosti eteričnih ulja bosiljka (lat. *Ocimum basilicum*), kadulje (lat. *Salvia officinalis*) i mente (lat. *Mentha piperita*), kako pojedinačno tako i u binarnim smjesama. Eksperimentalni dio se sastoji od dobivanja eteričnih ulja postupkom hidrodestilacije iz osušenog biljnog materijala, karakterizacije ulja FTIR-om i GC-MS-om, određivanja ukupnog sadržaja fenola Folin-Ciocalteu metodom te procjene antioksidacijske aktivnosti DPPH metodom. Analizirane su i binarne smjese menta–kadulja, menta–bosiljak i kadulja–bosiljak. Rezultati istraživanja pokazali su da eterično ulje bosiljka ima najveći ukupni sadržaj fenola i antioksidacijsku aktivnost, dok kombiniranje eteričnih ulja u binarne smjese nije rezultiralo sinergijskim, već blagim antagonističkim učinkom. Dobiveni rezultati doprinose boljem razumijevanju međudjelovanja eteričnih ulja te otvaraju mogućnosti za razvoj učinkovitijih prirodnih antioksidativnih formulacija.

Ključne riječi: eterična ulja, antioksidacijska svojstva, sinergijski učinak, antagonistički učinak



OPTIMIZATION OF RESVERATROL DIMERIZATION IN A BATCH REACTOR USING DESIGN OF EXPERIMENTS METHODOLOGY

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Resveratrol is a naturally occurring polyphenolic compound with significant biological activity. Recent studies indicate that dimeric stilbene derivatives may exhibit improved stability and enhanced bioactivity compared to the parent stilbene molecule. In this study, chemical dimerization of resveratrol was investigated in a batch reactor via photochemical dimerization under UV irradiation and oxidative coupling reactions. Both processes were optimized using a Design of Experiments (DoE) methodology to systematically evaluate the influence of irradiation time, oxidant concentration, catalyst type, solvent composition, resveratrol concentration, and reaction temperature on conversion and dimer selectivity. The experimental design enabled identification of the most significant process parameters affecting dimer formation and impurity generation. The obtained results provided deeper insight into the influence of reaction conditions on the outcome of stilbene coupling reactions and enabled determination of optimal operating conditions for selective resveratrol dimerization.

Keywords: resveratrol, dimerization, photochemistry, oxidative coupling

EXTRACTION OF BIOACTIVE COMPOUNDS FROM *Epilobium parviflorum* USING SUBCRITICAL FLUIDS

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Epilobium parviflorum is a herbaceous perennial plant with small pale pink flowers that has long been used in traditional herbal preparations. It contains various bioactive compounds, which contribute to its diverse biological activities. Due to growing interest in the sustainable recovery of such compounds, supercritical fluids have attracted attention as alternative extraction media. Among these, water and ethanol are the most widely used solvents because of their low toxicity, availability, and ability to extract a broad range of phytochemicals.

Three different solvents were used to extract bioactive compounds from *E. parviflorum*: ethanol, an ethanol–water mixture (50% v/v) and water. The effects of solvent type, temperature, and extraction time on the yield and composition of the extracts were investigated using a systematic experimental design. All extracts contained various groups of polyphenolic compounds, including phenolic acids (gallic and ellagic acid), flavonoids (rutin), and proanthocyanidins, and exhibited high antioxidant activity. Among the solvents studied, the ethanol–water mixture was the most effective, resulting in high polyphenol content and antioxidant activity above 90%. The highest extraction temperature (190 °C) also promoted the formation of 5-hydroxymethylfurfural, an important platform chemical.

Subcritical fluid extraction proved to be an effective approach for recovering bioactive compounds from *E. parviflorum*, with extraction conditions significantly influencing the composition and selectivity of the extract.

Keywords: Epilobium parviflorum, subcritical fluids, extraction, bioactive components

DESIGN AND TESTING OF A HYDRODYNAMIC CAVITATION MODULE FOR INTENSIFYING THE OXIDATION TREATMENT OF WATER MATRICES

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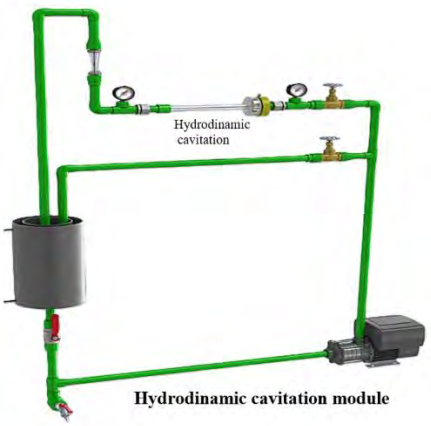
Process intensification (PI) is the application of innovative principles in the design of equipment and processes to increase the efficiency and economy of technological operations, achieving a greater effect with reduced consumption of energy, time and chemicals. In this context, hydrodynamic cavitation is an advanced technology that, through the formation and collapse of cavitation bubbles, generates locally very intense hydrodynamic conditions. This leads to the formation of free radicals, an increase in the mass transfer coefficient and interfacial area, and extreme temperature and pressure conditions capable of mechanical action and inactivation of microorganisms. In this work, a self-made hydrodynamic module was designed and tested to intensify the treatment of various water matrices. The testing phase included defining the basic hydraulic parameters (flow, pressure, temperature, system volume and pump power) and calculating the cavitation number for the selected operating conditions. In the constructed module, cavitation is established and areas with intense temperature and pressure conditions are observed, so the system can be used for oxidation treatment of aqueous matrices.

Keywords: design, hydrodynamic cavitation module, process intensification, oxidation treatment, water matrices



Hydrodinamic cavitation module

ANALIZA DEFEKATA POVRŠINE VIŠESLOJNE KOMPOZITNE AMBALAŽE
ANALYSIS OF SURFACE DEFECTS ON THE MULTILAYER COMPOSITE PACKAGING

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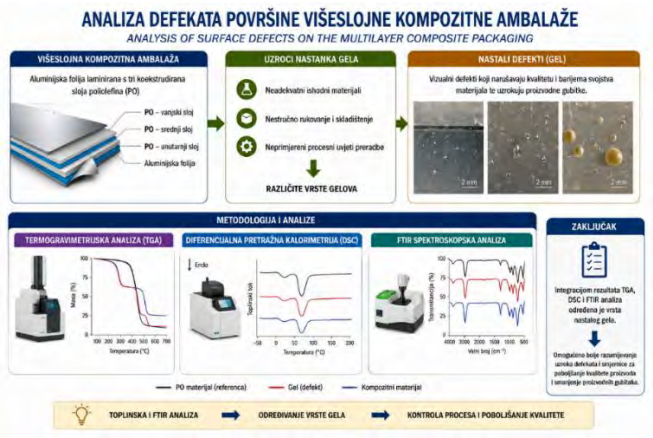
Tijekom prerade višeslojne kompozitne ambalaže sastavljene od aluminijske folije oplemenjene laminiranim poliolefinskim troslojem nastaju defekti poliolefinskog trosloja kao posljedica stvaranja gela koji uvelike smanjuju kvalitetu dobivenog proizvoda i posljedično dovode do značajnih proizvodnih gubitaka jer su, uz vizualna, narušena i barijerna svojstva materijala. Analizirana višeslojna kompozitna ambalaža se dobiva laminiranjem triju koekstrudiranih slojeva poliolefina na aluminijsku foliju. Uzroci nastajanja gela mogu biti različite prirode, kao što su neadekvatni ishodni materijali, nestručno rukovanje i skladištenje ili pak neprimjereni procesni uvjeti preradbe zbog čega mogu nastati i različite vrste gelova. U ovom radu provedena je toplinska analiza uzoraka poliolefinskih materijala, nastalih defekata te samog kompozitnog materijala termogravimetrijskom analizom i diferencijalnom pretražnom kalorimetrijom. Također, provedena je FTIR spektroskopska analiza. Temeljem dobivenih podataka određena je vrsta nastalog gela.

Ključne riječi: višeslojna ambalaža, gel, diferencijalna pretražna kalorimetrija, infracrvena spektroskopija



Fe/P/C/O/H FORCE FIELD PARAMETERS VS. MACHINE LEARNED POTENTIALS

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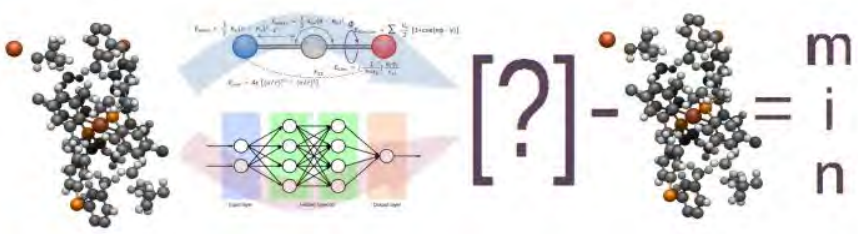
Lithium-iron tetraphosphate batteries are well implemented for energy storage in many areas. However, certain issues in their application remain [1]. The use of the reactive molecular dynamics (ReaxFF MD code) is fit well for multiscale modeling of reactions. However, the parameters for the atomic specia in the structures has to be available, but were not developed yet. In a recent work we designed and applied the novel protocol for optimizing force field parameters utilizing the Optuna Python library to obtain Li/O parameters [2]. In this work we compare this protocol for optimizing new set of parameters (for atomic specia Fe/P/C/O/H) and recently increasingly popular approach of using machine-learned interatomic potentials (MLIP) to estimate final performance of both approaches for reproduction of structures and charges in the Fe/P -containing compounds [3]. While reactive force-field is a well-established approach, it suffers from highly specific force fields. Here we design the MLIP from the first principles using TensorFlow Python library, train it on a similar set of structures as the one used in optimizing molecular dynamics force field and compare their performance by applying the models on the same set of validation structures, consisting of the same elements as included in training.

This is the first specific comparison of reactive MD force-filed with self-built and trained MLIP for these atomic species. Also, as the approach does not rely to large datasets or models apart from the available libraries, this examines the possibility of applying relatively simple steps to produce ad-hoc MLIPs for the specific conditions of scienific interest.

Keywords: molecular dynamics, MLIP, ReaxFF, iron-phosphorus compounds



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DEVELOPMENT OF ALKYL-GLUCOSIDE-BASED DETERGENT FOR MOTOR OIL STAINS REMOVAL

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Over the past decade, vehicle ownership has increased rapidly worldwide, driving the expansion of the car wash industry and the demand for various vehicle-cleaning products. Many conventional detergents used for this purpose are synthetic and pose significant environmental concerns due to their limited biodegradability and potential ecological impact [1]. Consequently, focus of scientific research has been shifted towards the development of environmentally friendly surface-active agents that can serve as biodegradable alternatives. An example of such compound is alkyl-glucoside [2], a non-ionic surfactant investigated in the present study. The alkyl-glucoside-based detergent formulation was designed by varying the concentrations of the surfactant and other components, while its cleaning performance was assessed through the removal of motor oil stains. To simulate realistic stains on vehicle surface, stains were prepared using both fresh and used motor oils applied to metallic surfaces. The physicochemical properties of effective formulations were subsequently characterized. Thermal stability was evaluated using thermogravimetric analysis (TGA) and cloud point temperature determination, whereas differential scanning calorimetry (DSC) was employed to investigate changes in specific thermal transitions. The formulation's viscosity was measured at several temperatures using the Stabinger method to assess its ability to adhere to vehicle surfaces under varying operating conditions.

Keywords: alkyl-glucoside, detergent, surfactant, motor oil stains removal

Figure 1. Development of alkyl-glucoside-based detergent for car maintenance

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COMPOSITION-DRIVEN RHEOLOGICAL BEHAVIOUR AND PROCESSABILITY OF PBAT/PHBV BLENDS FOR BIODEGRADABLE FOOD PACKAGING

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The widespread use of synthetic polymers has raised significant environmental concerns due to their persistence in the environment. Consequently, biodegradable polymers such as poly(butylene adipate-*co*-terephthalate) (PBAT) and poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV) have attracted considerable attention as sustainable alternatives to conventional plastics. Since the individual properties of these polymers limit their application in demanding fields such as food packaging, polymer blending offers an effective route to improve their performance. This study investigates the rheological behaviour of PBAT/PHBV blends to evaluate their processing potential. Rheological measurements were performed on the neat polymers and blends containing PHBV in 10 wt.% increments. Increasing the PHBV content gradually reduced the complex viscosity (η^*), while all compositions exhibited the characteristic frequency-dependent viscoelastic response of polymer melts. Dynamic mechanical analysis (DMA) confirmed the immiscibility of the PBAT and PHBV phases, whereas the elastic response decreased with increasing PHBV content. Dynamic mechanical analysis (DMA) indicated the immiscibility of the PBAT and PHBV phases, whereas the elastic response decreased with increasing PHBV content. Melt flow index (MFI) measurements supported the rheological results, showing higher viscosity and lower melt flow for blends with lower PHBV content due to the dominant influence of the PBAT matrix. These findings demonstrate that blend composition strongly affects rheological and viscoelastic behaviour, providing a basis for optimizing processing conditions and developing biodegradable materials for food packaging applications.

Keywords: poly(butylene adipate-co-terephtalate), poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate), rheological properties, food packaging

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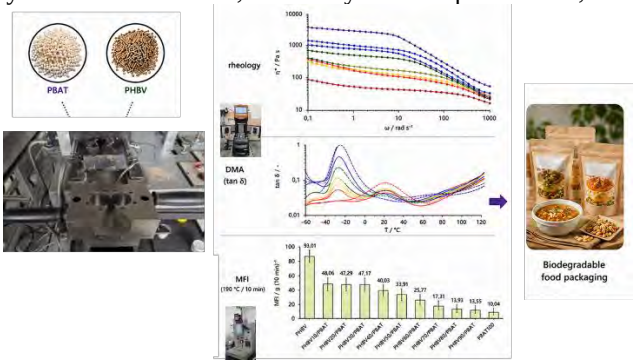

POLIMERNI KOMPOZITNI FILMOVI NA BAZI POLI(VINIL-ALKOHOLA) I MLJEVENIH LJUSKICA JAJA
POLYMER COMPOSITE FILMS BASED ON POLY(VINYL ALCOHOL) AND GROUND EGGSHELLS

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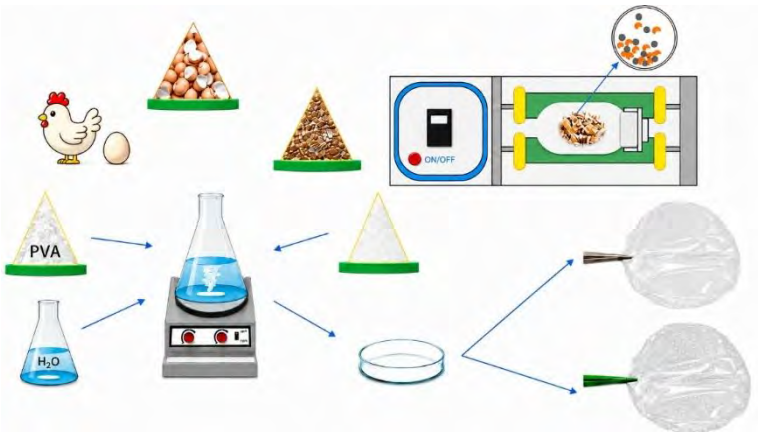
Istraživani su polimerni kompozitni filmovi na bazi poli(vinil-alkohola) (PVAL) s dodatkom mljevenih ljuskica jaja (ES) koji su pripremljeni tehnikom lijevanja filma iz otopine. Cilj istraživanja bio je procijeniti utjecaj dodatka ljuskica jaja na strukturu i toplinska svojstva, odnosno toplinsku postojanost vodotopljivog PVAL-a. Ljuskice jaja, odabrane kao dostupan i jeftin prirodni dodatak (otpad), mogu se na ovaj način korisno oporabiti. Primjenom infracrvene spektroskopije s Fourierovom transformacijom (FT-IR) potvrđena je ugradnja anorganskog dodatka u polimernu matricu, kao i pozitivne interakcije u istraživanom kompozitnom sustavu. Staklište PVAL-a u kompozitu određeno je primjenom diferencijalne pretražne kalorimetrije (DSC), te je pronađeno da dodatak ES-a ne utječe na staklište polimerne matrice. Također, provedena je termogravimetrijska analiza (TG) kojom je procijenjen utjecaj dodatka ES na toplinsku postojanost PVAL-a. Temeljem dobivenih rezultata može se zaključiti da istraživani polimerni kompozitni filmovi predstavljaju potencijalni ekološki prihvatljivi ambalažni materijal.

Ključne riječi: poli(vinil-alkohol), mljevene ljuskice jaja, polimerni kompozitni filmovi



EFFECT OF PLGA ARCHITECTURE ON THE RHEOLOGICAL BEHAVIOUR OF POLYMER SOLUTIONS IN DIFFERENT SOLVENTS

Maša Lač, Tatjana Baković Kultan, Ivana Šoljić Jerbić, Sonja Pavković, Monika Mihaljević, Anabela Ljubić

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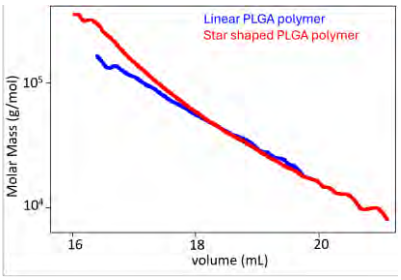
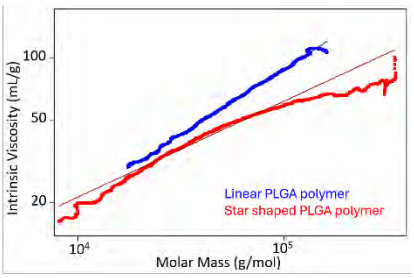
This study investigates the influence of PLGA polymer architecture on the rheological properties of concentrated polymer solutions. Linear and branched PLGA polymers with comparable chemical composition and molar mass are dissolved in two solvents with different solvation characteristics, dimethyl sulfoxide (DMSO) and ethyl lactate. The objective is to establish correlations between polymer architecture and solvent-dependent rheological behaviour, with emphasis on the effect of molecular topology on solution conformation, flow properties and viscoelastic response. The experimental approach combines SEC-MALS-VISCO-RI analysis with rheological characterization to obtain complementary information on molecular branching, hydrodynamic dimensions, intrinsic viscosity [1] and viscoelastic properties [2]. By comparing a strong solvent (DMSO) with a moderately solvating solvent (ethyl lactate), the study aims to identify architecture-dependent differences that may not be evident under ideal solvation conditions. The scientific novelty lies in the integrated evaluation of molecular and rheological properties of linear and branched PLGA in pharmaceutically relevant solvents. The results are expected to improve understanding of the relationship between PLGA topology and solution behaviour, supporting the rational design of formulations where viscosity, injectability and processability are critical quality attributes.

Keywords: PLGA, branching, rheology, polymer solutions, solvent quality





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LOTUS EFFECT NA DRVNO-CEMENTNIM PLOČAMA
LOTUS EFFECT ON THE WOOD-CEMENT BOARDS

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Wood-cement boards are a porous composite material consisting of an inorganic Portland cement binder mixed with wood wool as reinforcement. In construction, they are used for thermal and sound insulation due to their low density, high porosity, fire resistance, and compatibility with other building materials [1]. The cement-rich surface of wood-cement boards is highly hydrophilic, necessitating surface protection to enhance resistance to moisture and UV-induced degradation, particularly in exterior applications. Coatings such as mineral (silicate) and water-based low-VOC (volatile organic compound) formulations, as well as traditional lime coatings, are commonly used to enhance surface hydrophobicity [2].
To coat the wood-cement boards, five products were selected according to the following criteria: water resistance, water vapor permeability (diffusivity), environmental friendliness (water-based formulation with low VOC content), durability, and resistance to UV radiation and weathering. The morphology of the modified board surfaces was examined using scanning electron microscopy (SEM), and hydrophobicity was assessed by contact angle measurements. The modified wood-cement boards retained their original heterogeneous surface morphology, characterized by a non-uniform distribution of cement binder and exposed wood fibers, owing to the application of a thin transparent coating layer. All coatings improved the surfaces' hydrophobic performance, with some samples exhibiting contact angles exceeding 150°, indicating superhydrophobic behavior associated with the Lotus effect.

Keywords: wood-cement boards, contact angle, coating

Acknowledgement: This research was conducted in partnership with Fragmat H d.o.o, within the project IP.1.1.03.0059 financed by the EU EFRR and FPT funds through the ITP program.

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BIOCATALYTIC OXIDATION OF *rac*-BORNEOL TO (+)-CAMPHOR CATALYSED BY NAD$^+$-DEPENDENT BORNEOL DEHYDROGENASE

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Biocatalysis shows potential in the chemical industry by offering time-saving, highly efficient and enantio-selective synthesis routes to optically pure compounds under mild reaction conditions [1]. Enantiospecificity is the key feature exploited in the borneol dehydrogenase family. These enzymes, often referred to as BDH, belong to the short-chain dehydrogenase-reductase (SDR) family and offer potential for kinetic resolution of racemic alcohols. Plant-based borneol dehydrogenase from *Salvia rosmarinus* (*Sr*BDH1) catalyses the (+)-camphor production from borneol, which are valuable ingredients for the pharmaceutical industry [2]. The key requirement for the large-scale application of borneol dehydrogenase enzymes is the regeneration of the NAD$^+$ cofactor. Developing an efficient (+)-camphor synthesis route (Figure 1) requires determining kinetic parameters through enzyme activity assays and mathematical modelling. In this research, we have focused on establishing and optimising reaction conditions for the desired biocatalytic transformation with cofactor regeneration.

Keywords: biocatalysis, borneol dehydrogenase, cofactor regeneration

Acknowledgements: This work has been supported by the European Union's Horizon Europe Programme under the grant agreement No 101135542 (CirculH2).

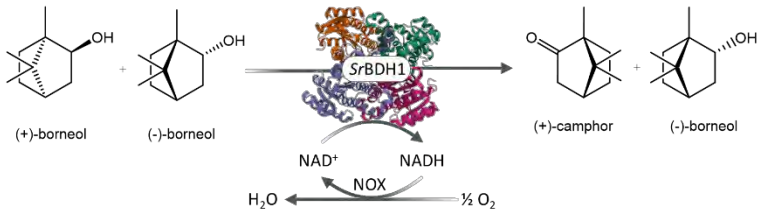

Figure 1. Reaction scheme of (+)-camphor synthesis with NAD$^+$-dependent borneol dehydrogenase

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OPTIMIZATION OF CELL PERMEABILIZATION CONDITIONS FOR IMPROVED ISOLATION OF HORSERADISH PEROXIDASE FROM HORSERADISH ROOT

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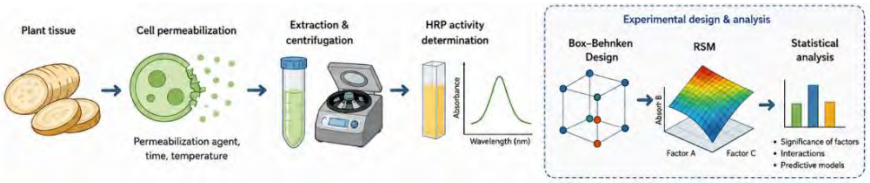
Horseradish peroxidase (HRP) is an important biocatalyst widely used in biotechnology, analytical chemistry, and environmental applications. Efficient recovery of HRP from plant tissues depends strongly on cell permeabilization, which facilitates enzyme release while preserving catalytic activity. In this study, the extraction of HRP from the autochthonous Ludbreg horseradish (*Armoracia rusticana*), a traditional Croatian cultivar known for its characteristic pungency and high biological value, was investigated. The aim of the study was to optimize cell permeabilization conditions to improve enzyme recovery and activity. The effects of permeabilization agent concentration, treatment time, and temperature were investigated using a Box-Behnken experimental design and Response Surface Methodology (RSM). Enzyme extracts were obtained following permeabilization and centrifugation, and HRP activity was determined spectrophotometrically. Statistical analysis was used to evaluate the significance of individual factors and their interactions and to develop predictive models describing the extraction process. The developed models enabled the identification of optimal permeabilization conditions and provided insight into the influence of process variables on enzyme recovery.

Keywords: horseradish peroxidase, cell permeabilization, enzyme extraction, Box-Behnken design, optimization



OPERATIONAL STABILITY OF PPK-2-III ENZYME FOR ATP REGENERATION

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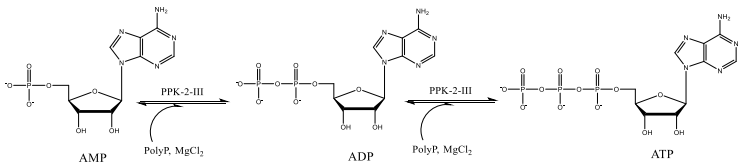
Biocatalysis enables sustainable synthesis of target products under mild reaction conditions, reducing energy consumption by avoiding high temperatures and pressures [1]. Operational stability depicts the ability of an enzyme to maintain its activity during the reaction. For industrial application, enzyme operational stability is a crucial parameter affecting process efficiency, productivity and overall economics [2].
ATP is considered the universal energy carrier in living cells. It is used as a coenzyme in numerous biocatalytic reactions, but as a substrate it is costly. Therefore an ATP regeneration step is necessary to enable cost-effective production [3]. PPK enzymes can be used for ATP regeneration during organic synthesis. The enzyme investigated in this work is polyphosphate kinase (PPK-2-III), which catalyses the conversion of AMP to ATP (Figure 1). PPK enzymes are classified into two subclasses, PPK-1 and PPK-2, based on the nucleotide they generate: ADP and ATP respectively [4]. The aim of this work is to investigate operational stability of PPK-2-III and its performance in batch reactors for ATP regeneration in biocatalytic synthesis.

Keywords: biocatalysis, batch reactors, operational stability, ATP regeneration

Acknowledgement: This work was funded by the European Union (CirculH2 grant no. 101135542).



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PRIMJENA HIBRIDNOG MAGNETSKOG BIOKATALIZATORA NANOCVJETOLIKE STRUKTURE U REAKCIJI RAZGRADNJE DIKLOFENAKA
APPLICATION OF HYBRID MAGNETIC BIOCATALYST WITH NANOFLOWER-LIKE STRUCTURE IN DICLOFENAC DECOMPOSITION

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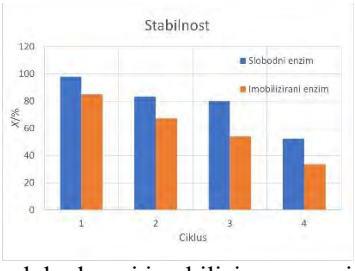
Diklofenak pripada skupini nesteroidnih protuupalnih lijekova (NSAID) i široko se primjenjuje zbog svojih protuupalnih i antipiretičkih svojstava. Zbog intenzivne i globalno rasprostranjene primjene, čija se godišnja potrošnja procjenjuje na približno 940 tona, tragovi diklofenaka danas se mogu pronaći u različitim vodenim sustavima, uključujući površinske i pitke vode. Učinkovitost uklanjanja diklofenaka u uređajima za pročišćavanje otpadnih voda vrlo je promjenjiva te se kreće od gotovo potpunog izostanka uklanjanja do približno 80 %, dok se najčešće vrijednosti nalaze između 21 i 40 % [1]. Oksidativni enzimi lakaze pokazale su se obećavajućima u razgradnji širokog spektra farmaceutskih spojeva, uključujući antibiotike, analgetike i hormone, putem ekološki prihvatljivih katalitičkih procesa. Međutim, praktična primjena slobodne lakaze ograničena je njezinom niskom stabilnošću, osjetljivošću na sastojke otpadnih voda i nedostatkom mogućnosti ponovne upotrebe. Imobilizirane lakaze pokazuju veću stabilnost, aktivnost u širem rasponu pH i temperatura, bolju mogućnost ponovne upotrebe te zadržavaju značajnu aktivnost i nakon više operacijskih ciklusa i duljeg skladištenja [2]. Cilj ovog rada bila je priprava kemijski modificiranog hibridnog magnetskog biokatalizatora Cu(II)-lakaza/Fe_3O_4 nanocvjetolike strukture te ispitivanje njegove primjenjivosti u razgradnji diklofenaka uz usporedbu aktivnosti s slobodnim enzimom lakazom.

Ključne riječi: Lakaza, imobilizacija, nanocvjetovi, diklofenak



Slika 1. Usporedba konverzija slobodnog i imobiliziranog enzima kroz četiri ciklusa reakcije

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ADITIVNA PROIZVODNJA U RAZVOJU PROTOČNIH SEPARATORA
ADDITIVE MANUFACTURING IN FLOW SEPARATOR DEVELOPMENT

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Ovaj rad istražuje primjenu aditivne proizvodnje u izradi miliseparatora za separaciju suspenzija čestica različitih oblika i veličina. Separacija u spiralnim kanalima temelji se na djelovanju inercijskih sila i Deanovog sekundarnog strujanja, pri čemu su ispitani utjecaji geometrije kanala (oblika poprečnog presjeka), dizajna separatora (različiti ulazi u separator-bočno i na sredini) i protoka na učinkovitost procesa. Separatori su izrađeni 3D-ispisom tehnologijom digitalne obrade svjetlom (engl. *digital light processing*, DLP) od fotopolimerne smole, pri čemu su se razlikovali po obliku poprečnog presjeka kanala (krug i trokut) te rasporedu ulaznih i izlaznih tokova. Ispitivane su suspenzije vode s talkom (sitne pločaste čestice), kalcijevim karbonatom (jako sitne čestice koje tvore aglomerate) i kvarcnim pijeskom (najveće čestice, nepravilnog oblika). Karakterizacija čestica provedena je metodama laserske difrakcije, prosijavanja i pretražne elektronske mikroskopije. Učinkovitost separacije određena je mjerenjem masa izdvojenih frakcija i raspodjele veličine čestica na izlazima separatora. Rezultati pokazuju razlike u masama izdvojenih frakcija, dok nema promjene u raspodjeli veličine čestica. Najveća učinkovitost separacije postignuta je za kvarcni pijesak pri protoku 300 mL/min kod trokutastog poprečnog presjeka kanala.

Ključne riječi: aditivna proizvodnja, spiralni separatori, digitalna obrada svjetlom, separacija kruto-kapljevito

OPTIMIZATION OF BIOHYDROGEN PRODUCTION IN A MICROREACTOR

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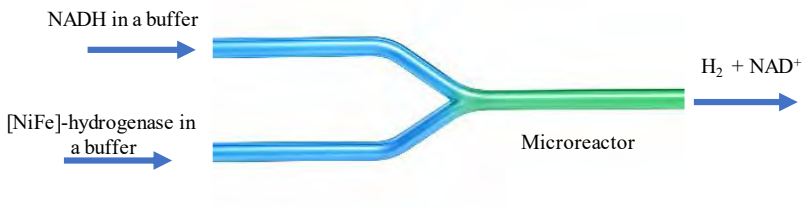
Microreactors are a promising technology for intensifying biocatalytic processes, including enzymatic biohydrogen production [1]. Their main advantage is a high surface-to-volume ratio, which significantly enhances heat and mass transfer, enabling efficient mixing and minimizing concentration and temperature gradients within the reaction system. Due to their small size, microreactors provide precise control of process parameters such as temperature, pressure, and residence time, which is particularly beneficial for reactions involving sensitive biocatalysts [2].
This study investigates the potential of microreactor technology for continuous biohydrogen production from NADH using recombinant [NiFe]-hydrogenase as a biocatalyst. Biohydrogen production is based on the enzymatic oxidation of NADH coupled with hydrogen production. The process was studied in batch and microreactor systems, with particular emphasis on key performance indicators such as conversion, yield and volumetric productivity. The effects of operating conditions, including residence time and initial NADH concentration, were systematically examined to assess their influence on process performance. The optimal process conditions that maximize biohydrogen production while ensuring stable and efficient process performance were identified.

Keywords: biohydrogen, microreactor, [NiFe]-hydrogenase, process optimization



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BIOSYNTHESIS OF SILVER NANOPARTICLES: A CRITICAL REVIEW OF FUNGAL BIOMOLECULAR REDUCING AGENTS AND BIOSYNTHETIC PARAMETERS

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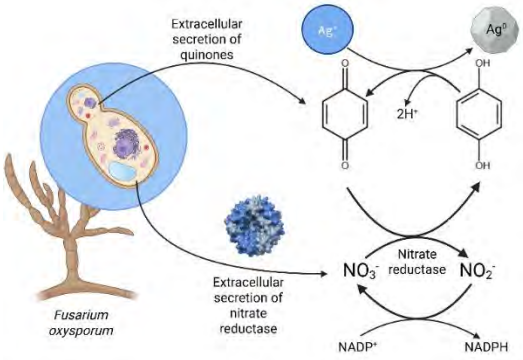
The use of hazardous chemicals and the generation of harmful by-products in conventional synthesis have stimulated the development of sustainable alternatives. Green chemistry promotes environmentally friendly synthetic and analytical methods that minimize toxic waste in research and industry. Among these approaches, fungal-mediated biosynthesis of silver nanoparticles (AgNPs) has attracted considerable attention due to the high efficiency of fungi in reducing silver ions [1]. This review examines the key biomolecules and biosynthetic parameters involved in AgNP formation, as well as the analytical techniques used for nanoparticle characterization (UV–Vis, FT-IR, XRD, TEM, SEM, AFM, DLS, and zeta potential analysis). The most commonly used fungal species are also discussed, given their significant influence on nanoparticle morphology and size. Extracellular biomolecules, particularly nitrate reductase, superoxide ions, and secondary metabolites, play crucial roles in silver ion reduction and nanoparticle stabilization. Important biosynthetic parameters include pH, temperature, incubation time, fungal biomass, and $AgNO_3$ concentration. Green-synthesized AgNPs exhibit promising antimicrobial properties and have applications in catalysis, biosensing, and bioimaging. Understanding the mechanisms underlying fungal AgNP biosynthesis is essential for process optimization and industrial-scale production.

Keywords: silver nanoparticles, fungal-mediated biosynthesis, green-nanotechnology



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USPOREDBA I OBJAŠNJIVOST MODELA STROJNOG UČENJA U PREDVIĐANJU NASTAJANJA FARMACEUTSKIH KOKRISTALA
COMPARISON AND EXPLAINABILITY OF MACHINE LEARNING MODELS FOR PREDICTING PHARMACEUTICAL COCRYSTAL FORMATION

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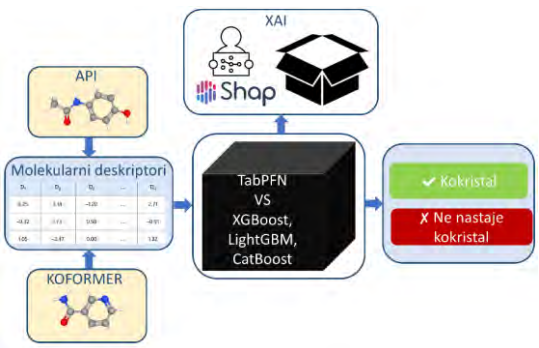
Razvoj farmaceutskih kokristala predstavlja važnu strategiju za poboljšanje fizikalno-kemijskih svojstava farmaceutskih djelatnih tvari (engl. *active pharmaceutical ingredient*, API), kao što su topljivost, kemijska stabilnost i bioraspoloživost. Međutim, razvoj novih farmaceutskih kokristala zahtijeva dugotrajno eksperimentalno ispitivanje prikladnosti velikog broja potencijalnih koformera. Ispitivanje prikladnih koformera može se ubrzati primjenom klasifikacijskih modela strojnog učenja. [1] U ovom radu uspoređen je generativni transformerski model TabPFN (engl. *Tabular Prior-data Fitted Network*), unaprijed naučen na milijunima sintetički generiranih tabličnih skupova podataka, s modelima temeljenima na gradijentnom pojačavanju stabala odlučivanja, koji se posljednjih dvadesetak godina smatraju vodećim modelima za tablične skupove podataka. [2] Kao ulazne varijable korišteni su molekularni deskriptori API-a i koformera, a kao ciljne varijable korišteni su eksperimentalni ishodi kokristalizacije preuzeti iz znanstvene literature. Zbog ograničene interpretabilnosti modela, modeli strojnog učenja često se smatraju modelima crne kutije (engl. *black-box models*). Stoga su u radu primijenjene metode objašnjive umjetne inteligencije (engl. *Explainable Artificial Intelligence*, XAI) kako bi se objasnili rezultati predviđanja modela i odredila važnost pojedinih molekularnih deskriptora.

Ključne riječi: kokristali, strojno učenje, objašnjiva umjetna inteligencija, TabPFN



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HARNESSING SEWAGE SLUDGE TO REMOVE HIGH ORGANIC LOADS THROUGH BIOSORPTION

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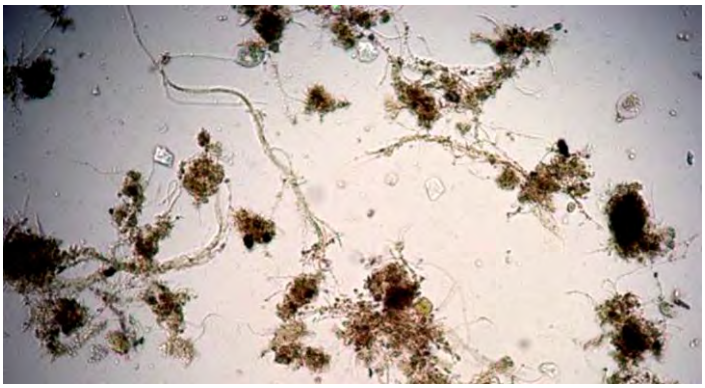
Biosorption is a physicochemical process in which pollutants bind to biological materials, enabling biomass to be used as a natural, accessible and environmentally friendly biosorbent. Highly loaded wastewater, particularly leachate from waste management systems, contains very high concentrations of organic matter and therefore requires efficient, sustainable and resource-oriented treatment approaches. This study investigates the valorisation of sewage sludge as a biosorbent for the removal of organic pollution from leachate with an initial chemical oxygen demand of 12,868 mg O_2/L. Biosorption was tested at sludge concentrations ranging from 1 to 6 g/L. The maximum removal efficiency achieved was 30.0%, and the biosorption capacity of the activated sludge was 649 mg/g, confirming the strong biosorption potential of sludge due to its floc structure, active EPS matrix and diverse functional groups. The Temkin isotherm model provided the most accurate description of biosorption equilibrium ($F = 0.971$).

Keywords: biosorption, sewage sludge, leachate, Temkin isotherm



ANTIMIKROBNA AKTIVNOST PINOCEMBRINA I KAEMPFEROLA PROTIV METICILIN-REZISTENTNOG *STAPHYLOCOCCUS AUREUS* I PROCJENA NJIHOVE ANTIOKSIDATIVNE AKTIVNOSTI
ANTIMICROBIAL ACTIVITY OF PINOCEMBRIN AND KAEMPFEROL AGAINST METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* AND ASSESSMENT OF THEIR ANTIOXIDATIVE ACTIVITY

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Flavonoidi su prirodni spojevi prisutni u propolisu, medu i brojnim biljnim vrstama te su poznati po svojim antimikrobnim i antioksidativnim svojstvima. S obzirom na sve veću pojavnost bakterija otpornih na antibiotike, istražuju se kao potencijalni alternativni ili komplementarni antimikrobni agensi. Cilj ovog istraživanja bio je procijeniti antimikrobnu aktivnost pinocembrina i kaempferola, pojedinačno i u kombinaciji, protiv meticilin-rezistentnog *Staphylococcus aureus* (MRSA), te odrediti njihovu antioksidativnu aktivnost. Antimikrobna aktivnost protiv meticilin-rezistentnog *Staphylococcus aureus* (MRSA ATCC BAA-1708) određena je metodom mikrodilucije u bujonu utvrđivanjem minimalnih inhibitornih koncentracija (MIC), dok je interakcija između flavonoida procijenjena checkerboard metodom i izračunom indeksa frakcijske inhibitorne koncentracije (FICI). Antioksidativna aktivnost određena je ABTS metodom mjerenjem sposobnosti uklanjanja slobodnih radikala pri različitim koncentracijama flavonoida. Pinocembrin i kaempferol pokazali su antimikrobnu aktivnost protiv MRSA, pri čemu su MIC vrijednosti iznosile 125 µg/mL i 32 µg/mL. Njihova kombinacija rezultirala je pojačanom antibakterijskom aktivnošću te smanjenjem koncentracija potrebnih za inhibiciju bakterijskog rasta za 2–4 puta u odnosu na pojedinačne MIC vrijednosti. U ABTS testu oba flavonoida pokazala su koncentracijski ovisnu antioksidativnu aktivnost. Povećanjem koncentracije zabilježen je porast inhibicije ABTS radikala, pri čemu je pinocembrin postizao veće vrijednosti inhibicije pri nižim koncentracijama u usporedbi s kaempferolom. Pri višim koncentracijama oba su flavonoida ostvarila više od 90 % inhibicije ABTS radikala, što ukazuje na izražen antioksidativni potencijal. Dobiveni rezultati ukazuju na antimikrobni i antioksidativni potencijal pinocembrina i kaempferola te pružaju osnovu za daljnja istraživanja njihove moguće primjene protiv rezistentnih bakterijskih sojeva.

Ključne riječi: antioksidativna aktivnost, flavonoidi, kaempferol, MRSA, pinocembrin

DOCKING AND MOLECULAR DYNAMICS ANALYSIS OF A NOVEL RHENIUM(I) COMPLEX BOUND TO JAK1 PROTEIN

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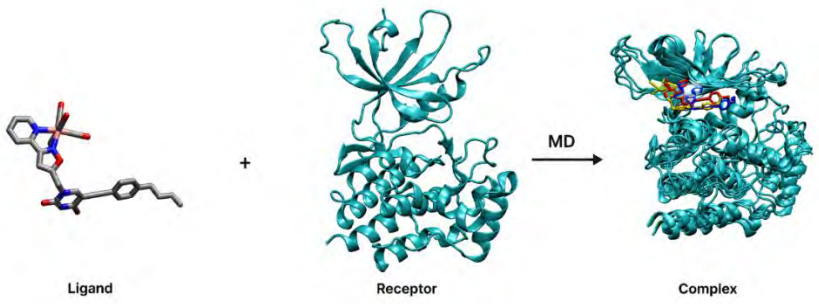
The JAK/STAT signaling pathway, specifically JAK1 protein represents an important therapeutic target in the HuT-78 cell line, because it carries JAK1 mutations within an activated JAK/STAT cascade. Literature shows that inhibitors of this pathway can reduce the proliferation of CTCL cells, including HuT-78 [1] [2].

An MTT assay of the novel rhenium(I) complex 7d'$_{Re}$ shows a low IC_{50} value (2.1 µM) for HuT-78 treatment. According to molecular docking results, 7d'$_{Re}$ binds to the JAK1 active site (PDB code 3EYG). To prove the docking results, molecular dynamics (MD) simulations were performed in three runs, each 500 ns. The MD simulations show a H-bond between the ligand and Leu95, carbon–hydrogen bonds with Arg15, π-alkyl interactions with Val25, and van der Waals interactions with Arg15, Gly18, Lys24, Leu27, Gly98, and Leu146 in all runs.

Keywords: MD simulation, docking, JAK1, rhenium(I) complex



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A DESIGN-OF-EXPERIMENTS APPROACH TO STUDYING THE "COFFEE RING" EFFECT IN ACTIVE PHARMACEUTICAL INGREDIENTS

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The final morphology of a dried droplet — whether it forms a pronounced edge ring, a uniform film, a central deposit or a multi-ring pattern — depends on many coupled, nonlinear factors and is therefore difficult to anticipate from intuition alone. We propose a Design-of-Experiments (DoE) approach to systematically study the coffee-ring effect in active pharmaceutical ingredients (APIs) [1]. Instead of varying one factor at a time, a structured experimental plan simultaneously explores the key drivers of deposit formation: initial concentration, the concentration-to-solubility (saturation) ratio, evaporation rate (set by temperature and relative humidity), droplet volume and substrate wettability, as well as their interactions, and quantifies their influence on measurable morphology responses such as the rim-to-centre intensity ratio, the number and position of internal rings and the overall deposit width. A two-stage strategy is outlined: an initial screening design (fractional-factorial or Plackett–Burman) identifies the dominant factors and interactions, followed by a response-surface design (central-composite or Box–Behnken) that builds a predictive model and locates the conditions giving a target morphology. This approach extracts maximum information from a minimal number of experiments, makes factor interactions explicit and yields a statistically grounded, transferable model — offering an efficient route to the rational control of evaporation-driven deposition in pharmaceutical formulation screening.

Keywords: design of experiments (DoE), coffee-ring effect, droplet evaporation, active pharmaceutical ingredients, response surface methodology, formulation screening

Acknowledgments: This work was supported by the Croatian Science Foundation through the project IP-2024-05-4339 entitled "'Coffee ring' effect in 'Lab on a Chip' environments in the development of new drug formulations".

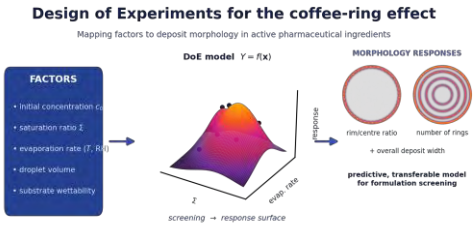

Figure 1. Graphical abstract, DoE for the coffee-ring effect

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KONTROLA I STABILNOST *N*-NITROZO-FOLATNE KISELINE U TABLETAMA FOLATNE KISELINE: PROCJENA RIZIKA, ANALITIČKA POTVRDA I REGULATORNE IMPLIKACIJE
CONTROL AND STABILITY OF *N*-NITROSOFOLIC ACID IN FOLIC ACID TABLETS: RISK ASSESSMENT, ANALYTICAL CONFIRMATION AND REGULATORY IMPLICATIONS

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Sveobuhvatna procjena potencijalnih izvora *N*-nitrozamina u tabletama folatne kiseline, uključujući pregled dokumentacije proizvođača sirovina, dostupne literature te vlastita ispitivanja, ukazala je na niski početni rizik. Inicijalni *screening* verificiranom UHPLC-MS/MS metodom potvrdio je prisutnost *N*-nitrozo-folatne kiseline u tabletama folatne kiseline. Utvrđeno je da je dominatni izvor ovog onečuišćenja aktivna susptancija, dok su proizvodna oprema, proces, voda, sredstva za čišćenje i pakirni materijal isključeni kao izvori kontaminacije. Potvrdno ispitivanje validiranom metodom na deset serija gotovog proizvoda, starosti 18–36 mjeseci, čuvanih na 25 °C/60 % RH, pokazalo je da su rezultati za sve serije ispod tada važeće prihvatljive granice (≤ 2,5 ppm), bez trenda porasta tijekom starenja. Budući da su izmjerene koncentracije prelazile 30 % granice bazirane na prihvatljivom unosu (AI, *Acceptable Intake*) sukladno smjernici EMA/409815/2020 [1], uvedeno je rutinsko ispitivanje nitrozamina u gotovom proizvodu, čime je potvrđena stabilnost i kontroliran rizik tijekom roka valjanosti. Naknadno je utvrđeno da *N*-nitrozo-folatna kiselina nije mutagena *in vivo*, zbog čega se prema revidiranoj regulatornoj smjernici može kontrolirati kao razgradni produkt u skladu s ICH Q3A/B [2] smjernicom.

Ključne riječi: *N*-nitrozo-folatna kiselina, UHPLC-MS/MS analiza, procjena rizika

[1] EMA, Questions and Answers on Nitrosamine Impurities (EMA/409815/2020), European Medicines Agency, 2020.
[2] ICH, Q3A(R2): Impurities in New Drug Substances, International Council for Harmonisation, 2006.

SYNTHESIS, ANTITUMOR ACTIVITY AND FORCED DEGRADATION OF ACYLHYDRAZONE BENZOXAZOLONE DERIVATIVES

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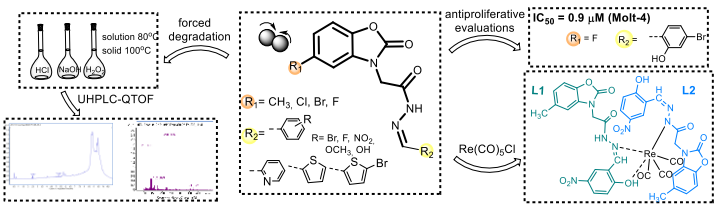
The benzo[*d*]oxazol-2-one core represents a promising scaffold in medicinal chemistry due to its favorable physicochemical properties and bioisosterism with purine DNA bases.[1] Furthermore, acylhydrazone derivatives exibit a wide range of biological activities, owing to the bioisosteric hydrazone subunit of the amide bond, making them promising candidates for modern drug design.[2] Herein, we present the synthesis of novel acylhydrazone benzo[*d*]oxazol-2-one derivatives, their forced hydrolytic, thermal, and oxidative degradation, as well as the evaluation of their antiproliferative activity. The synthetic route involved the cyclization of 4-substituted 2-aminophenols followed by alkylation and subsequent reaction with hydrazine hydrate to afford the benzo[*d*]oxazol-2-one *N*-hydrazides. The target acylhydrazone derivatives were synthesized as *Z*-isomers by mechanochemical approach involving the reaction of the benzoxazolone *N*-hydrazides with aromatic aldehydes. In addition, a tricarbonylrhenium(I) complex of the selected acylhydrazone ligand was successfully prepared. The structures of the synthesized compounds were confirmed by ^{1}H and ^{13}C NMR spectroscopy, complemented by NOESY experiments. The most pronounced antitumor activity (Molt-4, IC_{50}= 0.9 mM) was observed for the 5-fluorobenzoxazolone derivative bearing 4-bromo-2-hydroxyphenyl substituent attached to the acylhydrazone linker.

Keywords: benzo[*d*]oxazol-2-one, acylhydrazones, antitiumor activity, forced degradation



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STRUCTURE, REDOX PROPERTIES, AND ANTITUMOR POTENTIAL OF A NOVEL TERNARY COPPER(II) COMPLEX

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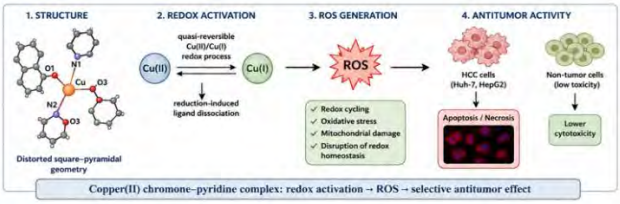
Hepatocellular carcinoma (HCC) remains one of the leading causes of cancer-related mortality, highlighting the urgent need for the development of novel antitumor agents with improved selectivity and efficacy [1,2]. In this study, a ternary copper(II) complex containing chromone-2-carboxylate and pyridine was synthesized and comprehensively characterized using infrared and UV–Vis spectroscopy, thermogravimetric analysis, powder and single-crystal X-ray diffraction, and cyclic voltammetry. Single-crystal structural analysis revealed a distorted square-pyramidal coordination geometry with pronounced Jahn–Teller elongation of the axial Cu–O bond. Electrochemical measurements and DFT calculations indicated a quasi-reversible Cu(II)/Cu(I) redox process accompanied by reduction-induced ligand dissociation and the formation of a more labile Cu(I) species, supporting a redox activation mechanism associated with the generation of reactive oxygen species. The complex exhibited pronounced antiproliferative activity against Huh-7 and HepG2 hepatocellular carcinoma cell lines, while showing significantly lower cytotoxicity toward non-tumor cells. Fluorescence staining confirmed the induction of late apoptosis/necrosis, whereas alterations in glutathione levels indicated disruption of redox homeostasis. These findings demonstrate that the biological activity arises from the interplay between coordination geometry, redox properties, and ligand framework, highlighting copper(II) chromone–pyridine complexes as promising platforms for the development of selective antitumor agents.

Keywords: copper(II) complex, chromone-2-carboxylate, redox activation, hepatocellular carcinoma, antiproliferative activity



Scheme 1. Redox activation of a copper(II) chromone–pyridine complex triggers ROS-mediated selective antitumor activity

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CHOOSING OPTIMAL PH RANGE FOR PRODUCT *LATANOPROST + NETARSUDIL, 50 µg/ml + 200 µg/ml, EYE DROPS, SOLUTION*

Roberta Kurelić, Ivona Pečurlić, Nina Popović, Dijana Jureša, Ivan Sušanj
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JGL product *Latanoprost + Netarsudil, 50 µg/ml + 200 µg/ml, eye drops, solution*, further referred to as Test product, is indicated to lower elevated intraocular pressure (IOP) in adult patients with primary open-angle glaucoma or ocular hypertension for whom monotherapy with a prostaglandin or netarsudil provides insufficient IOP reduction. Reference medicinal product is Roclanda with pH value set to approximately pH 5 [1]. Forty-five days long stability study was conducted to test pH range in which Test product is stable. Main goal of stability study was to confirm lower and upper value of the pH range through shelf-life period, as well to set pH value at which drug product will be adjusted during manufacturing process. Test product with initially adjusted pH values within proposed pH range was monitored on long term storage (2-8°C) and stress (25°C/60%RH) conditions. Analysed parameters, such as appearance, pH, osmolality, buffer capacity, viscosity (rheology), density, surface tension, assay of netarsudil and assay and impurities of latanoprost were stable during stability study. Study revealed that with increase in pH value in the solution of the final product, impurities of netarsudil show upward trend over period of time at 25°C/60%RH (Figure 1). To summarize major outcomes from this stability study, formulation of Test product will be adjusted to pH value 4.8, while IPC requirement during manufacturing process will be set to pH range 4.7 – 4.9. According to findings in this study, acceptance criteria for pH range throughout shelf-life period of Test product will be set to 4.5 – 5.2, what is additionally supported by literature due to netarsudil dimesylate precipitation above pH value of 5.4 [2].

Keywords: netarsudil, latanoprost, pH, impurities of netarsudil

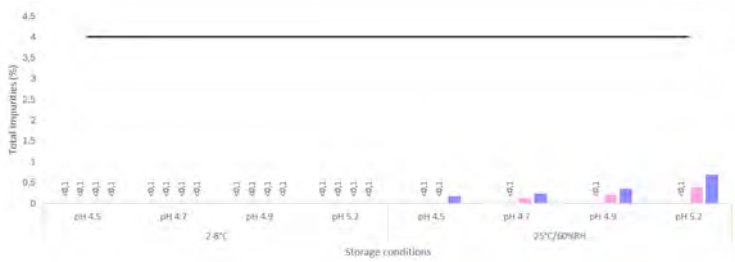

Figure 1. Graphical representation of data for total impurities of netarsudil measured during stability study (intervals: T0-T14-T28-T45) for Test product with differently adjusted pH value (black lines represent Test product specification requirements for total impurities of netarsudil (shelf-life requirements): 4.0%)

[1] Roclanda | European Medicines Agency (EMA).
[2] Wang T, Zhang Y, Chi M, et al. A novel fixed-combination timolol-netarsudil-latanoprost ophthalmic solution for the treatment of glaucoma and ocular hypertension. *Asian J Pharm Sci*. 2022, 17(6), 938-948. doi:10.1016/j.ajps.2022.11.001.

SERUM CONCENTRATIONS OF COPPER AND ZINC IN PATIENTS WITH MULTIPLE SCLEROSIS

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Previous studies indicate that serum copper (Cu) and zinc (Zn) concentrations in multiple sclerosis (MS) patients may differ from normal, but the findings are limited and inconsistent. This study aimed to examine serum concentrations of Cu and Zn in MS patients from Eastern Croatia and healthy controls from the same region, and to determine whether there are differences in serum concentrations of Cu and Zn between these groups. The case-control study was conducted at the Department of Clinical Laboratory Diagnostics, Clinical Hospital Center Osijek, from April 1, 2019, to July 31, 2019. The study included 67 MS patients from Eastern Croatia and 67 healthy controls from the same area. Serum concentrations of Cu and Zn were measured by atomic absorption spectroscopy. The median serum Cu concentration in MS patients was 17.0 µmol/L (interquartile range 15.6–19.4 µmol/L), compared to 19.1 µmol/L (interquartile range 16.6–20.7 µmol/L) in healthy controls (p=0.030). The median serum Zn concentration in MS patients was 13.6 µmol/L (interquartile range 12.4–14.9 µmol/L), compared to 12.5 µmol/L (interquartile range 10.7–14.2 µmol/L) in healthy controls (p=0.009). The Cu-to-Zn ratio in MS patients was 1.3 (interquartile range 1.1–1.5), compared to 1.5 (interquartile range 1.3–1.7) in healthy controls (p=0.003). MS patients had significantly lower serum Cu concentration, significantly higher serum Zn concentration, and significantly lower Cu-to-Zn ratio than healthy controls. Further studies are needed to clarify these differences more thoroughly.

Keywords: multiple sclerosis, copper, zinc, serum concentrations, Croatia

SYNTHESIS, STRUCTURAL CHARACTERIZATION AND BIOLOGICAL ACTIVITY OF PYRIDINE BENZAMIDES

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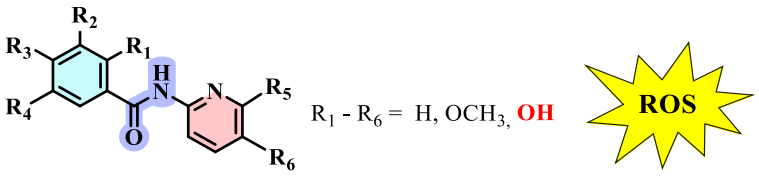
Amide bonds are ubiquitous structural motifs present in natural products, peptides, agrochemicals, functional materials, and pharmaceutical agents. Their broad occurrence and unique physicochemical properties make amide-containing molecules indispensable precursors and intermediates in the synthesis of pharmaceuticals and other useful chemical entities. Pyridine derivatives exhibit a wide range of biological activities, making them valuable scaffolds in medicinal chemistry and drug development. Among these, pyridylbenzamides constitute an important class of nitrogen-containing heterocyclic amides that have attracted considerable attention due to their diverse pharmacological properties. [1,2] This work presents the synthesis, structural characterization and biological activity of pyridine derived benzamides bearing several hydroxy groups. Benzamides were prepared from corrersponding benzoyl chlorides and 2-aminopyridines. Targeted hydroxy substituted benzamides obtained by demethylation of methoxy derivatives with BBr_3. The structures of the prepared compounds were characterized by menas of 1D and 2D NMR spectroscopy and MS spectrometry. Antiproliferative activity *in vitro* was tested on human cancer cells and on normal PBMC cells, while antioxidant activity *in vitro* was determined by three methods.

Keywords: benzamides, biological activity, pyridines, structural characterization

Acknowledgement: The Croatian Science Foundation funded this work (BenzHetPot (IP-2024-05-7208).



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CHEMOTHERAPEUTIC CYTOTOXICITY IN 2D VS 3D HEAD AND NECK CANCER MODELS

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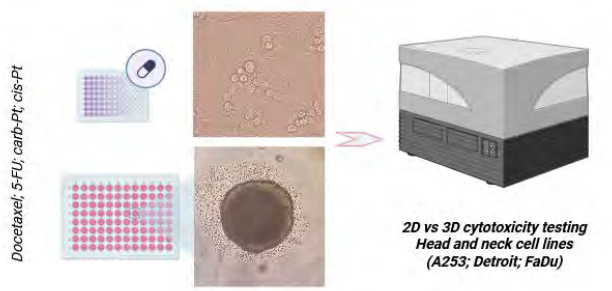
Head and neck cancers are the sixth most common cancers worldwide. Although these sites are easily accessible, the disease is generally diagnosed at advanced stages (III, IV). Standard clinical practice involves a combination of radiotherapy and chemotherapy using the following agents: docetaxel, carboplatin or cisplatin, and 5-fluorouracil (5-FU). The aim of this study was to examine the antitumour effects of these chemotherapeutic agents on head and neck squamous cell carcinoma (HNSCC) cell lines using two cell models: a classic 2D monolayer culture model and a 3D spheroid culture model. The MTT assay was used to assess the sensitivity of cell lines from the HNSCC group: salivary gland (A253), hypopharyngeal (Detroit 562), and metastatic pharyngeal cell line (FaDu). A normal cell line (MRC-5) was also included in the study. The 2D model revealed marked cellular sensitivity to the chemotherapeutic agents. The Detroit 562 cell line showed the highest sensitivity to docetaxel (IC_{50} = 6.3 nM), while FaDu and A253 exhibited the highest sensitivity to cisplatin (IC_{50} = 4.1 µM and 1.8 µM, respectively). All cell lines showed the lowest sensitivity to 5-FU, as follows: Detroit 562 (60.6 µM), FaDu (45.1 µM), and A253 (> 100 µM). The MRC-5 cell line demonstrated sensitivity to cisplatin (3.8 µM) and docetaxel (71.9 µM), whereas IC_{50} values for carboplatin and 5-FU exceeded 100 µM. Compared with the 2D model and the tested concentration range (10^{-4} to 10^{-9} mol/dm³), cells in the 3D cytotoxicity model were exposed to specific IC_{50} values for each chemotherapeutic, resulting in very high survival rates (73–104 %). The results suggest that cells cultured in a 3D model, which more closely resembles *in vivo* conditions, are a superior choice for predicting the effects of known and unknown compounds compared with 2D models.

Keywords: HNSCC, cell line, inhibitory concentration, sferoids



FARMAKOEKONOMSKA ANALIZA PRIMJENE GLP-1 AGONISTA U HRVATSKOJ
PHARMACOECONOMIC ANALYSIS OF GLP-1 RECEPTOR AGONIST USE IN CROATIA

Ivan Miškulin[1], Matea Matić Ličanin[1,2], Stela Jokić[3], Iva Krolo[4], Ivana Kotromanović Šimić[1], Ivan Vukoja[1], Darko Kotromanović[1], Jelena Šakić Radetić[1,2], Dunja Damjanović[1,2], Martina Rikert[1,2]

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[2]*Dom zdravlja Osječko-baranjske županije, Park kralja Petra Krešimira IV 6, 31000, Osijek, Hrvatska*
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Farmakoekonomija predstavlja ključnu disciplinu u vrednovanju novih farmakoterapijskih mogućnosti, posebice u kontekstu ubrzanog rasta potrošnje agonista receptora glukagonskog peptida-1 (GLP-1 RA) i dualnog GLP-1/GIP agonista u Republici Hrvatskoj. Analiza nacionalnih podataka Agencije za lijekove i medicinske proizvode (HALMED) za razdoblje 2017.–2024. pokazuje da je ukupna potrošnja antihiperglikemika porasla s 66,9 na 96,8 DDD/1000 stanovnika/dan (+44,7 %), dok su ukupni troškovi skupine A10 rasli s 54,2 na 96,5 milijuna EUR, što znači da je rast troškova nadmašio rast korištenja [1]. Posebno je značajan rast troškova za GLP-1 RA s 5,2 milijuna EUR (2018.) na 28,6 milijuna EUR (2024.), što odgovara godišnjoj stopi rasta (CAGR) od 33,0 %, dostižući 29,8 % ukupnih troškova antihiperglikemika u 2024. godini [1]. Ovaj disproporcionalan utjecaj na proračun Hrvatskog zavoda za zdravstveno osiguranje (HZZO) naglašava hitnu potrebu za robusnim i transparentnim okvirom procjene zdravstvenih tehnologija (HTA) u skladu s Uredbom EU 2021/2282 o zajedničkoj kliničkoj procjeni [5]. Farmakoekonomska analiza temelji se na metodama analize troška i učinkovitosti (CEA) te analize troška i korisnosti (CUA) korištenjem inkrementalnog omjera troškova i učinkovitosti (ICER) te kvalitativno prilagođenih godina života (QALY) u okviru Markovljevih modela prijelaza stanja [6]. Sustavni pregledi i meta-analize ekonomskih evaluacija semaglutida pokazuju da, uz primjerenu primjenu praga voljnosti plaćanja, ovaj lijek može biti isplativi izbor u liječenju šećerne bolesti tipa 2 i pretilosti [3]. Istovremeno, istraživanja na uzorku liječnika obiteljske medicine u Hrvatskoj pokazuju da su propisivanje GLP-1 RA i suradnja sa specijalistima i dalje nedostatni, što dodatno otežava implementaciju smjernica temeljenih na dokazima [4]. Rezultati upućuju na nužnost razvoja transparentnih kriterija uvrštenja na liste lijekova HZZO-a, utemeljenih na dokazima isplativosti, uz redovitu reviziju cijena referentnim sustavom zemalja EU.

Ključne riječi: farmakoekonomija, GLP-1 agonisti, procjena zdravstvenih tehnologija, analiza isplativosti, Hrvatska

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PRESERVING THE BIOACTIVITY OF ELDERFLOWER THROUGH MULTIFUNCTIONAL MICROPARTICLES

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Development of multifunctional natural bioactive systems with improved stability and biological activity is a key challenge in pharmaceutical and biomedical research. *Sambucus nigra* L. flowers are rich in polyphenols with antioxidant, antimicrobial, and antidiabetic properties; however, their application is limited by poor stability. Spray-drying microencapsulation represents an effective strategy to overcome this limitation. This study developed spray-dried elderflower extract microparticles using inulin and polydextrose as carriers, individually and in combination. The formulations were evaluated for antioxidant, antidiabetic (*α*-glucosidase and *α*-amylase inhibition), and antimicrobial activities. Microencapsulation successfully preserved biological activity. The free extract showed the highest antioxidant activity (DPPH IC_{50} 0.27 mg/mL), while inulin-based formulations demonstrated improved *α*-glucosidase inhibition (IC_{50} 3.66–3.74 mg/mL) compared to the non-encapsulated extract (IC_{50} 4.18 mg/mL). Antimicrobial activity was also confirmed. Overall, the results indicate that inulin- and polydextrose-based microparticles represent promising multifunctional delivery systems for bioactive compounds with potential pharmaceutical applications.

Keywords: bioactive stabilization, functional carriers, spray-drying systems

MOLECULAR ORBITALS STUDY ON DERIVATIVES OF ARYLAMIDE IMIDAZOLES AS INHIBITORS OF BUTYRYLCHOLINESTERASE

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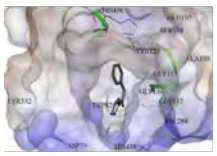
Butyrylcholinesterase (BuChE) is a serine hydrolase enzyme that catalyses the hydrolysis of choline-based esters. The activity of BuChE increases in the temporal lobe and hippocampus during Alzheimer's Disease (AD) progression. Inhibition of these enzymes is a treatment strategy for AD [1]. The synthesized arylamide imidazole derivatives (1a–1e and 2a–2e) were tested for *in vitro* inhibitory activity butyrylcholinesterase (BuChE). They showed from low to strong against BuChE. Derivative without substitution at the phenyl ring, 1a, exhibited very high inhibition (87.13%, IC_{50} = 23.83 μmol dm^{-3}). In order to investigate the relation between the quantum properties of observed compounds and their inhibition potential, the highest occupied molecular orbital (HOMO), the lowest unoccupied molecular orbital (LUMO) was calculated using using the semiempirical PM3 method. The frontier orbital energies (HOMO and LUMO) were highly correlated (R = 0.77 and 0.84, respectively) with the *in vitro* inhibitory activity against BuChE, suggesting structural features important for enzyme inhibition. HOMO orbitals of the leading compound 1a are localised on the phenyl ring, nitrogen and oxygen atoms from the amide group, while the LUMO orbitals are extend throughout the whole molecule.

Ključne riječi: imidazoli, kolinesteraze, molekulske orbitale, inhibicija



BuChE

E_{LUMO} = 0.051 eV

IC_{50}(**1a**) = 23.83 μmol dm^{-3}

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BIOAKTIVNI SPOJEVI HRANE I DODATAKA PREHRANI KAO MODULATORI ENDOKANABINOIDNOG SUSTAVA
BIOACTIVE COMPOUNDS FROM FOOD AND DIETARY SUPPLEMENTS AS MODULATORS OF THE ENDOCANNABINOID SYSTEM

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Endokanabinoidni sustav (ECS) složena je signalna mreža uključena u regulaciju homeostaze, energetskog metabolizma, imunološkog odgovora, neuroprotekcije i upalnih procesa. Njegovo otkriće uslijedilo je nakon identifikacije receptora na koje djeluju fitokanabinoidi iz biljke Cannabis sativa, što je potaknulo intenzivna istraživanja endogenih liganada, kanabinoidnih receptora i njihove fiziološke uloge. Posljednjih godina sve više znanstvenih spoznaja upućuje na to da brojni bioaktivni spojevi prisutni u hrani i dodacima prehrani mogu modulirati aktivnost ECS-a različitim molekularnim mehanizmima. Cilj ovoga rada je prikazati suvremene spoznaje o djelovanju bioaktivnih spojeva hrane i dodataka prehrani na endokanabinoidni sustav te uspostaviti funkcionalno-mehanistički okvir za njihovu klasifikaciju prema molekularnim metama, signalnim putevima i načinu modulacije ECS-a. Poseban naglasak stavljen je na spojeve koji izravno ili neizravno moduliraju aktivnost kanabinoidnih receptora, utječu na sintezu i razgradnju endokanabinoida ili djeluju putem drugih signalnih putova funkcionalno povezanih s ECS-om. U radu se razmatraju beta-kariofilen, omega-3 masne kiseline, polifenoli, flavonoidi, terpeni, palmitoiletanolamid (PEA) i drugi prehrambeni bioaktivni spojevi za koje postoje eksperimentalni i klinički podaci o mogućim učincima. Novost rada ogleda se u objedinjavanju dostupnih spoznaja kroz funkcionalni model koji bioaktivne spojeve razvrstava prema mehanizmu djelovanja na ECS, a ne isključivo prema njihovu kemijskom podrijetlu. Takav pristup omogućuje bolje razumijevanje interakcija prehrane i endokanabinoidnog sustava te može predstavljati osnovu za razvoj funkcionalne hrane, dodataka prehrani i personaliziranih nutritivnih strategija usmjerenih na očuvanje zdravlja i prevenciju kroničnih nezaraznih bolesti.

Ključne riječi: endokanabinoidni sustav, bioaktivni spojevi, dodaci prehrani, funkcionalna hrana, beta-kariofilen

SYNTHESIS AND BIOLOGICAL ACTIVITY OF NOVEL OXAZOLO[4,5-*b*]PYRIDINE DERIVATIVES

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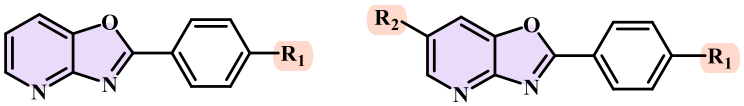
Nitrogen containing heterocycles, especially bicyclic benzazole derivatives, have been recognized as unavoidable structural motifs of most biologically important molecules in in the rational design of novel drugs. Oxazolo[4,5-*b*]pyridines have been associated with a broad range of versatile biological activities, while their isosterism with naturally occurring purine bases improve the interaction with biological targets like DNA, RNA or proteins.[1]

Herein we report the synthesis, structural characterization and biological activity of oxazolo[4,5-*b*]pyridine derivatives obtained using a multistep synthetic approach and optimization of synthetic methods. Targeted compounds were prepared by condensation reaction of 2-amino-3-hydroxypyridines with chosen benzoic acids in polyphosphoric acid (PPA).[2] The structures of the prepared compounds were confirmed using ^{1}H and ^{13}C NMR spectroscopy and MS spectrometry. Antiproliferative activity *in vitro* was tested on several human cancer cells as well as on normal PBMC cells, while antifungal assays will be performed against chosen agricultural phytopathogens.

Keywords: antiproliferative activity, oxazolo[4,5-*b*]pyridines, structural characterization

Acknowledgement: The Croatian Science Foundation funded this work within the project BenzHetPot (IP-2024-05-7208).



R_1 = H, F, Br, CN, NO_2
R_2 = H, Br

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EFFECT OF pH VALUE ON TECHNO-FUNCTIONAL PROPERTIES OF BROAD BEAN PROTEIN IN OLEOGEL PRODUCTION

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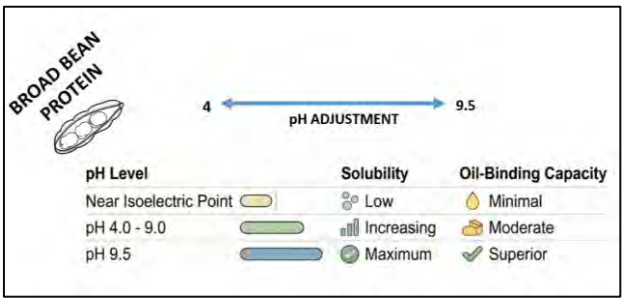
Oleogels are semi-solid systems formulated for the replacement of saturated and trans fats in food products, as a texture improvers or for active compounds formulations. They enhance nutritional quality, but also improve techno-functional properties of food products. This study investigates the impact of pH value on the techno-functional properties of broad bean (*Vicia faba* L.) protein isolates and their subsequent ability to form stable oleogels. Broad bean protein solutions were prepared and adjusted to a wide pH range from 4 to 9.5 to evaluate changes in solubility and water/oil binding capacity. Oleogels were subsequently formulated using palm oil and tested for stability. The results indicated that pH significantly influenced the protein's structural network, with shifts away from the isoelectric point enhancing protein solubility and oil-binding capacity. Oleogels formed at 9.5 exhibited the highest oil-binding capacity and superior techno-functional properties. These findings demonstrate that adjusting pH value is an important parameter in producing plant-based food substitutes.

Keywords: broad bean, techno-functional properties

Acknowledgement: This work has been supported by the Croatian Science Foundation under the project IP-2022-10-1960.



COMPARATIVE ANALYSIS OF PIGMENTS IN DIFFERENT MARINE MACROALGAE

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Macroalgae represent an important group of marine organisms, capable of biosynthesizing various natural compounds, including pigments. In this study, the concentrations of chlorophyll *a*, chlorophyll *b*, fucoxanthin and astaxanthin were analyzed in three different macroalgal species: *Ulva lactuca* (green alga), *Fucus virsoides* (brown alga), and *Asparagopsis taxiformis* (red alga). Pigments were extracted using a methanol:dichloromethane solvent mixture (1:1), followed by ultrasound-assisted extraction and fractionated using the SPE method. Fractions 3 and 4 were analyzed by HPLC-PDA method. Chlorophyll *a* and chlorophyll *b* were most abundant in *Ulva lactuca*, while lower concentrations were observed in *Fucus virsoides* and *Asparagopsis taxiformis*. In contrast, fucoxanthin was most pronounced in *F. virsoides*, whereas *A. taxiformis* showed intermediate values and *U. lactuca* the lowest. Astaxanthin content was highest in *A. taxiformis*, while lower amounts were detected in *F. virsoides* and *U. lactuca*. The obtained results confirm differences in pigment composition among green, brown, and red macroalgae. The presence of chlorophylls, fucoxanthin and astaxanthin highlights the potential of macroalgae as valuable sources of bioactive compounds for applications in the food and pharmaceutical industries.

Keywords: chlorophylls, fucoxanthin, astaxanthin, marine macroalgae, HPLC

Acknowledgment: This work was funded by the Croatian Government and the European Union, through the European Regional Development Fund—the Competitiveness and Cohesion Operational Program (KK.01.1.1.01), for funding this research through the project Sustainable Bioprospecting of Organisms from the Adriatic Sea for Innovative Natural Products (KK.1.1.10.0001)—BioProCro, granted to the Center of Research Excellence for Marine Bioprospecting.

KEMIJSKI KONTAMINANTI U KUHINJI: RIZICI, MIGRACIJA I NAVIKE POTROŠAČA
CHEMICAL CONTAMINANTS IN KITCHENWARE AND CONSUMER HABITS IN THE USE OF FOOD-CONTACT MATERIALS

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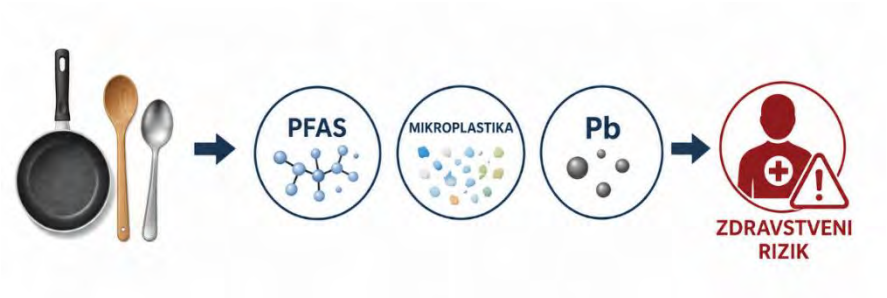
U kuhinjskom okruženju svakodnevno se primjenjuju različiti materijali, posuđe, pribor i ambalaža koji dolaze u neposredan kontakt s hranom te mogu predstavljati potencijalni izvor kemijskih kontaminanata. U radu su razmotreni teški metali, PFAS spojevi, mikroplastika, bisfenoli, ftalati i drugi spojevi koji pod utjecajem uvjeta uporabe mogu migrirati u hranu i time utjecati na zdravlje potrošača. Uz teorijski pregled migracijskih mehanizama, zdravstvenih rizika i preventivnih mjera, provedeno je anketno istraživanje na 50 ispitanika radi utvrđivanja njihovih navika, informiranosti i stavova. Dobiveni rezultati pokazuju da su ispitanici bolje upoznati s mikroplastikom i teškim metalima nego s ostalim navedenim kontaminantima, što potvrđuje važnost daljnje edukacije i promicanja sigurnijih materijala za kontakt s hranom.

Ključne riječi: kemijski kontaminanti, kuhinjsko posuđe, navike potrošača, zdravstveni rizici



INDUSTRIAL APPLICATION OF MASS SPECTROMETRY FOR THE VALORIZATION OF AGRI-FOOD AND FORESTRY BY-PRODUCTS

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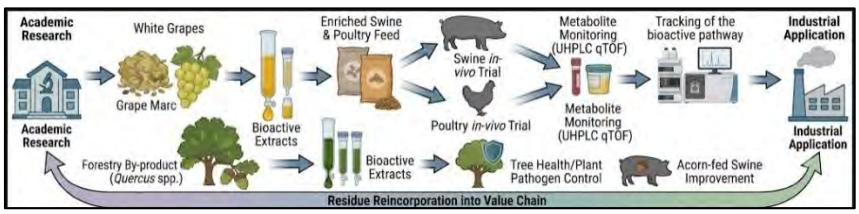
High-resolution mass spectrometry (HR-MS)-based metabolomics, although well established as a highly impactful analytical tool in academic research, has gained increasing relevance in the industrial sector, experiencing exponential growth in its application over recent years. Its ability to provide detailed structural information on chemical compounds enables process optimization, quality control, and the development of innovative solutions across various industries, particularly in the agri-food sector [1]. Furthermore, the integration of artificial intelligence and machine learning has significantly streamlined the processing of large metabolomic datasets and the identification of biomarkers [2]. In this context, this work presents several industrial applications of HR-MS, including metabolomic studies combined with supervised and unsupervised machine learning models, using ultra-high-performance liquid chromatography coupled to quadrupole time-of-flight mass spectrometry (UHPLC-QTOF-MS) for the analysis of agro-industrial matrices. Within the framework of agri-food by-product valorization, the objective is to reincorporate these residues into the value chain by exploiting their remaining bioactive compounds. As a case study, the enrichment of swine and poultry feed with a phenolic-rich extract obtained from grape marc is investigated. A metabolomic workflow is applied to monitor the fate of these bioactive compounds from ingestion to their bioconversion during *in vivo* trials, evaluating multiple biological matrices. Additionally, the phytochemical profiling of *Quercus spp.* acorn extracts is presented, assessing different operational extraction parameters aimed at enhancing the recovery of specific bioactive compounds with potential applications in the control of plant pathogens.

Keywords: grape marc, acorns, metabolomics, phenolic compounds, product development



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PHENOLIC COMPOUNDS IN SPRAY-DRIED BERRY LEAF POWDERS: IMPACT OF CARRIER AGENTS ON *IN VITRO* BIOAVAILABILITY

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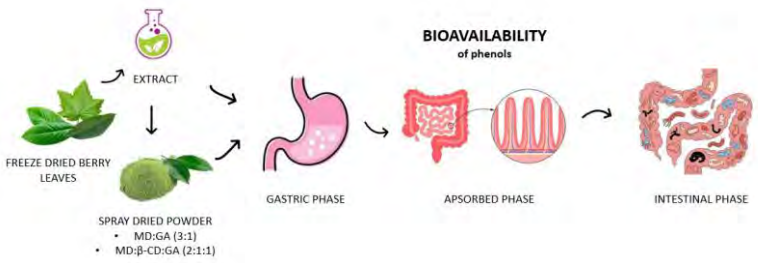
Berry fruit leaves are often considered waste and by-products, despite being a rich source of polyphenols with significant antioxidant and health-promoting properties. Due to their sensitivity to environmental conditions, stabilization is required to preserve their biological activity. Spray drying, combined with different carrier agents, represents an effective approach for protecting these compounds. Therefore, the aim of this study was to evaluate the influence of different carrier combinations (MD:GA and MD:β-CD:GA) during spray drying on the bioavailability of phenolic compounds from blackcurrant, redcurrant, blueberry, and chokeberry leaves, and to compare their bioavailability with that of the corresponding extracts. The highest phenolic content was observed in the initial stages of digestion in both extracts and powders. Depending on the sample, 20–93% of phenolic compounds were available during the gastric phase, 1.60–4.65% were absorbed through the small intestine, and 13.90–64% remained available for the colonic microbiota. No substantial differences were observed between the carrier combinations regarding phenolic compound bioavailability. Blueberry leaves exhibited the highest phenolic content and the greatest bioavailability. The results indicate that spray drying effectively preserves phenolic compounds and enables their controlled release during digestion.

Keywords: berry fruit leaves, bioavailability, phenols, spray drying



SHAPE DESCRIPTORS OF EGGSHELL PIECES AFTER EGG MEMBRANE EXTRACTION

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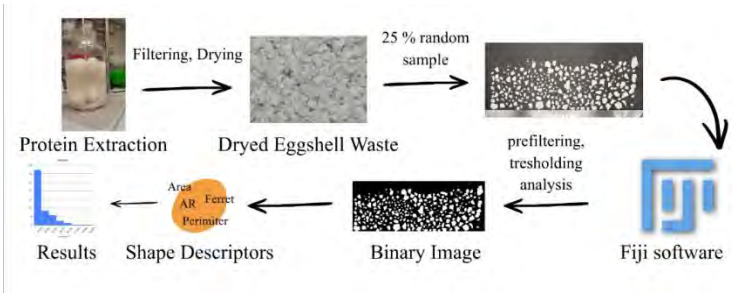
Eggshells are highly valuable byproduct in food industry which can be reused in many ways [1]. In general, it comes from industry in form of halves after egg braking and separation egg white and egg yolk from shell. Aim of this research is to determine size distribution and shape of eggshell particles after 60 minutes hydrodynamical extraction of egg inner membrane in three different weight to weight ratio, water to eggshell: 1:5, 1:10 and 1:15 with constant mixing speed and same mixing body (four blade metal impeller), in order to find optimal filter dimension for separation of eggshells and membranes from water solution. Size and shape descriptors are determined by image analysis from digital images obtained after photographing 25 % of randomized eggshells particles from whole sample. Image analysis was performed by open-source Fiji software [2] and measured parameters (descriptors) are number of eggshell particles, area [mm^2], perimeter [mm], Ferret diameter [mm], minimal Ferret diameter [mm], aspect ratio, roundness and solidity.

Keywords: egg shell waste, image analysis, particle size, Fiji



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INFLUENCE OF ULTRASOUND-ASSISTED EXTRACTION ON PHENOLIC COMPOUND RECOVERY FROM SELECTED MACROALGAE SPECIES

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Marine macroalgae are increasingly recognised as sustainable resources and are widely regarded as foods of the future due to their rich nutritional profiles and abundance of bioactive compounds. Consequently, considerable attention has been devoted to developing efficient extraction techniques for the recovery of valuable phytochemicals, such as phenolic compounds. In this study, phenolic compounds were extracted from three macroalgal species (*Ulva lactuca*, *Corallina elongata*, and *Halopteris scoparia*) using high-power ultrasound-assisted extraction (UAE). UAE parameters included extraction times of 4, 6, and 8 min, ethanol concentrations of 0, 20, and 40%, and ultrasound amplitudes of 60, 80, and 100%. Obtained extracts were analysed for total phenolic content (TPC) and the resulting data were statistically analysed. Considerable differences in TPC were observed among the macroalgae studied. The highest TPC values were recorded in *H. scoparia* extracts (20.89 ± 0.63 to 27.72 ± 0.63 mg GAE/g $_{d.m.}$), followed by *U. lactuca* (0.68 ± 0.02 to 8.64 ± 0.35 mg GAE/g $_{d.m.}$), while *C. elongata* exhibited the lowest phenolic yields (0.41 ± 0.01 to 1.28 ± 0.08 mg GAE/g $_{d.m.}$). No statistically significant effects of the UAE parameters on TPC were observed in *H. scoparia* extracts. Conversely, ethanol concentration and extraction time had a statistically significant effect on TPC in *U. lactuca* extracts, while a statistically significant effect of mutual interaction was observed in *C. elongata* extracts. These results highlight substantial differences in phenolic recovery among green, red, and brown macroalgae. Therefore, direct comparisons of TPC between these macroalgae should be interpreted with caution due to their different chemical compositions. Nevertheless, such comparisons provide valuable insights into the selection of suitable macroalgal biomass for the recovery of specific bioactive compounds.

Keywords: ultrasound-assisted extraction, total phenolic content, *Ulva lactuca, Corallina elongata, Halopteris scoparia*

TRADITIONAL APPLE CULTIVARS: A PROMISING RESOURCE FOR BY-PRODUCT VALORIZATION

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The growing interest in sustainable food production has underscored the importance of agro-industrial by-product valorisation as a source of valuable bioactive compounds. Because the composition of apple processing by-products depends on the fruit's chemical composition, characterising apple cultivars is essential for identifying raw materials with high valorisation potential. Therefore, this study compared three traditional (´Winter Banana´, ´Bobovec´, and ´Božićnica´) and three commercial (´Jonagold´, ´Idared´, and ´Golden Delicious´) apple cultivars for their chemical composition and bioactive properties. The results showed that the traditional apple cultivar ´Božićnica´ exhibited the highest total polyphenol content (857.98 ± 11.30 mg/L), total flavonoid content (572.47 ± 12.45 g CE/kg), and antioxidant activity. Polyphenol profiling revealed chlorogenic acid, procyanidin B1, procyanidin B2, catechin, and epicatechin as the predominant compounds in traditional apple cultivars, whereas quercetin and pelargonidin-3-glucoside predominated in commercial cultivars. These findings highlight the potential of traditional apple cultivars as a source of bioactive compounds and provide a basis for the valorisation of apple processing by-products within a circular bioeconomy.

Keywords: traditional apple cultivars, bioactive compounds, by-products, polyphenols

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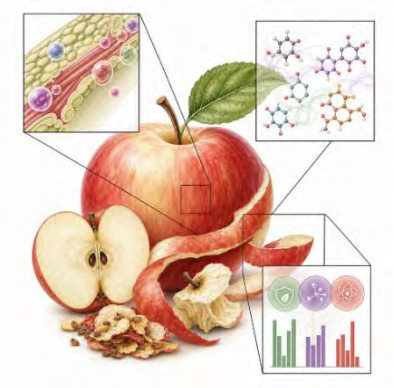

ANTIMICROBIAL ACTIVITY OF EXTRACTS OBTAINED FROM SELECTED FRUIT AND VEGETABLE PROCESSING BYPRODUCTS

Karla Hanousek Čiča, Ena Cegledi, Ana Martić, Josipa Dukić, Damir Stanzer, Jasna Mrvčić, Ivona Elez Garofulić, Maja Repajić

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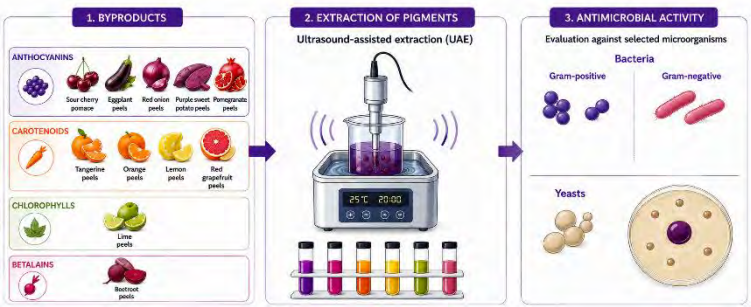
Processing of fruits, vegetables, cereals, and other agricultural raw materials generates significant quantities of byproducts, which are often discarded as waste. In recent years, increased environmental awareness and the growing adoption of circular economy principles have stimulated interest in the valorization of agro-food by-products as sustainable and renewable sources of valuable bioactive compounds, including polyphenols, pigments, dietary fibers, and other functional biomolecules. Their effective utilization contributes not only to waste reduction and environmental protection but also to the development of innovative, value-added bio-based products. Therefore, the present study aimed to evaluate the antimicrobial activity of pigment-rich extracts from selected fruit and vegetable processing by-products against selected Gram-positive and Gram-negative bacteria, and yeasts, specifically sour cherry pomace and the peels of eggplant, red onion, purple sweet potato, beetroot, pomegranate, tangerine, orange, lemon, grapefruit, and lime. The results showed that the red onion extract had the highest antimicrobial potential among the tested extracts, inhibiting the growth of almost all tested microorganisms at a concentration of 100 mg/mL. Pomegranate and lime extracts also showed antimicrobial potential against selected microorganisms.

Keywords: antimicrobial activity, extract, fruit and vegetable by-products, pigments



OPTIMIZATION OF THE CONDITIONS FOR MICROBIAL FERMENTATION OF BLACK CHOKEBERRY (*Aronia melanocarpa* L.) POMACE

Karla Hanousek Čiča, Ena Cegledi, Damir Stanzer, Jasna Mrvčić, Maja Repajić, Verica Dragović-Uzelac, Ivona Elez Garofulić

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Interest in the valorization of fruit processing by-products as sources of bioactive compounds has increased significantly in recent years. Black chokeberry pomace possesses considerable bioactive potential and health-promoting properties, making it a promising raw material for functional food applications. Microbial fermentation has emerged as a cost-effective, environmentally friendly, and low-toxicity method for modifying pomace composition and enhancing the content of compounds responsible for its biological activity. The aim of this study was to optimize the fermentation conditions of black chokeberry pomace. A full factorial experimental design was used to evaluate the effects of microorganism type (*Lactiplantibacillus plantarum*, *Candida utilis*, and their combination), glucose supplementation as a carbon source, yeast extract supplementation as a nitrogen source, and the addition of pectinolytic enzymes. The effects of these factors were assessed through the determination of total phenolic content (TPC), total anthocyanin content (TAC), antioxidant activity (FRAP and ABTS assays), and selected physicochemical properties. The best results were obtained after 24 hours of fermentation with *Lactiplantibacillus plantarum* in the presence of yeast extract. This treatment produced the highest increases in TPC, TAC, and antioxidant activity, confirming fermentation as an effective strategy for enhancing the value of black chokeberry pomace.

Keywords: black chokeberry pomace, fermentation, lactic acid bacteria, yeast, phenolic compounds

Acknowledgement: This research was funded by the Croatian Science Foundation project, grant number IP-2022-10-5499.

ULTRASOUND-ASSISTED EXTRACTION OF POLYPHENOLS FROM CHOKEBERRY POMACE

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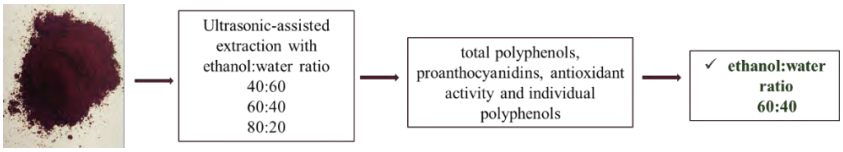
Chokeberry (*Aronia melanocarpa*) pomace, a by-product of juice production, is a valuable but underutilised source of polyphenols, which are recognised for their significant health benefits, particularly antioxidative and anti-inflammatory properties. It therefore represents a good baseline material for the preparation of upcycled foods. The aim of this research was to extract polyphenols from chokeberry pomace by ultrasonic extraction using three solvent mixtures. Ethanol and water were used in ethanol:water (E:W) ratios of 40:60, 60:40 and 80:20. The obtained extracts were evaluated for total polyphenols, proanthocyanidins and antioxidant activity (DPPH, ABTS, FRAP and CUPRAC) using spectrophotometric methods. Individual polyphenols were determined by HPLC. Comparing all three solvent variations, the best results for total polyphenols, proanthocyanidins and antioxidant activity were achieved with an E:W ratio of 60:40, followed by 40:60, while the lowest values were obtained with 80:20. Cyanidin-3-galactoside, cyanidin-3-arabinoside, neochlorogenic acid, chlorogenic acid, quercetin-3-rutinoside, quercetin-3-galactoside, quercetin-3-glucoside, catechin, epicatechin and procyanidin B1 were identified in the extracts by HPLC. A different trend was observed for the concentrations of individual polyphenols. For all phenolics, the highest concentration was found in the extract obtained with an E:W ratio of 60:40. For cyanidin-3-galactoside, cyanidin-3-arabinoside, quercetin-3-rutinoside, catechin, epicatechin and procyanidin B1, the second-best ratio was 40:60, while for the others it was 80:20. The results of this research showed that the choice of extraction method and solvents plays an important part in determining the final polyphenol profile, as polyphenols differ in their structure and properties.

Keywords: chokeberry pomace, polyphenols, ultrasonic extraction, solvents

Acknowledgements: This research was conducted as part of the project „From food industry by-products to new functional products (NUS-PRO-FUN, 581-UNIOS-94)" funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).



USPOREDNA ANALIZA TERMIČKE I OKSIDACIJSKE STABILNOSTI EKSTRA DJEVIČANSKOG ULJA MASLINE (*Olea europaea*), BUČE (*Cucurbita pepo*) I KONOPLJE (*Cannabis sativa*) U UVJETIMA SIMULIRANOG DUBOKOG PRŽENJA
COMPARATIVE ANALYSIS OF THERMAL AND OXIDATIVE STABILITY IN EXTRA VIRGIN OLIVE (*Olea europaea*), PUMPKIN SEED (*Cucurbita pepo*), AND HEMP SEED (*Cannabis sativa*) OILS UNDER SIMULATED DEEP-FRYING CONDITIONS

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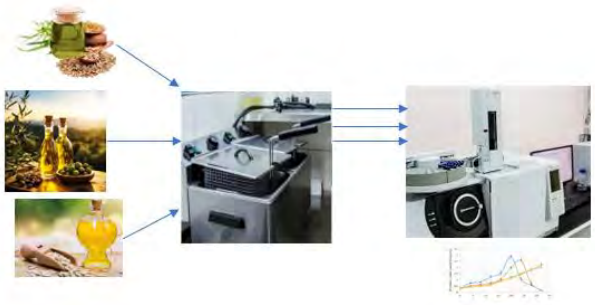
Ovo istraživanje procjenjuje termičku i oksidacijsku stabilnost ekstra djevičanskog maslinovog ulja (Olea europaea), ulja bučinih sjemenki (Cucurbita pepo) i ulja konopljinih sjemenki (Cannabis sativa) podvrgnutih temperaturama simuliranog dubokog prženja (od 175 °C do 190 °C). Parametri stabilnosti — uključujući profile masnih kiselina, peroksidni broj, p-anisidinski broj i slobodne masne kiseline — kvantificirani su prije i nakon termičke obrade. Rezultati pokazuju da extra djevičansko maslinovo ulje zadržava dobru oksidacijsku stabilnost. Nasuprot tome, ulja buče i konoplje pokazuju nižu oksidacijsku stabilnost pri ovim povišenim temperaturama, što je vjerojatno uzrokovano brzom termičkom degradacijom njihovih antioksidativnih svojstava. Pokazalo se da je extra djevičansko maslinovo ulje iznimno prikladno za kulinarske primjene na visokim temperaturama, dok su ulja buče i konoplje neprikladna za duboko prženje te ih je bolje koristiti kao nezagrijana ulja za završnu obradu ili začinjavanje jela.

Ključne riječi: oksidativna stabilnost, ekstra djevičansko maslinovo ulje, ulje bundevinih sjemenki, ulje konopljinih sjemenki, duboko prženje



EFFECT OF BLACK CHOKEBERRY POMACE ON ICE CREAM ANTIOXIDANT PROPERTIES AND COLOR

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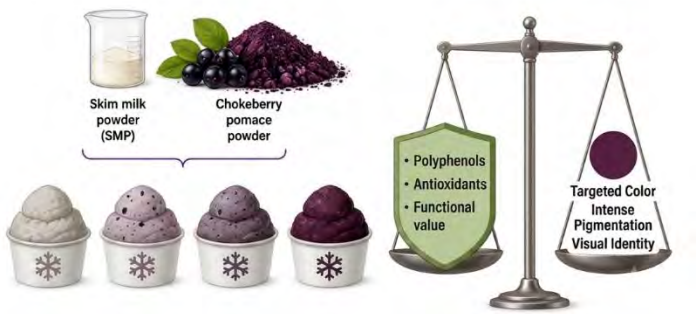
Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia

Black chokeberry (*Aronia melanocarpa*) pomace is a juice industry by-product rich in dietary fiber, polyphenols, and other bioactive compounds, with strong potential for enriching various food products, including dairy. This study examined ice cream enrichment by replacing skim milk powder (SMP) with black chokeberry pomace powder at levels of 50%, 75%, and 100%. Total phenolic content (Folin–Ciocalteu), antioxidant capacity (DPPH, ABTS, FRAP assay), and CIELAB color properties were evaluated immediately after production. Replacing SMP with black chokeberry powder significantly increased total polyphenol content, from 0.198 mg GAE/g for the control sample to 0.575 mg GAE/g for the sample with 100% replacement. Antioxidant activity increased accordingly across all methods, confirming the presence of bioactive compounds in the pomace. This replacement also altered color properties: lightness (L^*) decreased markedly from 90.80 in the control sample to 38.89 in the sample with the highest black chokeberry concentration, while redness (a^*) increased. In conclusion, black chokeberry pomace successfully enhanced the antioxidant activity of ice cream, indicating its potential as a functional ingredient; however, further studies are needed to assess the sensory acceptability of this innovative dairy product.

Keywords: ice cream, black chokeberry pomace, antioxidant potential, color

Acknowledgment: This work was supported by the European Union – NextGenerationEU under the project "Application of Plant-Based Ingredients in the Development of Low-Carbon Functional Food Products Based on the Principles of Transformative Bioeconomy – MultiFunFood (581-UNIOS-95)".

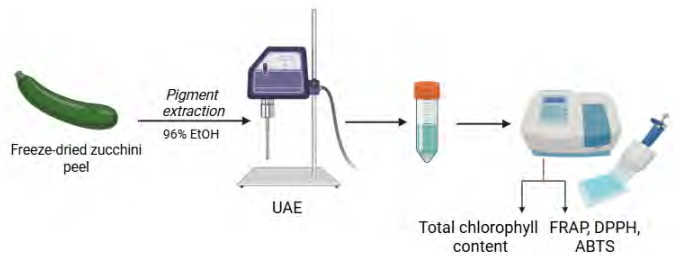


OPTIMIZATION OF ULTRASOUND-ASSISTED EXTRACTION CONDITIONS FOR ENHANCED CHLOROPHYLL RECOVERY AND ANTIOXIDANT CAPACITY FROM ZUCCHINI PEEL

Ana Martić, Ena Cegledi, Barbara Solomun, Augustina Bukvić, Verica Dragović-Uzelac, Ivona Elez Garofulić, Maja Repajić
University of Zagreb Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000 Zagreb, Croatia

Large quantities of fruit and vegetable by-products are generated during food processing, although they represent a valuable source of bioactive compounds. Chlorophylls are natural pigments with notable antioxidant properties. Therefore, the aim of this study was to optimize ultrasound-assisted extraction (UAE) of chlorophylls from zucchini peel using 96% ethanol. For this purpose, ultrasound amplitude (50 and 100 %), extraction time (5, 10, and 15 min) and solid-to-solvent ratio (SSR) (1:20, 1:40, and 1:60 g/mL) were varied. The obtained extracts were analyzed for total chlorophyll content (TCC) and antioxidant capacity using FRAP, ABTS, and DPPH assays. Ultrasound amplitude was identified as the most influential extraction parameter. Increasing the amplitude from 50 to 100 % significantly increased TCC from 97.4 to 310.8 mg/100 g d.w., FRAP values from 475.2 to 1539.9 µmol/100 g d.w., and ABTS values from 324.6 to 500.8 µmol/100 g d.w. In contrast, DPPH values decreased from 438.8 to 251.0 µmol/100 g d.w. Extraction time had no significant effect on any of the analyzed responses, despite a numerical increase in all measured parameters. The SSR significantly affected antioxidant capacity, with ABTS increasing from 245.7 to 592.8 µmol/100 g d.w. and DPPH from 206.5 to 499.5 µmol/100 g d.w. as the ratio increased from 1:20 to 1:60, whereas no statistically significant effect of the ratio was observed on total chlorophyll content or FRAP values. Overall, ultrasound amplitude was the key factor for maximizing chlorophyll recovery and antioxidant capacity (as determined by the FRAP and ABTS assays), while a higher SSR enhanced radical scavenging activity. These findings demonstrate the potential of zucchini peel as a sustainable source of chlorophyll-rich extracts with antioxidant properties.

Keywords: Cucurbita pepo L. peel, UAE, chlorophylls, by-product valorization



VALORIZATION OF BLACKCURRANT POMACE AFTER SUPERCRITICAL CO_2 EXTRACTION: PHENOLIC CONTENT AND ANTIOXIDANT CAPACITY

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Blackcurrant pomace (BP), a major by-product of juice processing, is a valuable source of bioactive compounds, particularly phenolic compounds with strong antioxidant potential, making its valorization increasingly important in sustainable processing and circular economy approaches. The aim of this study was to evaluate the total phenolic content (TPC) and antioxidant capacity (DPPH and ABTS) of BP remaining after supercritical CO_2 lipophilic fraction extraction (SC-CO_2) conducted at various temperatures (40, 50, and 60 °C), pressures (200, 300, and 400 bar), and CO_2 flow rates (30 and 40 g/min). The results showed that temperature significantly affected TPC, with the highest value obtained at 50 °C (40.03 mg/g dw), compared to 40 °C (31.39 mg/g dw) and 60 °C (31.91 mg/g dw). However, no significant effect of temperature was observed on DPPH or ABTS activity. Pressure did not significantly affect any of the analyzed responses. CO_2 flow rate significantly influenced ABTS values, with higher activity expressed at 30 g/min (452.85 µmol/g dw) compared to 40 g/min (379.54 µmol/g dw), while no significant effects were observed for TPC and DPPH. Considering all variables, the optimal supercritical CO_2 extraction conditions for the maximum recovery of phenolic compounds from BP residue were identified as 50 °C, 200 bar and 30 g/min. Under these conditions, SC-CO_2 treated BP showed significantly higher TPC (43.37 vs. 28.89 mg/g dw) and ABTS activity (548.86 vs. 290.08 µmol/g dw) compared to untreated BP, while DPPH activity showed no significant difference. These results demonstrate that BP after supercritical CO_2 extraction remains a rich source of phenolic compounds with considerable antioxidant potential.

Keywords: Ribes nigrum L. Pomace, supercritical CO_2 extraction, total phenolic content, antioxidant activity, by-product valorization

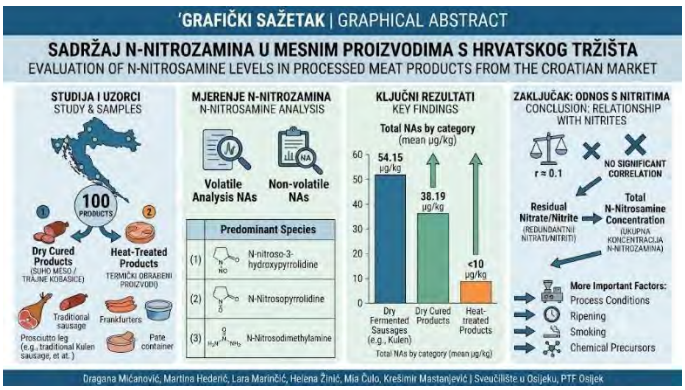
EVALUATION OF *N*-NITROSAMINE LEVELS IN PROCESSED MEAT PRODUCTS FROM THE CROATIAN MARKET

Dragana Mićanović, Martina Hederić, Lara Marinčić, Helena Žinić, Mia Čulo, Krešimir Mastanjević

Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia

This study investigates the occurrence and concentration of volatile and non-volatile *N*-nitrosamines (NAs) in 100 meat products collected from the Croatian market. The analyzed samples were classified into dry cured meat products and heat treated meat products. The results demonstrated significant differences in nitrosamine concentrations among product categories. The highest total nitrosamine levels were detected in dry fermented sausages (mean 54.15 μg/kg), followed by dry cured meat products (mean 38.19 μg/kg), whereas heat-treated products contained considerably lower concentrations (<10 μg/kg). The predominant nitrosamine species identified were *N*-nitroso-3-hydroxypyrrolidine, *N*-Nitrosopyrrolidine and *N*-Nitrosodimethylamine. Furthermore, no significant correlation was observed between residual nitrate/nitrite levels and total nitrosamine concentration (r \approx 0.1), indicating that technological factors such as processing conditions, ripening, smoking, and the presence of chemical precursors may play a more important role in nitrosamine formation than residual curing additives alone.

Keywords: *N*-nitrosamines, dry cured meat products, heat treated meat products



STABILIZACIJA DJEVIČANSKOG I HLADNO PREŠANOG BUČINOG ULJA S ANTIOKSIDANSIMA
STABILIZATION OF VIRGIN AND COLD-PRESSED PUMPKIN SEED OIL WITH ANTIOXIDANTS

Tihomir Moslavac[1], Drago Šubarić[1], Krunoslav Aladić[1], Karlo Dudaš[2], Vlatka Iživkić[1], Martina Marijanović[1], Daniela Paulik[1], Antun Jozinović[1]

[1]Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek, Franje Kuhača 18, 31000 Osijek, Hrvatska

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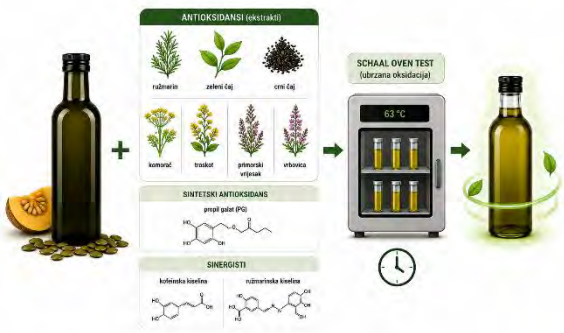
Zadatak istraživanja ovog rada bio je ispitati utjecaj dodatka prirodnih antioksidanasa (ekstrakt ružmarina, ekstrakt zelenog čaja, ekstrakt crnog čaja, ekstrakt komorača, ekstrakti čajne prašine primorskog vrijeska, troskota i vrbovice), sintetskog antioksidansa (propil galat) i sinergista (kofeinska kiselina, ružmarinska kiselina) na oksidacijsku stabilnost djevičanskog bučinog ulja i hladno prešanog bučinog ulja. Oksidacijska stabilnost ispitivanih bučinih ulja, sa i bez dodanog antioksidansa i sinergista, provedena je primjenom testa ubrzane oksidacije (Schaal Oven test). Rezultati ispitivanja promjene stabilnosti ulja prikazani su vrijednostima peroksidnog broja tijekom određenog vremena držanja ulja u termostatu pri konstantnoj temperaturi 63 °C. Rezultati istraživanja pokazuju da dodani antioksidansi efikasno štite bučino ulje od oksidacijskog kvarenja. Ekstrakt zelenog čaja najbolje štiti djevičansko bučino ulje od oksidacije, a ekstrakt ružmarina (Oxy'Less® CS) više povećava stabilnost hladno prešanog bučinog ulja u odnosu na druge ispitivane antioksidanse. Primjenom sinergista ružmarinska kiselina uz antioksidans dodatno se povećava stabilnost bučinog ulja.

Ključne riječi: bučino ulje, oksidacijska stabilnost, antioksidansi, sinergisti

Zahvala: Ovo istraživanje provedeno je u sklopu projekta „Od nusproizvoda prehrambene industrije do novih funkcionalnih proizvoda" (NUS-PRO-FUN, 581-UNIOS-94) financiranog iz Nacionalnog plana oporavka i otpornosti (financira Europska unija – NextGeneration EU).



PRIMJENA RAZLIČITIH ŠKROBOVA U RAZVOJU INOVATIVNIH SNACK PROIZVODA
APPLICATION OF DIFFERENT STARCHES IN THE DEVELOPMENT OF INNOVATIVE SNACK PRODUCTS

Valentina Obradović, Ivan Lasić, Maja Ergović Ravančić, Svjetlana Škrabal, Veronika Barišić Pavičić

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Molekularna gastronomija temelji se na primjeni znanstvenih principa u razvoju novih tekstura, oblika i senzorskih svojstava hrane, pri čemu hidrokoloidi i škrobovi imaju značajnu ulogu u oblikovanju strukture proizvoda. Cilj ovog rada bio je istražiti utjecaj različitih vrsta škroba i aromatskih dodataka na tehnološka i senzorska svojstva čipsa proizvedenog metodama karakterističnim za molekularnu gastronomiju.

Proizvedeno je ukupno 16 uzoraka korištenjem škroba tapioke, škroba boba, kukuruznog i modificiranog kukuruznog škroba uz dodatke dimljene paprike, curryja i kurkume te cimeta. Proces proizvodnje uključivao je kuhanje škrobne smjese, dehidriranje pri 50 do 60 °C i prženje pri 190 do 210 °C. Uzorci na bazi škroba tapioke imali su najkraće vrijeme sušenja (od 2 h 10 min do 2 h 20 min), stvarali su prozirne i krhke listove te pokazali jaku ekspanziju tijekom prženja. Čipsevi proizvedeni od škroba boba pokazali su najveću stabilnost i ekspanziju tijekom prženja, posebno u kombinaciji s dimljenom paprikom te curryjem i kurkumom. Proizvodi od modificiranog kukuruznog škroba zahtijevali su najdulje vrijeme sušenja (do 4 h 15 min) te su imali tvrđu strukturu i slabiju ekspanziju. Dodatak cimeta negativno je utjecao na ekspanziju i hrskavost kod svih vrsta škroba.

Senzorska analiza provedena je pomoću 21 panelista, pri čemu su ocjenjivani hrskavost, tekstura, okus, miris, boja i ukupna prihvatljivost proizvoda. Uzorci na bazi škroba tapioke ocijenjeni su kao najhrskaviji i najprozračniji, dok su uzorci od škroba boba ostvarili najbolju ukupnu prihvatljivost zbog izraženijeg okusa i stabilnije teksture. Uzorci s dimljenom paprikom imali su najvišu prihvatljivost arome i okusa, dok su uzorci s dodatkom cimeta pokazali niže ocjene zbog slabije hrskavosti i manje izražene ekspanzije.

Dobiveni rezultati potvrđuju potencijal primjene različitih škrobnih sustava u razvoju inovativnih proizvoda molekularne gastronomije i suvremene ugostiteljske ponude.

Ključne riječi: molekularna gastronomija, škrob, senzorska analiza, čips

GREEN EXTRACTION OF PHENOLIC COMPOUNDS FROM *Matricaria chamomilla* L. HERBAL DUST

Ema Pavičić[1], Valentina Masala[2], Carlo Ignazio Giovanni Tuberoso[2], Krunoslav Aladić[1], Snježana Keleković[1], Stela Jokić[1]

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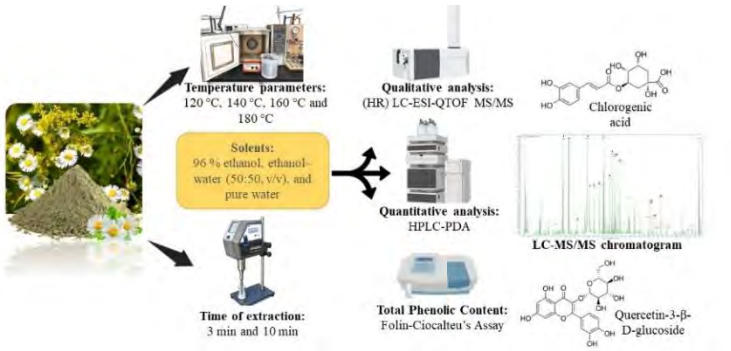
Chamomile (*Matricaria chamomilla* L.) is widely recognised for its rich phytochemical profile and frequent use in herbal infusions. During the industrial processing of dried flowers for tea production, a fine particulate fraction known as herbal dust is generated in considerable quantities. In this study, chamomile herbal dust was investigated as a potential source of phenolic compounds using two green extraction techniques: ultrasound-assisted extraction (UAE) with a sonotrode and subcritical fluid extraction (SBFE). The effects of solvent composition (96% ethanol, ethanol:water 50:50 (v/v), and water), and process conditions (temperature in SBFE: 120, 140, 160 and 180 °C; extraction time in UAE: 3 and 10 min) were evaluated. The total phenolic content (TPC) was determined using the Folin–Ciocalteu method, while individual phenolic profiles were assessed by LC-ESI-QTOF MS/MS and quantified by HPLC-PDA. The highest TPC values were obtained with 50% (v/v) ethanol as solvent with SBFE at 180 °C yielding 2244.05 mg GAE/L. The extracts contained a range of phenolic acids and flavonoids, with chlorogenic acid, protocatechuic acid, trans-ferulic acid, and quercetin-3-β-D-glucoside identified as dominant compounds. The findings confirm that chamomile herbal dust is a valuable biomass for the production of phenolic-rich extracts.

Ključne riječi: chamomile, phenolic compounds, green extraction, herbal by-products

Acknowledgement: This research was conducted as part of the project „From food industry by-products to new functional products (NUS-PRO-FUN, 581-UNIOS-94)" funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).



COMPARISON OF RHEOLOGICAL, TEXTURAL, COLOR, AND SENSORY PROPERTIES OF COMMERCIAL WHITE, MILK, AND DARK CHOCOLATES

Karlo Pirizović, Helena Marčetić, Valentina Obradović, Svjetlana Škrabal, Ante Lončarić, Maja Ergović Ravančić, Josip Mesić, Veronika Barišić Pavičić

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Chocolate quality is determined by the interaction of physical, rheological, and sensory properties, which directly influence consumer acceptance. The most important parameters that determine chocolate quality are rheology, texture, colour, and sensory perception, all contributing to the total impression. The aim of this study was to evaluate and compare the physicochemical and sensory characteristics of fifteen commercial chocolates (white, milk, and dark chocolates), to determine the relationships between instrumental measurements and sensory perception. Fifteen commercially available chocolate samples were analysed, consisting of five white chocolates, five milk chocolates, and five dark chocolates obtained from different manufacturers. Methods used included rheological behaviour, textural properties, and colour measurements, followed by sensory evaluation by a sensory panel. Rheological properties were determined using rotational rheometry, while textural properties were evaluated using texture profile analysis (TPA), where hardness was determined. Colour analysis was performed using the CIELAB colour system to determine visual differences between chocolates. Sensory evaluation was conducted by a sensory panel based on appearance, aroma, sweetness, bitterness, texture, melting behaviour, and overall acceptability. Each attribute was scored using a structured hedonic scale, and the sensory data were statistically compared with instrumental results to identify correlations. The results showed significant differences among white, milk, and dark chocolates in all analysed parameters. White chocolates exhibited the highest lightness values (L*) compared to milk and dark chocolates. Hardness showed mixed results depending on chocolate type and thickness. Significant differences in rheological parameters were also observed between chocolate types. Positive correlations were found between instrumental hardness and perceived firmness, as well as between viscosity and mouthfeel perception. Colour parameters also showed an impact on sensory preference.

Ključne riječi: chocolate, texture, rheology, colour, sensory analysis

SEED PRIMING AS A SUSTAINABLE APPROACH FOR IMPROVING PEPPER (*Capsicum annuum* L. cv. Podravka) GROWTH UNDER ABIOTIC STRESS

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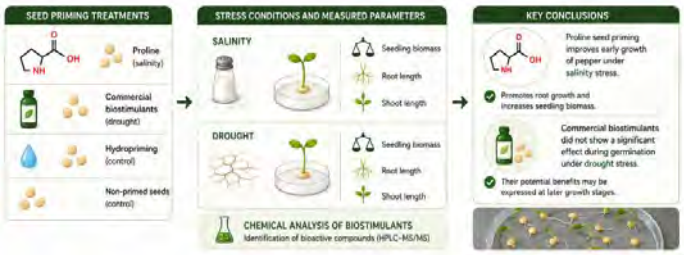
Climate change is increasing the frequency of abiotic stresses, adversely affecting seed germination and early plant development. Seed priming is an environmentally friendly pre-sowing technique that activates metabolic processes prior to germination and can enhance plant tolerance to adverse environmental conditions. The aim of this study was to evaluate the effect of seed priming on the early development of pepper (*Capsicum annuum* L. cv. Podravka) under salinity and drought stress. The effect of proline seed priming was evaluated under salinity stress, while several commercial biostimulants were tested as priming agents under drought stress. Seedling biomass, root length and shoot length were assessed, and the chemical composition of the tested biostimulants was characterized. Proline seed priming positively affected seedling development under salinity stress by promoting root growth and increasing seedling biomass compared with untreated seeds and hydropriming. In contrast, the commercial biostimulants did not show a significant effect on seedling performance during germination under drought stress, although their beneficial effects may become apparent during later stages of plant development. Chemical analysis revealed that the investigated biostimulants contained polyamines and phenolic acids, compounds known to play important roles in plant responses to abiotic stress. The obtained results confirm the potential of proline seed priming to improve the early development of pepper under salinity stress and highlight the need for further research on the application of commercial biostimulants and their mechanisms of action.

Keywords: seed priming, pepper, proline, biostimulants



EFFECT OF ACID HYDROLYSIS CONDITIONS ON ISOFLAVONE AGLYCONE FORMATION IN SOYBEAN (*GLYCINE MAX* L. MERRILL)

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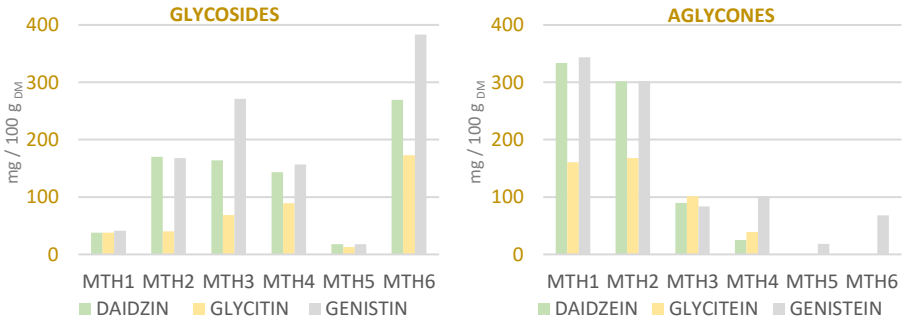
Soybean (Glycine max L. Merrill) is one of the most important legumes worldwide, recognized for its high nutritional value and bioactive isoflavones. In soybeans, isoflavones predominantly occur as β-glycosides, which can be hydrolyzed into biologically active aglycones with enhanced bioavailability and health–promoting properties. The aim of this study was to evaluate isoflavone profiles in five yellow soybean samples during the conversion of glycosides to aglycones under different acid hydrolysis conditions and to compare them with profiles obtained using a modified AOAC 2001.10 method based on alkaline hydrolysis. Ground soybean samples were extracted with 80% aqueous methanol containing HCl at final concentrations of 2.0, 1.0, 0.3, 0.2, and 0.1 M (MTH1–MTH5). MTH6 represented the modified AOAC method using 2 M NaOH. Individual isoflavones were determined by HPLC and quantified using external calibration curves. The highest aglycone concentrations were obtained with 2 M HCl, reaching 333.49 mg/100 g DM for daidzein and 343.42 mg/100 g DM for genistein, while the highest glycitein concentration (167.93 mg/100 g DM) was observed with 1 M HCl. Hydrolysis efficiency decreased with decreasing acid concentration. In contrast, the AOAC procedure yielded the highest concentrations of glycosides, with daidzin, glycitin, and genistin reaching 269.63, 173.01, and 383.46 mg/100 g DM, respectively. Strong acid hydrolysis promoted glycoside conversion to aglycones, whereas alkaline hydrolysis retained a higher proportion of glycoside forms.

Keywords: soybean, hydrolysis, extraction, isoflavones, HPLC

Acknowledgment: This research was funded by the National Recovery and Resilience Plan 2021–2026 and the European Union–NextGenerationEU through the project "Legumes as a Source of Biologically Active Phytochemicals (LEGOFIT)" (541/23-207).



OLEOGELS BASED ON CELLULOSE MICROFIBRILS FROM COCOA BEAN SHELL

Dario Šarić, Ivona Fogadić, Lara Ivanac, Karla Ivandić, Daniela Paulik, Antun Jozinović, Jurislav Babić, Drago Šubarić, Đurđica Ačkar
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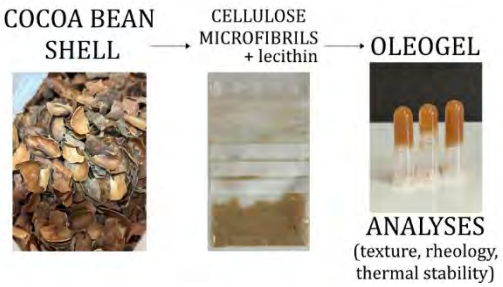
Widespread use of fats rich in trans and saturated fatty acids leads to cardiovascular diseases and obesity. Structuring oils into oleogels is a promising strategy for replacing unhealthy fatty acids with unsaturated ones. This study investigated oleogel production based on cellulose microfibrils isolated from the food industry by-product cocoa bean shell. Ground cocoa bean shell was subjected to alkaline and bleaching treatments to remove lignin and hemicellulose. After isolation, the washed cellulose was treated with an ultrasonicator and then lyophilised. The resulting microfibrils were used as oleogelators. Oleogels were produced by an emulsion-templated method. Emulsions composed of sunflower oil with 1%, 2%, and 4% lecithin and a water suspension of microfibrils, were dried and then sheared to form the oleogel structure. Thermal sensitivity of the oleogel structure was determined by incubation for 30 minutes in a water bath at 25, 50, and 70 °C, followed by decanting the supernatant after centrifugation. All oleogels remained thermally stable up to 70 °C, as oil loss did not change significantly with increasing temperature, indicating that the structure did not collapse at higher temperatures. In addition, the linear viscoelastic region (LVR) was not determined within the tested strain range (0.1–100%) (f = 1 Hz), indicating that the limit of the LVR was below 0.1% strain, which suggests that structural changes occur at small strains. Among all samples, the oleogel with the highest lecithin concentration had the highest rupture strength value (97.84 ± 0.31 g), showing that lecithin can improve mechanical properties of oleogels. This study demonstrated the potential of cellulose microfibrils as oleogelators, with lecithin acting as a synergist in strengthening the gel network.

Keywords: cocoa bean shell, cellulose microfibrils, oleogel, lecithin

Acknowledgment: This work was supported by the Croatian Science Foundation under the project number HRZZ-IP-2022-10-1960.



CHEMICAL QUALITY AND MICROBIOLOGICAL COMPLIANCE OF BUTTER AVAILABLE ON THE CROATIAN MARKET

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Butter is a traditional dairy product of considerable nutritional value, making regular monitoring of its chemical quality and microbiological safety essential. The aim of this study was to evaluate the chemical and microbiological quality indicators of five butter samples produced by different manufacturers and available on the Croatian market. The samples were stored at 4 °C and analyzed using standard methods. Chemical analyses included the determination of water, milk fat, and non-fat dry matter content, while microbiological analyses assessed the presence of *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli*, coagulase-positive staphylococci, yeasts, and molds. The results showed that all samples complied with the legal requirements for butter. Milk fat content ranged from 82% to 85%, water content ranged from 13% to 16%, and non-fat dry matter content ranged from 1% to 2%, with four samples containing 2% and one sample containing 1% non-fat dry matter. No pathogenic bacteria were detected, and the counts of other microorganisms were within the permitted limits. All analyzed samples were found to be microbiologically safe and suitable for human consumption.

Keywords: butter, chemical quality, microbiological safety, food safety, quality assessment

BIPHASIC DEEP EUTECTIC SOLVENTS FOR ONE-STEP EXTRACTION AND FRACTIONATION OF MICROALGAL BIOACTIVE COMPOUNDS

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Microalgae are increasingly recognized as sustainable sources of proteins, pigments and other high-value bioactive compounds for food and nutraceutical applications. [1] However, conventional extraction processes typically require multiple unit operations, including cell disruption, extraction, purification and fractionation, often relying on organic solvents and generating significant waste streams. [2] This work explores biphasic deep eutectic systems (DESs) as a green strategy for the simultaneous pretreatment, extraction, fractionation, and stabilization of microalgal bioactives. The coexistence of hydrophilic and lipophilic phases enables the selective recovery of compounds with different polarities while reducing downstream processing requirements. Several hydrophilic/hydrophobic DES combinations based on betaine, organic acids, sugar alcohols, menthol and fatty acids were evaluated for the extraction of compounds from *Tetraselmis chuii* biomass. Ultrasound-assisted extraction was performed using biomass-to-solvent ratios ranging from 1:20 to 1:100 to assess the influence of solvent composition and extraction conditions on compound partitioning. Among the systems investigated, betaine:malic acid:water/menthol:lauric acid at a biomass-to-solvent ratio of 1:40 showed the most effective protein-pigment fractionation. The biphasic DES promoted selective distribution of compounds according to polarity, yielding a protein-rich hydrophilic fraction with an extract concentration of 2490 ± 650 mg L^{-1}, while chlorophylls were preferentially recovered in the lipophilic phase, with 118.5 ± 9.03 mg L^{-1} chlorophyll *a* and 3.95 ± 0.39 mg L^{-1} chlorophyll *b*. Only minor pigment concentrations were detected in the hydrophilic phase. These results demonstrate the potential of biphasic DES systems to integrate extraction and fractionation within a single processing step. By generating protein-rich and pigment-rich fractions without additional separation procedures, this approach reduces solvent consumption and downstream purification requirements, supporting the development of sustainable microalgal biorefineries and zero-waste biomass valorization strategies. Furthermore, the use of naturally derived DES components may facilitate the direct incorporation of recovered bioactives into food and nutraceutical formulations.

Keywords: Tetraselmis chuii, biphasic DES, microalga, ultrasound-assisted extraction

Acknowledgement: This work was supported by Fundação para a Ciência e a Tecnologia, I.P. through the research project 2024.15940.PEX. The authors also acknowledge FCT/MCTES for financial support to LAQV-REQUIMTE through projects UID/50006/2025, UID/PRR/50006/2025 and LA/P/0008/2020.

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CONSTRAINTS ON STABLE ISOTOPE ANALYSIS OF PARTICULATE ORGANIC MATTER IN A EUTROPHIC MARINE LAKE ZMAJEVO OKO (ROGOZNICA)

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Rajna Marija Jozić, Irena Ciglenečki
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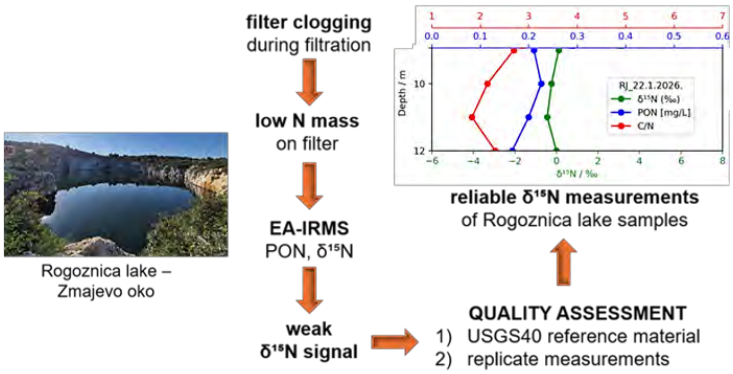
The elemental analyzer–isotope ratio mass spectrometry (EA-IRMS) technique is widely used to determine carbon and nitrogen isotope ratios ($\delta^{13}C$, $\delta^{15}N$) in environmental samples, but its performance is limited for samples with low nitrogen content. This is particularly important for analyses of stable isotope ratio of nitrogen ($\delta^{15}N$) and elemental C/N composition of particulate organic matter (POM) in water samples from strongly stratified eutrophic marine lake with high suspended particulate loads. Elevated POM causes rapid filter clogging, limiting the volume of water that can be processed and resulting in low nitrogen masses and weak ^{15}N signal intensities. To assess the quality of elemental and isotopic analyses under these low-mass conditions, repeated measurements of USGS40 reference material and lake samples (Zmajevo oko), including different pre-analysis treatments, were performed.

Keywords: stable N and C isotopes, EA-IRMS, eutrophic marine lake



DEFINING THE CRITICAL TEMPERATURE FOR POWDER OF PLANTS FROM THE CROATIAN COAST USED IN THE PRODUCTION OF 3D PRINTED FILAMENTS

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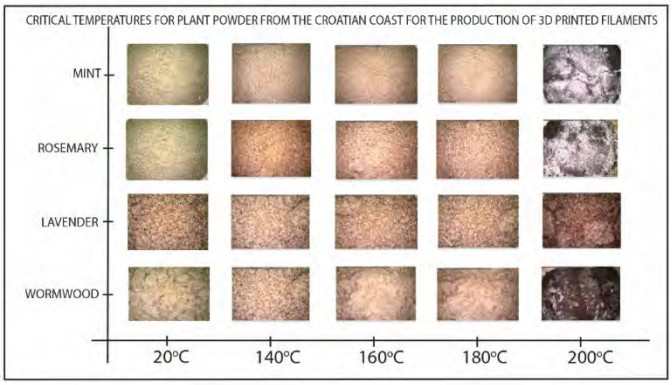
Recently, plants have been increasingly used as a resource for various industries, including additive manufacturing (i.e. 3D printing) due to their natural and biodegradable properties. In order to improve the environmental acceptability of the base material for the filament production, in this study, powder obtained from plants collected on the Croatian coast was analysed as a possible sustainable biofiller. In the extrusion process of filament production and in 3D printing itself, temperature plays a key role for the melting and interlayer adhesion of polymer materials. Thus, the colorimetric grayscale and mass stability of four plant powders (mint, rosemary, lavender and wormwood) were studied at a temperature range from 140 °C to 230 °C. It was observed that for all analysed plant powders, the critical temperature for mass loss was 200 °C, except for lavender, where the critical temperature was 220 °C. The same temperature was critical for colour degradation for all analysed plant powders, with no plant being singled out.

Keywords: critical temperature, filament, plant powder, 3D printing



FROM AGRO-INDUSTRIAL WASTE TO POLYHYDROXYALKANOATES (PHA): SUBMERGED FERMENTATION USING MIXED AND PURE BACTERIAL CULTURES

Dora Bramberger[1],Viktoria Bačić[1], Karlo Grgurević[1], Laura Jaklenec[1], Vesna Ocelić Bulatović[1], Marinko Markić[1], Anja Rakas[1], Lidija Furač[1], Matija Cvetnić[1], Tomislav Bolanča[1], Šime Ukić[1†], Stela Jokić[2], Krunoslav Aladić[2], Ivica Strelec[2], Jasmina Ranilović[3], Dajana Kučić Grgić[1]

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This study investigated the possibility of producing poly(3-hydroxybutyrate) (PHB) or poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) biopolymers from agro-industrial waste using acid hydrolisis and submerged fermentation. A mixture of waste chickpeas, plums, eggplant, peppers and tomatoes was used as the substrate, from which reducing sugars were released by hydrolysis. The obtained hydrolysate was used as a carbon source in fermentation carried out in a bioreactor at 30 °C and pH 6.5 –7.0. A comparison of PHB or PHBV production using pure and mixed bacterial cultures was performed using Pseudomonas putida and the mixture of Cupriavidus necator and Pseudomonas putida. During fermentation, optical density, pH, dissolved oxygen, and reducing sugars concentration were monitored. After fermentation, the biopolymer was isolated and analyzed using the GC-MS method. The mixed culture resulted in a slightly higher extracted compound yield (40.53%) compared to the pure culture of P. putida (39.44%). GC-MS analysis identified the produced biopolymer as copolymer PHBV.

Keywords: polyhydroxyalkanoate, submerged fermentation, agro-industrial waste, *Pseudomonas putida*

Acknowledgement: This research was conducted as part of the project „Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products" (NPOO.C3.2.R3-I1 .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).

AKTIVNI MULJ KAO SIROVINA ZA SINTEZU BIORAZGRADIVIH POLI(HIDROKSIALKANOATA)
ACTIVATED SLUDGE AS A FEEDSTOCK FOR THE SYNTHESIS OF BIODEGRADABLE POLYHYDROXYALKANOATES

Kristina Bule Možar, Anja Rakas, Laura Jaklenec, Dora Bramberger, Luka Večenaj, Lidija Furač, Marinko Markić, Šime Ukić†, Matija Cvetnić, Tomislav Bolanča, Dajana Kučić Grgić

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Aktivni mulj predstavlja zajednicu mikroorganizama sastavljenu od bioloških flokula, odnosno smjese mikroorganizama te organskih i anorganskih čestica nastalih tijekom biološke obrade otpadnih voda. Karakterizacijom aktivnog mulja određena su fizikalna, kemijska i mikrobiološka svojstava, pri čemu su ključni parametri ovog istraživanja bili ukupna koncentracija suspendirane tvari (engl. *Mixed Liquor Suspended Solids*, MLSS) i udio hlapljive suspendirane tvari (engl. *Mixed Liquor Volatile Suspended Solids*, MLVSS). Omjer MLSS-a i MLVSS-a bio je u željenom rasponu između 60 i 80 % na temelju čega je zaključeno da je mulj pogodan za proizvodnju poli(hidroksialkanoata) (PHA). Za proizvodnju PHA-a koriste se hlapive organske kiseline, poput octene, propionske, maslačne i valerijanske kiseline, koje nastaju anaerobnom fermentacijom aktivnog mulja. Proces se odvija u anaerobnim reaktorima pri kontroliranim uvjetima pH-vrijednosti, temperature i vremena zadržavanja, a sastav dobivenih kiselina značajno utječe na svojstva sintetiziranog PHA. Cilj istraživanja bio je optimizirati uređaj za anaerobnu fermentaciju aktivnog mulja, odnosno za proizvodnju hlapivih organskih kiselina koje bi se dalje koristile za proizvodnju PHA.

Ključne riječi: aktivni mulj, MLSS, MLVSS, poli(hidroksialkanoat), hlapive organske kiseline

Zahvala: Ovo istraživanje provedeno je u okviru projekta BioSmart (112101), financiranog sredstvima Europske unije – NextGenerationEU iz izvora 581 – Mehanizam za oporavak i otpornost, u sklopu Programa financiranja javnih visokih učilišta i javnih znanstvenih instituta.

INTEGRACIJA BILJNO – BIOLOŠKIH SUSTAVA U OBRADI PROCJEDNIH VODA S ODLAGALIŠTA OTPADA
INTEGRATION OF PLANT-BASED BIOLOGICAL SYSTEMS IN THE TREATMENT OF LANDFILL LEACHATE

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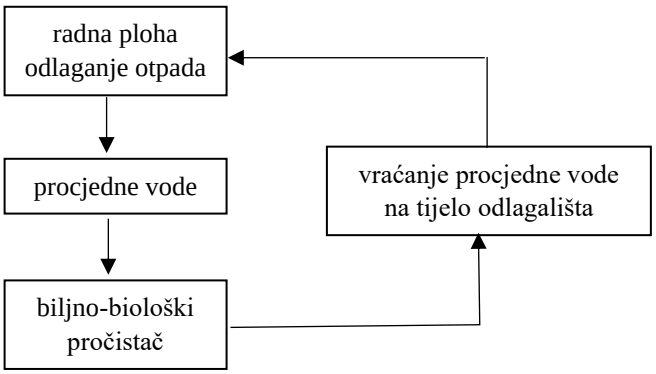
U radu je dan teorijski prikaz osnovnih vrsta otpadnih voda prema mjestu njihova nastanka te najčešćih konvencionalnih metoda pročišćavanja. Posebna pozornost posvećena je biljno-biološkom pročišćavanju kao održivom i ekološki prihvatljivom rješenju, s prednostima kao što su niži troškovi, manja potrošnja energije i dobra uklopljenost u okoliš. Primjena takvog pristupa prikazana je na primjeru pročišćavanja procjednih voda na odlagalištu neopasnog otpada „Goričica“ u blizini grada Siska.

Ključne riječi: procjedne vode, odlagalište otpada, pročišćavanje, biljno-biološki pročistač



MICROPLASTICS IN THE ADRIATIC SEA – DEPENDENCE ON ORGANISM SPECIES, TISSUE AND HABITAT TYPE

Vlatka Filipović Marijić[1], Martina Ugrinović[1], Fabio Faraguna[2], Dajana Kučić Grgić[2], Marija Kuštro[2], Candice Magnouloux[3], Sara Zrinić[2], Helena Stipetić[2], Damir Valić[1]

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Microplastics (MPs) are pervasive and due to their small dimensions (<5 mm) may be ingested by different aquatic organisms, causing physiological damage. Data on the occurence of MPs in the Adriatic Sea are still scarce, so our study compared MPs types and quantity in fish (gilthead seabream, *Sparus aurata*) and bivalves (mussels, *Mytilus galloprovincialis*) from the Šibenik Bay. The dependence on organism (free and sedentary living organism), tissue (digestive tract and gills) and habitat types (wild and farmed) were investigated. In our research we combined few commonly used methodologies (different acids, hydroxides, peroxide) for tissue digestion, followed by vacuum filtration over gold-coated polyester filters with a pore size of 0.8 μm. Isolated MPs were determined by FT-IR microscopy, showing higher abundance in the farmed and sedentary organisms, and in digestive tract than gills of both species. The most common MP types determined were polystyrene, polyethylene, polypropylene, poly(ethylene-co-vinyl acetate). Our study highlighted the importance of the dietary uptake route in organisms and evident exposure to MPs in the Adriatic Sea, indicating importance of further research on MP exposure, accumulation, and potential biological effects.

Keywords: microplastics, fish, bivalves, Adriatic Sea, FT-IR microscopy

Acknowledgement: This research was conducted as part of the Croatian Science Foundation project „Exposure, biological effects and fate of microplastics in aquatic organisms under different anthropogenic impacts (PlastOrgAnoTox)" (IP-2024-05-8918).



IONSKA KROMATOGRAFIJA KAO ROBUSTNA METODA ZA PRAĆENJE KRATKOLANČANIH ORGANSKIH KISELINA U BIOREAKTORU ZA PROIZVODNJU PHA
ION CHROMATOGRAPHY AS A ROBUST METHOD FOR MONITORING SHORT-CHAIN ORGANIC ACIDS IN A BIOREACTOR FOR PHA PRODUCTION

Lidija Furač, Matija Cvetnić, Laura Jaklenec, Dora Bramberger, Luka Večenaj, Anja Rakas, Kristina Bule Možar, Dora Lastovčić, Marinko Markić, Šime Ukić†, Tomislav Bolanča, Dajana Kučić Grgić
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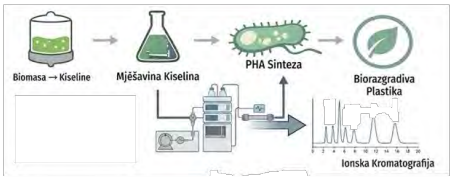
Poli(hidroksialkanoati) (PHA) predstavljaju skupinu biorazgradivih biopolimera koje mikroorganizmi sintetiziraju prirodnim putem, najčešće fermentacijom biomase. Hlapive organske kiseline, nastale anaerobnom digestijom, važan su izvor ugljika u bioprocesima proizvodnje PHA. Njihov sastav i koncentracija značajno utječu na kinetiku rasta mikroorganizama i prinos polimera. U ovom radu ispitan je utjecaj mješavina kratkolančanih organskih kiselina (octena, propionska, mravlja, valerijanska kiselina i limunska kiselina) u različitim koncentracijama na rast bakterije *Cupriavidus necator*. Rast biomase praćen je mjerenjem optičke gustoće (OD) tijekom vremena, dok su promjene u koncentracijama pojedinih kiselina određene primjenom ionske kromatografije (IC). Poseban naglasak stavljen je na primjenu IC metode kao robusnog i selektivnog analitičkog alata za istovremeno određivanje više organskih kiselina u kompleksnom bioprocesnom mediju. Rezultati pokazuju da IC omogućuje pouzdano praćenje dinamike potrošnje supstrata i promjena u sastavu kiselina tijekom procesa. Uočeno je da uvjeti u kojima dolazi do pada pH vrijednosti dovode do inhibicije rasta biomase, dok stabilizirani uvjeti omogućuju učinkovitiju potrošnju kiselina i povećanje OD. Dobiveni rezultati potvrđuju važnost kontrole sastava i koncentracije organskih kiselina te ističu IC kao prikladnu metodu za njihovo praćenje u realnim bioprocesnim sustavima.

Ključne riječi: poli(hidroksialkanoat), kratkolančane organske kiseline, optička gustoća, biofermentacija, biopolimer, ionska kromatografija

Zahvala: Istraživanje je provedeno je u okviru projekta BioSmart (112101), financiranog sredstvima Europske unije – NextGenerationEU iz izvora 581 – Mehanizam za oporavak i otpornost, u sklopu Programa financiranja javnih visokih učilišta i javnih znanstvenih instituta.



GREEN SYNTHESIS AND MODIFICATION OF ADSORBENTS FOR WATER TREATMENT APPLICATIONS

Mirna Habuda-Stanić[1], Dajana Gašo-Sokač[1], Valentina Bušić[1], Antonija Kristek Janković[2], Zorica Kuveždić[3]

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The removal of inorganic ions from water is an important challenge in the development of efficient and sustainable water treatment technologies. In recent years, increasing attention has been given to the use of natural, renewable, and low-cost materials, particularly lignocellulosic biomass and by-products of the food and agricultural industries, as potential adsorbents. Their abundance, availability, biodegradability, and favorable surface properties make them promising alternatives to conventional synthetic adsorbents. This paper reviews the potential of natural lignocellulosic materials and their modified forms for the removal of inorganic ions from aqueous systems. Particular attention is given to the application of physical and chemical modification methods aimed at improving surface characteristics, increasing the number of active binding sites, and enhancing adsorption capacity and selectivity. The influence of key operational parameters, including contact time, pH, initial ion concentration, adsorbent dosage, and temperature, on adsorption efficiency is also considered. Although natural lignocellulosic materials may exhibit limitations related to hydrophilicity, swelling, biodegradation, and mechanical stability, appropriate modification can significantly improve their functional and adsorption properties. The use of such materials offers a promising and environmentally friendly approach to water treatment while supporting the valorization of renewable resources, reduction of industrial and agricultural waste, and implementation of circular economy principles. Modified lignocellulosic adsorbents therefore represent a valuable pathway toward more sustainable and cost-effective technologies for the removal of inorganic ions from water.

Keywords: lignocellulosic materials, green synthesis, adsorbents, chemical modification, wastewater treatment, food industry by-products

Acknowledgement: This research was funded by the European Union—NextGenerationEU, Institutional Research Project "Environmentally friendly methods for the synthesis and extraction of organic compounds with potential biological activity" (581-UNIOS-92).

ACID AND ENZYMATIC PRETREATMENT OF FOOD INDUSTRY BY-PRODUCTS FOR POLYHYDROXYALKANOATE PRODUCTION

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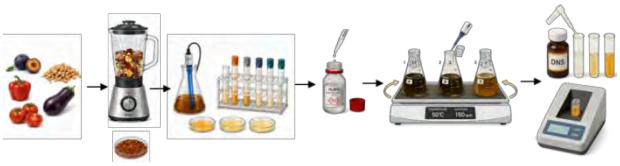
In recent years, agro-industrial waste has gained attention as a low-cost and renewable feedstock for the production of polyhydroxyalkanoates (PHA), biodegradable and biocompatible biopolymers considered a sustainable alternative to conventional plastics. The aim of this study was to investigate the effect of agro-industrial waste pretreatment on improving nutrient availability to microorganisms and to determine the most efficient pretreatment method. Mixed agro-industrial waste, consisting of plum, chickpea, pepper, eggplant and tomato residues, was subjected to physicochemical and microbiological characterization, as well as acid and enzymatic hydrolysis. Acid hydrolysis was performed using sulfuric acid, while enzymatic hydrolysis was carried out using the fungus *Trichoderma reesei*. The efficiency of individual and combined hydrolysis treatments was evaluated. The results showed that acid hydrolysis was the most effective pretreatment method, resulting in the highest concentration of reducing sugars and enhancing the availability of fermentable sugars, thereby providing an efficient carbon source for microbial growth and PHA biosynthesis.

Keywords: polyhydroxyalkanoates, agro-industrial waste, acid hydrolysis, enzymatic hydrolysis

Acknowledgement: This research was carried out as part of the project "Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products" (NPOO.C3.2.R3-I1.04.0059) financed by the National Recovery and Resilience Plan (financed by the European Union, NextGenerationEU).



MONITORING OF ETHYLENE OXIDE CONTAMINATION IN HERBAL DIETARY SUPPLEMENTS

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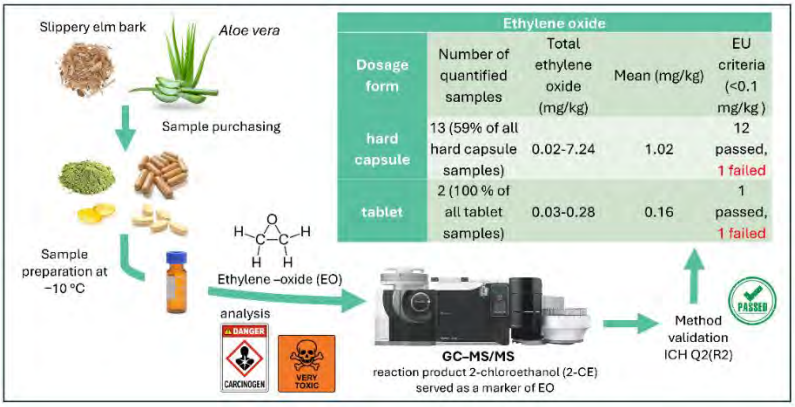
Herbal dietary supplements are widely used for gastrointestinal disorders, including inflammatory bowel disease, but microbial decontamination may introduce ethylene oxide (EtO), a toxic and highly reactive contaminant. [1] Residual EtO and its reaction product 2-chloroethanol (2-CE) may pose a potential health risk. This study evaluated EtO contamination in 28 commercially available herbal dietary supplements containing *Aloe vera* and/or *Slippery elm* in Croatia using GC-MS/MS, with 2-CE as a marker for total EtO content. Low-temperature sample preparation was applied to reduce analyte loss. Total EtO residues were detected in 53.6% of samples, with most complying with the European Union limit (0.1 mg/kg). No quantifiable residues were found in soft capsules or powders. However, two multiherbal formulations exceeded the limit, containing 0.28 mg/kg and 7.24 mg/kg, respectively. These findings emphasize the need for continuous monitoring of EtO residues in herbal dietary supplements to ensure consumer safety and regulatory compliance.

Keywords: ethylene oxide, slippery elm, *Aloe vera*, dietary supplements, quality control

[1] D. Amidžić Klarić, J. Kovačić, M.-L. Jeličić, S. Zubčić, V. Stankov, M. Gulan Čičak, B. Bučar, I. Klarić, A. Mornar, *Pharmaceuticals* 16 (2023) 893.



PHOTOCATALYTIC DEGRADATION OF NITRIC OXIDE IN AN ANNULAR REACTOR: EXPERIMENTAL STUDY AND CFD MODELING

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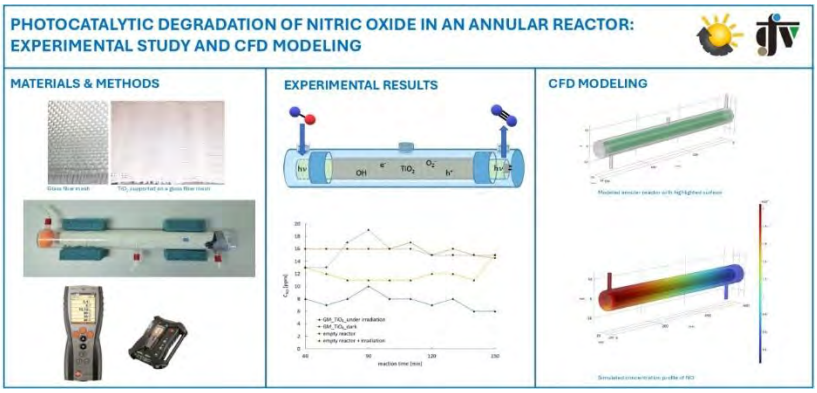
Photocatalysis has been extensively studied as a promising technology for air purification, particularly for the removal of nitrogen oxides (NO_x), which are major air pollutants emitted from industrial and traffic emissions. These pollutants contribute to environmental and health problems, including tropospheric ozone formation, acid rain, global warming, and respiratory diseases. In photocatalytic processes, reactive species generated through the interaction of solar irradiation, a semiconductor photocatalyst, and moisture degrade airborne contaminants. This study investigated the degradation of nitric oxide (NO) in an annular reactor under simulated solar irradiation. Titanium dioxide (TiO_2 P25) was used as the photocatalyst and immobilized on glass fiber by the sol–gel method. The primary objective was to remove NO from an air stream.

Kinetic analyses showed that NO degradation follows first-order reaction kinetics. The results confirmed the successful photocatalytic conversion of NO, including reduction to molecular nitrogen (N_2) and oxidation to nitrate species. Reactor design, irradiation conditions, and mass transfer effects were identified as key factors affecting the process efficiency.

The obtained experimental results provide a basis for the development of computational fluid dynamics (CFD) models, which can be used to optimize reactor performance and support the design and scale-up of air purification systems.

Ključne riječi: nitric oxide, photocatalysis, titanium dioxide, CFD model



CONTAMINATION IN THE INVASIVE PACIFIC OYSTER (*Magallana gigas*) IN THE NORTHERN ADRIATIC

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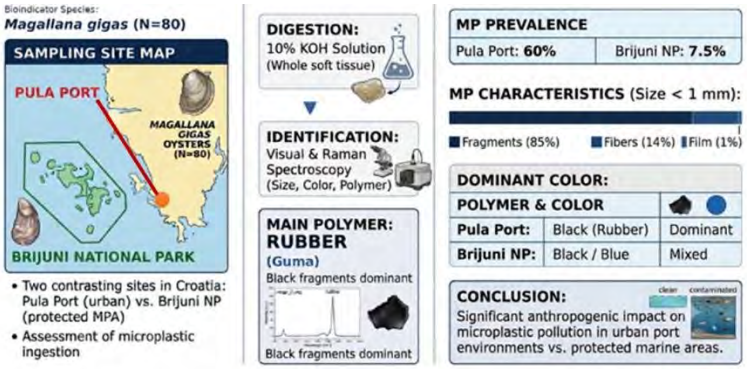
Microplastic contamination of marine ecosystems remains one of the major environmental challenges worldwide, with bivalves used for monitoring local microplastic pollution. To evaluate local contamination levels, samples of the invasive Pacific oyster (*Magallana gigas* Thunberg, 1793, $N = 80$) were collected from Pula Port and the protected marine area of Brijuni National Park, followed by digestion using 10% KOH to isolate microplastics. A marked spatial disparity was observed between the study sites: microplastics were present in 60.0% of oysters from Pula Port (45 particles total; average 1.9 particles/individual), whereas only 7.5% of oysters from Brijuni National Park contained microplastics (3 particles total; average 1.0 particle/individual). Morphological analysis revealed that fragments were the predominant particle shape (85%), followed by fibers (14%) and films (1%). Black was the dominant color, primarily in the form of fragments, followed by blue. All identified particles exhibited an average size below 1 mm, with fragments averaging ~200 µm, fibers ~800 µm, and films ~300 µm. Raman spectroscopy classified the particles as PET, PA, PS and rubber. These findings highlight a strong anthropogenic influence on microplastic prevalence, with significantly higher contamination levels observed in the urbanized port environment than in the protected marine area, despite their close geographical proximity. This suggests that local anthropogenic activities can outweigh regional-scale environmental similarities in determining microplastic contamination.

Ključne riječi: microplastics, *Magallana gigas*, bioindicators, rubber particles



WATER QUALITY MONITORING IN MOUNTAIN STREAMS OF THE MEDVEDNICA NATURE PARK

Dajana Kučić Grgić, Anja Rakas, Lidija Furač, Laura Jaklenec, Dora Bramberger, Kristina Bule Možar, Luka Večenaj, Marinko Markić, Matija Cvetnić, Šime Ukić†, Tomislav Bolanča
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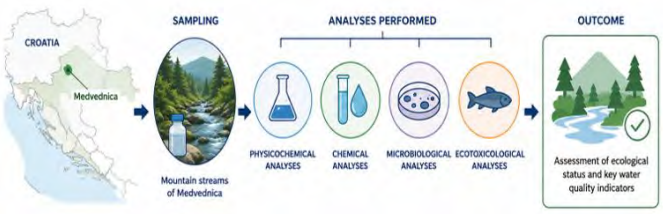
Mountain streams represent sensitive freshwater ecosystems that play an important role in maintaining forest ecosystem health and supporting downstream water management. This study assessed the water quality of selected streams on Medvednica Mountain, Croatia, through systematic sampling and laboratory analyses.
The monitoring program included the determination of key physicochemical, chemical, microbiological, and ecotoxicological indicators. Organic matter content was evaluated using permanganate consumption and total organic carbon (TOC). Major inorganic ions (Ca^{2+}, Mg^{2+}, K^{+}, SO_4^{2-}, NO_3^{-}, NO_2^{-}, NH_4^{+}) and selected metals (e.g., Pb, Cd, As, Ni, Cu, Zn, Cr, Fe, and Mn) were analysed. Microbiological assessment included total and fecal coliforms, *Escherichia coli*, enterococci, *Clostridium perfringens*, and *Pseudomonas* spp. In addition, pH, electrical conductivity, and temperature were measured. Ecotoxicological evaluation was performed using the acute toxicity test with *Aliivibrio fischeri* according to ISO 11348-2:2007. The obtained results provided baseline information on the ecological status of Medvednica streams and enabled the identification of the most relevant water quality indicators affecting both the surrounding forest ecosystem and local drainage systems. The findings contribute to a better understanding of water quality dynamics in mountain catchments and support sustainable water resource management.

Keywords: Medvednica, monitoring, physicochemical, chemical, microbiological, ecotoxicological indicators

Acknowledgment: This research was supported by the European Regional Development Fund under the PKK 2021-2027 programme, project Upravljanje rizicima od pluvijalnih poplava kroz mjere prilagodbe klimatskim promjenama na urbanim područjima (HORUS) grant number PK.3.4.17.0009.



UTJECAJ IZABRANIH FARMACEUTIKA NA EKOTOKSIČNOST NAKON FOTOLIZE
THE INFLUENCE OF SELECTED PHARMACEUTICALS ON ECOTOXICITY AFTER PHOTOLYSIS

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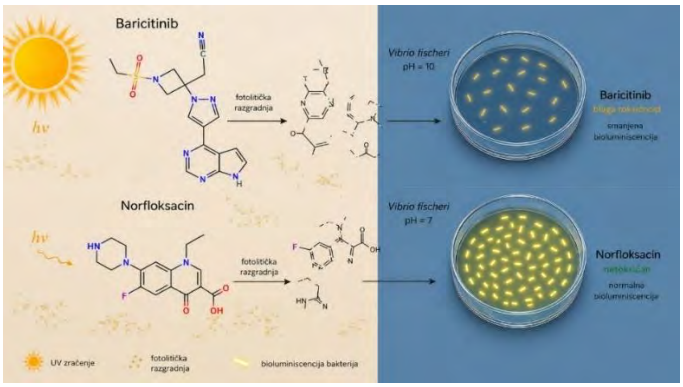
Praćenje fotolitičke razgradnje farmaceutika važno je s ekološkog aspekta jer oni često dospijevaju u otpadne vode, gdje su tijekom procesa pročišćavanja istodobno izloženi biorazgradnji i sunčevoj svjetlosti. U ovome radu ispitana je fotolitička razgradnja baricitiniba i norfloksacina, kako bi se procijenio doprinos fotolize njihovoj razgradnji, uz praćenje nastanka razgradnih i/ili transformacijskih produkata te procjenu ekotoksičnosti fotoliziranih uzoraka primjenom bakterije *Vibrio fischeri*. Rezultati su pokazali da se baricitinib nakon 5 h fotolize nije u potpunosti razgradio te je pri pH-vrijednosti 10 imao vrijeme poluraspada od 630,13 min, dok se norfloksacin pri pH-vrijednosti 7 potpuno razgradio uz vrijeme poluraspada od 4,64 min. Kod oba spoja uočene su nove kromatografske krivulje koje upućuju na nastanak razgradnih i/ili transformacijskih produkata. Ispitivanje ekotoksičnosti pokazalo je blagu toksičnost fotoliziranog baricitiniba pri pH-vrijednosti 10, dok kod norfloksacina nije utvrđena toksičnost kod ispitivanih koncentracija.

Ključne riječi: farmaceutici, fotoliza, ekotoksičnost

This research was funded by the NATO Science for Peace and Security Programme under grant id. G6087.



PHOSPHATE REMOVAL FROM AQUEOUS SOLUTIONS USING MXENE MATERIAL

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MXenes, a family of transition metal carbides and nitrides, have emerged as one of the fastest-growing groups of 2D materials. They are represented by the chemical formula $M_{n+1}X_nT_x$ (n=1-4), where M represents early transition metals, X is carbon and/or nitrogen, and T stands for surface termination groups (-OH, -F, -O or -Cl). Owing to their layered structure, hydrophilicity, high surface area and tunable surface chemistry, MXenes have attracted considerable attention for applications in energy storage, electronics, sensors, biomedicine and environmental remediation. Phosphate contamination in aqueous systems represents an important environmental issue, particularly in the context of nutrient pollution and water quality deterioration. Therefore, the development of efficient adsorbent materials for phosphate removal from water is very important.

In this work, the adsorption of phosphate ions from aqueous solutions onto $Ti_3C_2T_x$ MXene was investigated. Batch adsorption experiments were conducted to evaluate the effects of contact time, adsorbent dose, initial phosphate concentration and pH on phosphate removal efficiency. The kinetic data were analyzed using pseudo-first-order, pseudo-second-order and Elovich models. The Elovich model provided the best fit which suggests the contribution of surface heterogeneity and different active adsorption sites. The material was characterized by Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX).

Keywords: MXene, $Ti_3C_2T_x$, phosphate removal, adsorption

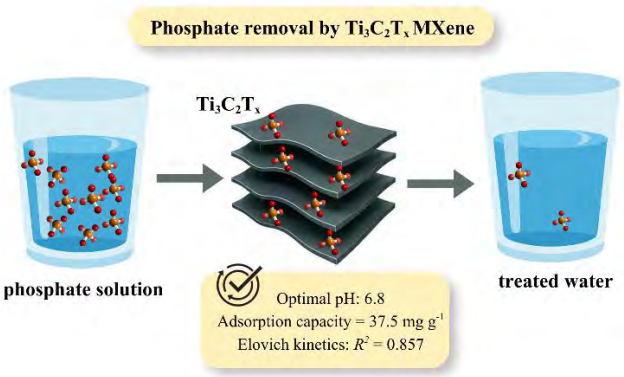


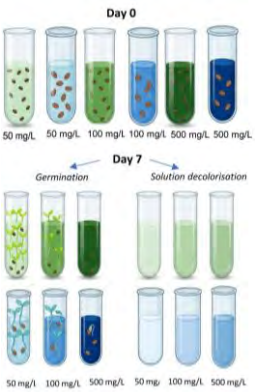
Figure 1. Schematic illustration of phosphate removal from aqueous solution using MXene

PHYTOACCUMULATIVE POTENTIAL OF MICROGREEN AND CROP SPECIES FOR THE SYNTHETIC DYES REMOVAL

Tihana Marček, Natalija Velić, Tanja Mađarević Pavetić, Mario Krišto, Marija Stjepanović
Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia

Phytoremediation is a low-cost, eco-friendly strategy for removing dyes from soil or water using plants. In our study, two cationic dyes (malachite green, MG, and methylene blue, MB) were used to compare their effects on seed germination in triticale (× *Triticosecale*), cress (*Lepidium sativum* L.), rocket (*Eruca sativa* L.), and alfalfa (*Medicago sativa* L.). Also, the percentage of decolourisation of seed presoaking dye solutions was determined. Seeds of triticale (5 per tube), rocket, cress and alfalfa (20 per tube) were separately exposed to MG or MB at specified concentrations (0, 50, 100 or 500 mg/L), with dH_2O as a control. After 7 days, the germination and percentage of decolourisation were calculated. The highest MG and MB concentrations (100 and 500 mg/L) significantly reduced germination in cress and triticale. MG was more harmful to germination than MB. At 500 mg/L, alfalfa showed 15% germination with MB but none with MG. Cress also germinated better under MB than MG at 100 and 500 mg/L, while triticale (50 mg/L) showed higher germination under MG than MB. Rocket seeds did not germinate under either control or dye treatments. The highest decolourisation of MG was achieved in triticale at 50 mg/L (98%) and in alfalfa at 100 mg/L (94%). The most efficient microgreens in MB adsorption were alfalfa (95–97% at 50 to 500 mg/L) and triticale (91–98% at 50 to 500 mg/L), while rocket was the least capable of removing dyes at all concentrations. In conclusion, alfalfa and triticale are the most promising candidates for seed-based phytoremediation of MG and MB, implying a direct correlation between germination rate and dye removal capacity.

Keywords: syntetic dyes, phytoaccumulation, microgreens, crops, decolorisation



AQUAGUARDIAN BASELINE WATER QUALITY SCREENING IN THE SISAK WATER SUPPLY NETWORK

Marinko Markić[1], Dora Bramberger[1], Anja Rakas[1], Lidija Furač[1], Laura Jaklenec[1], Luka Večenaj[1], Kristina Bule Možar[1], Matija Cvetnić[1], Šime Ukić[1†], Magdalena Ujević Bošnjak[2], Tomislav Bolanča[1], Dajana Kučić Grgić[1]

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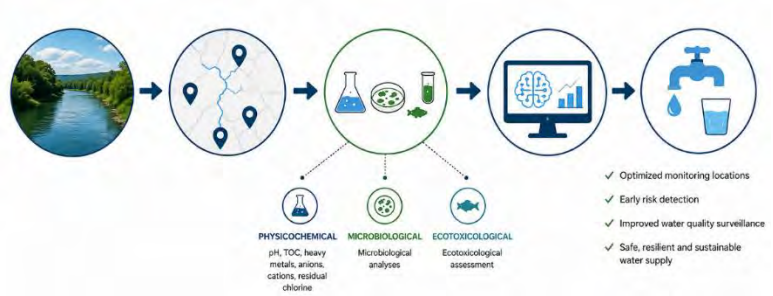
Ensuring the safety of drinking water supplies is an increasing challenge under changing environmental conditions and growing pressures on water resources. The AquaGuardian project develops an integrated early-warning approach that combines advanced analytical methods and artificial intelligence to support the proactive management of water quality risks. As part of the project, a baseline screening campaign will be conducted within the Sisak water supply system, which uses the Kupa River as its primary water source. Selected locations intended for future real-time monitoring will be characterized through comprehensive physicochemical (pH, TOC, heavy metals, major anions and cations, residual chlorine), microbiological, and ecotoxicological analyses. The results will provide the scientific basis for optimizing monitoring locations and supporting the development of a future early-warning system. The project is expected to contribute to improved water quality surveillance and enhance the safety, resilience, and sustainable management of drinking water supply systems.

Keywords: AquaGuardian, water quality monitoring, baseline screening, Kupa River, Sisak water supply system

Acknowledgements: This work was supported by the project A Comprehensive AI-Powered Early Warning System for Digital Management of Water Supply Security, Resilience, and Sustainability (AquaGuardian) (DIGIT.2.1.02.001), funded through World Bank Loan No. 9558-HR under the Digital, Innovative and Green Technologies Project (DIGIT Project).



PRESENCE OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN SURFACE WATERS OF THE KOPRIVNICA-KRIŽEVCI COUNTY AREA

Tiana Novosel[1], Marija Denžić Lugomer[1], Damir Pavličeka[1], Vesna Jaki Tkalec[1], Sanja Furmeg[1], Ana Končurat[1], Nina Bilandžić[2], Ivana Kmetič[3], Teuta Murati[3], Željko Cvetnić[4], Ivka Kvaternjak[5], Dijana Mijač Dretar[6], Maja Đokić[2]

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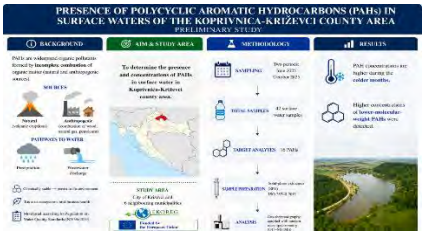
Polycyclic aromatic hydrocarbons (PAHs) are widespread organic pollutants produced during the incomplete combustion of organic matter from both natural and anthropogenic sources. They enter aquatic systems through atmospheric deposition and wastewater discharges. Due to their persistence and toxic properties, PAHs pose a potential risk to ecosystems and human health. Their concentrations are monitored in accordance with the Regulation on Water Quality Standards (NN 96/2019). The aim of this preliminary study was to determine the presence and concentrations of PAHs in surface waters of the Koprivnica-Križevci county area. Sampling was conducted during two periods (June and October 2025) in the area of the City of Križevci and six neighbouring municipalities, and a total of 42 samples were analysed for the presence of 16 PAHs. Solid-phase extraction (SPE) disks were used for sample preparation, in accordance with HRN EN 16691:2015. The analysis was performed using gas chromatography coupled with tandem mass spectrometry (GC–MS/MS). The obtained results indicated that PAH concentrations were higher during the colder months, with lower-molecular-weight PAHs dominating the PAH profile. Among the compounds analysed, naphthalene and acenaphthylene showed the highest average concentrations, ranging from 0.10 to 5.53 µg/l and 0.22 to 10.8 µg/l, respectively. Measured benzo(a)pyrene (0.001 - 0.003 µg/l), benzo(b)fluoranthene (0.001 - 0.005 µg/l), benzo(k)fluoranthene (0.001 - 0.005 µg/l), benzo(g, h, i)perylene (0.0002 - 0.004 µg/l) concentrations were below the maximum annual concentration prescribed of by the Regulation on Water Quality Standards (NN 96/2019). Future research should include long-term seasonal monitoring and identification of potential PAH sources to improve understanding of their occurrence and distribution in surface waters.

Keywords: PAHs, surface water, solid-phase extraction, GC-MS/MS

Acknowledgements: This study was funded by the European Union NextGenerationEU and supported by the Ministry of Science and Education of the Republic of Croatia through the project No. NPOO 3 of Croatian Veterinary Institute titled “The impact of organic pollutants on the ecological footprint of the region” (EKOREG).



FTIR ANALYSIS OF ALGAE POWDER UTILIZED AS NATURAL FILLERS IN 3D PRINTING FILAMENTS

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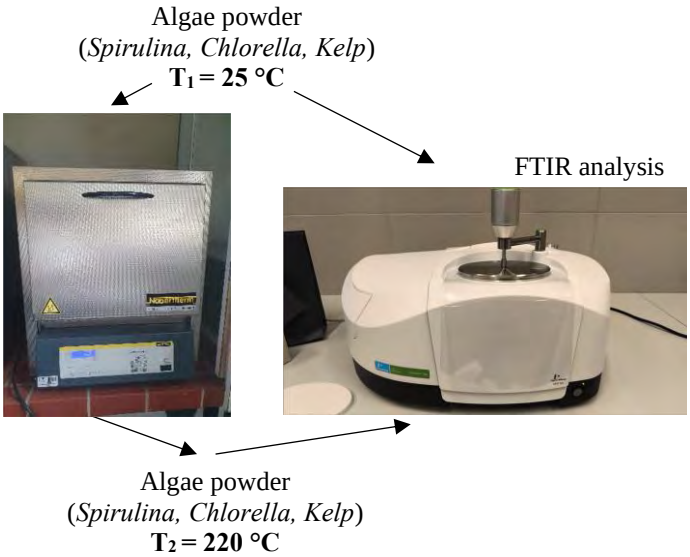
The temperature management during additive manufacturing, also known as 3D printing, is a critical factor for achieving high-quality, stable and durable prints. Polylactic Acid (PLA) as a standard 3D printing material, typically requires a nozzle temperature of 190 °C to 220 °C. If the natural fillers are added into polymer matrix as reinforcement, it will affect the filament's temperature behaviour and rheological properties. Algae are a widely available renewable material that is increasingly used in various industries, including the graphic industry. In this study, the stability of powders gained from three algae species at a processing temperature of 220 °C was observed by FTIR analysis. This analysis will indicate the stability of algae powders under extrusion conditions as they will be used as natural fillers in PLA polymer matrices with variations in weight ratios to ensure proper flow, interfacial adhesion and print quality of laboratory-produced 3D printing filaments.

Ključne riječi: algae powder, FTIR analysis, 3D printing



TEXTILE WASTEWATER TREATMENT

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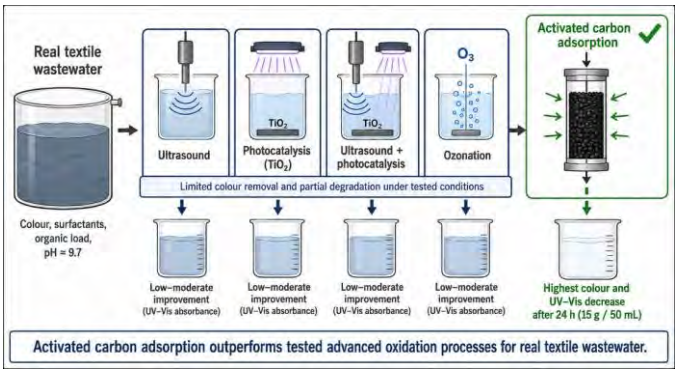
The textile industry is an important economic sector but also a major source of water pollution, producing complex wastewater containing dyes, surfactants, recalcitrant organics and metals that threaten aquatic ecosystems and human health. Conventional mechanical, chemical and biological treatments often cannot adequately remove these persistent contaminants, so advanced oxidation processes (AOPs) are employed to generate highly reactive hydroxyl radicals capable of mineralising pollutants to carbon dioxide, water and mineral salts rather than merely transferring them to another phase [1]. In this context, the present study investigated ultrasound, photocatalysis, sonophotocatalysis, ozonation and activated carbon adsorption for treating real textile wastewater, with process performance evaluated by UV–Vis spectrophotometry under near-neutral conditions. Ultrasound, photocatalysis and their combination showed only limited efficiency, and ozonation mainly reduced absorbance in the ultraviolet range without noticeable decolorisation. Activated carbon adsorption was clearly the most effective method, achieving up to 82% removal in the ultraviolet and 78% in the visible range after 24 hours at the highest adsorbent dose. Overall, the findings highlight adsorption as a robust primary treatment for complex textile effluents and suggest that oxidation-based processes should be further optimised and applied in sequential schemes following initial contaminant load reduction.

Keywords: textile wastewater, organic pollutants, advanced oxidation processes, activated carbon adsorption, decolorization

[1] M.A. Hassaan, A. El Nemr, *Int. J. Photochem. Photobiol.* 1(1), (2017) 27–35.



SUSTAINABLE PRODUCTION OF POLYHYDROXYALKANOATES FROM VOLATILE FATTY ACIDS

Anja Rakas[1], Lidija Furač[1], Kristina Bule Možar[1], Dora Lastovčić[1], Luka Večenaj[1], Matija Cvetnić[1], Šime Ukić[1], Marinko Markić[1], Tomislav Bolanča[1], Stela Jokić[2], Krunoslav Aladić[2], Dajana Kučić Grgić[1]

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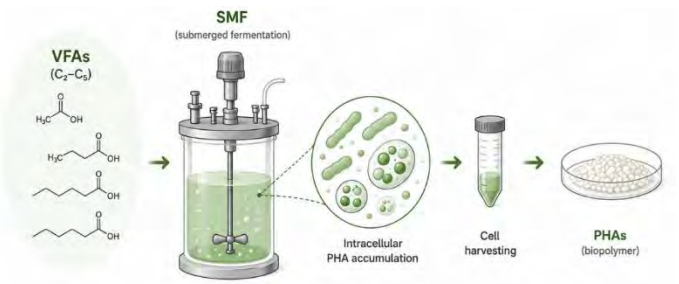
The growing environmental impact of conventional petroleum-based plastics has accelerated the development of sustainable biopolymer production processes. In this study, polyhydroxyalkanoates (PHAs) were synthesized under submerged fermentation (SMF) conditions using volatile fatty acids (VFAs) as carbon substrates for microbial growth and PHA biosynthesis. Acetic, propionic, butyric, and valeric acids were investigated due to their high bioavailability and efficient microbial conversion potential. Fermentation was conducted in a bioreactor over a three-day period at 30 °C, with the pH maintained between 6.5 and 7.0, using the bacterial strain *Cupriavidus necator*. Fermentation parameters influencing microbial activity and PHA synthesis were evaluated to assess process performance and production efficiency. The results confirm the applicability of VFAs as sustainable feedstocks for PHA biosynthesis and demonstrate the potential of SMF-based biotechnological systems for the development of environmentally sustainable materials and circular resource utilization strategies.

Keywords: polyhydroxyalkanoates, VFA, *Cupriavidus necator,* SMF

Acknowledgements: This research was conducted within the project BioSmart (112101) financed by the European Union's- NextGenerationEU fund from the source 581 – The recovery and resilience mechanism, in the frame of Programme financing of public higher education institutions and public scientific institutes.



MULTIELEMENTNA KARAKTERIZACIJA VODE TRIBALJSKOG JEZERA
MULTI-ELEMENTAL CHARACTERISATION OF WATER OF THE TRIBALJ LAKE (PRIMORSKO-GORANSKA COUNTY)

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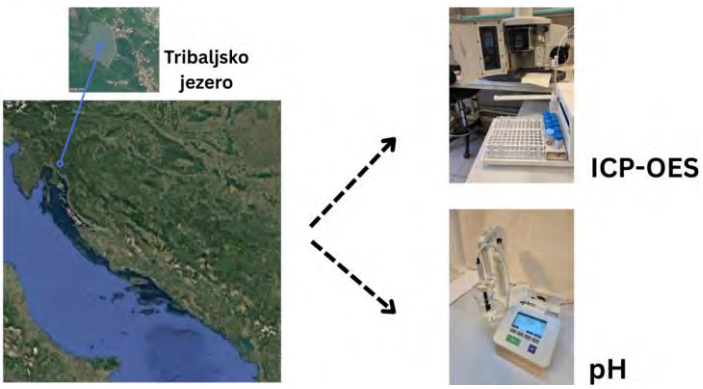
Vodu odnosno vodne resurse čovjek, osim za prehranu, često koristi za rekreaciju u slobodno vrijeme. Mnoga jezera, i ona umjetna, privlačna su i redovito posjećivana kako od obližnjeg stanovništva tako i od turista. Tribaljsko jezero, smješteno u crikveničkom zaleđu, jedno je od takvih. U okviru ovog rada poduzeta je multielementna analiza i određivanje pH uzoraka vode Tribaljskog jezera.

28 odabranih kemijskih elemenata kvantificirano je u filtriranim (0.45 μm) i zakiseljenim (HNO_3, *supra pur*, 65 %, 1 % *v*/*v*) uzorcima optičkom emisijskom spektrometrijom uz induktivno spregnutu plazmu (ICP–OES) [1]. Vrijednosti pH izmjerene su u nefiltriranim uzorcima pH-metrom s kombiniranom elektrodom. Usporedba rezultatâ s graničnim vrijednostima pokazateljâ zadanima *Uredbom o klasifikaciji voda* [2] upućuje na zaključak da voda Tribaljskog jezera, glede koncentracijâ odabranih analitâ, spada u vode I. vrste.

Ključne riječi: ICP-OES, jezerska voda, metal(loid)i, pH, Primorsko-goranska županija

[1] V. Roje, J. Dukić, P. Šutalo, *Environ. Sci. Pollut. Res.* 26 (2019) 2635.
[2] ***Uredba o klasifikaciji voda, *Narodne novine* 77 (1998) 1037.



INFLUENCE OF 3D PRINTING TEMPERATURE ON THE COLORIMETRIC PROPERTIES OF SPIRULINA-PLA BASED FILAMENT

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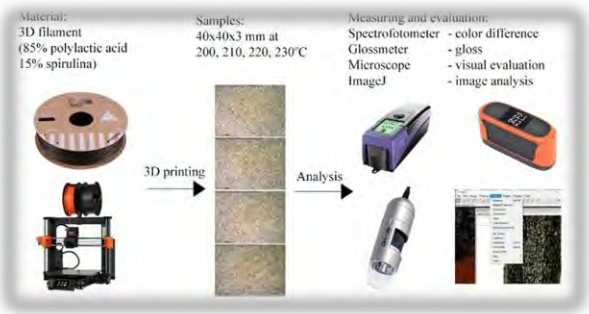
University of Zagreb Faculty of Graphic ArtsGetaldićeva 2, 10000 Zagreb, Croatia

As additive manufacturing (3D printing) is becoming a credible production technique on a larger scale, there is a need for development of sustainable and environmentally acceptable filaments. Unlike petroleum-based pigments or fillers commonly used to colour or reinforce 3D printing filaments, pigments derived from algae and biomass offer a lower environmental footprint and reduce reliance on synthetic additives. This study evaluates a 3D printing filament made as a biocomposite of 85% polylactic acid (PLA) and 15% spirulina. Both PLA and spirulina are biodegradable under appropriate composting conditions, improving the end-of-life profile of printed parts compared to conventional plastics derived from petroleum. Test specimens were printed at five nozzle temperatures (190 °C, 200 °C, 210 °C, 220 °C and 230 °C) under constant printing parameters, and the resulting colour changes were quantified using CIE$L^*a^*b^*$ colorimetry and total colour difference (ΔE^*_{00}). Surface gloss and roughness were also evaluated to correlate optical changes to print surface characteristics. These findings provide guidance for selecting printing temperatures that balance dimensional/mechanical print quality with preservation of the spirulina pigment's visual properties, which is relevant for aesthetic and functional applications of algae-based biocomposite filaments.

Keywords: 3D printing, biocomposite, color difference, filament, printing temperature



ENVIRONMENTAL IMPACT ANALYSIS OF MUNICIPAL WASTE MANAGEMENT IN THE CITY OF ZADAR: AN LCA APPROACH

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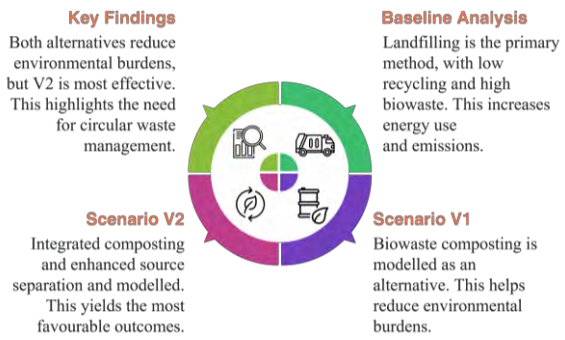
University of Split, Faculty of Chemistry and Technology, Ruđera Boškovića 35, 21000 Split, Croatia

This study assessed the environmental impacts of the municipal waste management system in Zadar, Croatia, from 2020 to 2024, utilising the Life Cycle Assessment (LCA) methodology. As a prominent urban-tourist destination, Zadar faces unique seasonal pressures that strain its waste infrastructure. The baseline analysis revealed a systemic reliance on landfilling, characterized by low recycling rates and high biowaste disposal, which drove increased energy consumption and greenhouse gas emissions. To address these inefficiencies, the study modelled two alternative scenarios: V1 (biowaste composting) and V2 (integrated composting and enhanced source separation). Comparative results demonstrated that both alternatives significantly mitigated environmental burdens. Specifically, Scenario V2 yielded the most favourable outcomes, showing substantial reductions in resource depletion, climate change contribution, acidification, and smog formation. The findings underscored a critical need to transition toward circular waste management and energy-efficient practices to ensure long-term regional sustainability and improved urban environmental quality.

Keywords: Life Cycle Assessment (LCA), waste treatment variants, urban-tourist destination, environmental sustainability



UTJECAJ POVRŠINSKOG MODIFICIRANJA NZVI NA KOLOIDNU STABILNOST I UKLANJANJE TEŠKIH METALA IZ VODE
EFFECT OF SURFACE-MODIFIED NZVI ON COLLOIDAL STABILITY AND REMOVAL OF HEAVY METALS FROM WATER

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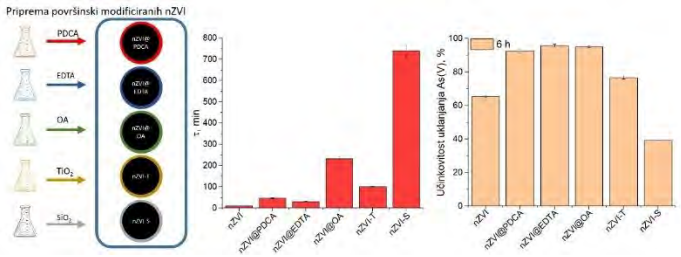
Nanočestice elementarnog željeza (engl. *nano zero-valent iron*, nZVI) široko se primjenjuju u *in situ* remedijaciji podzemnih i površinskih voda zbog sposobnosti redukcije i adsorpcije anorganskih i organskih onečišćivala. Njihova primjena u okolišu ograničena je brzom aglomeracijom i sedimentacijom, što smanjuje pokretljivost, raspoloživu reaktivnu površinu i učinkovitost uklanjanja onečišćivala. Površinsko modificiranje nZVI pokazalo se učinkovitom strategijom za povećanje koloidne stabilnosti i kontrolu površinskog naboja, čime se poboljšava učinkovitost uklanjanja metala iz vode [1]. U ovom radu ispitano je ponašanje nemodificiranih i površinski modificiranih nZVI čestica (nZVI@PDCA, nZVI@EDTA, nZVI@OA, nZVI-TiO_2, nZVI-SiO_2) u vodenoj disperziji kroz određivanje ζ-potencijala pri različitim pH vrijednostima (izoelektrična točka) te određivanje sedimentacijskog vremena. Na temelju ζ-potencijala procijenjena je elektrostatska stabilnost i površinski naboj čestica. Ispitivanjem sedimentacijskog vremena dobiven je uvid u kinetiku taloženja i utjecaj različitih površinskih modifikatora na sprječavanje aglomeracije čestica. Dobiveni rezultati pokazuju da površinska modifikacija dovodi do povećanja apsolutne vrijednosti ζ-potencijala i znatnog produljenja sedimentacijskog vremena u odnosu na nemodificirane nZVI. Pojedini modifikatori (npr. SiO_2 i OA) učinkovito odgađaju taloženje nZVI čestica zbog steričkih i elektrostatskih učinaka. Rezultati pokazuju ključnu ulogu odabranog modifikatora za dizajn stabilnih i učinkovitih nZVI sustava za uklanjanje anorganskih onečišćivala iz vode.

Ključne riječi: izoelektrična točka, sedimentacijsko vrijeme, nZVI, krom, arsen



[1] A. K. Saha, A. Sinha, S. Pasupuleti, *Environ. Technol.* 40(12) (2018) 1543–1556.

ELECTROCHEMICAL LAB-ON-CHIP BIOSENSORS FOR BISPHENOL A MONITORING IN WATER SYSTEMS

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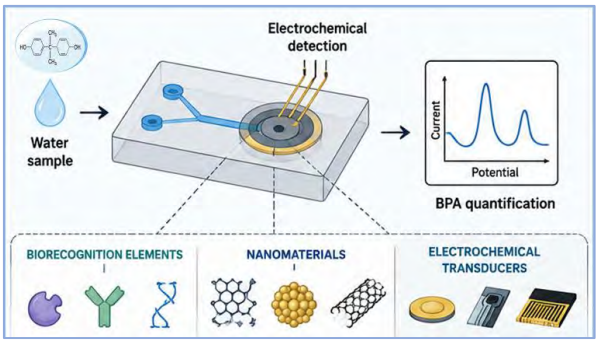
Bisphenol A (BPA) is a widespread organic pollutant that is considered a significant threat to aquatic ecosystems and human health due to its endocrine-disrupting activity. In recent years, numerous analytical approaches have been developed for its determination, among which electrochemical biosensors integrated into lab-on-chip platforms have attracted increasing attention because of their high sensitivity, selectivity, portability, and potential for real-time analysis. This review provides an overview of recent advances in the development of electrochemical lab-on-chip biosensors for BPA detection in water systems. Particular emphasis is placed on different types of biorecognition elements, including enzymes, antibodies, and aptamers, as well as on the role of nanostructured materials in enhancing the analytical performance of sensing platforms. The advantages of miniaturization, microfluidic integration, and the applicability of these devices for on-site environmental monitoring are also discussed. A review of the available literature confirms that electrochemical lab-on-chip biosensors represent a promising technology for the rapid, reliable, and cost-effective monitoring of BPA in water systems, with considerable potential for broader applications in environmental protection and water quality assessment.

Keywords: bisphenol A, lab-on-chip, electrochemical biosensors, water systems



UV-C INDUCIRANA OKSIDACIJA SARS-COV-2 ANTIVIROTIKA
UV-C INDUCED OXIDATION OF SARS-COV-2 ANTIVIRALS

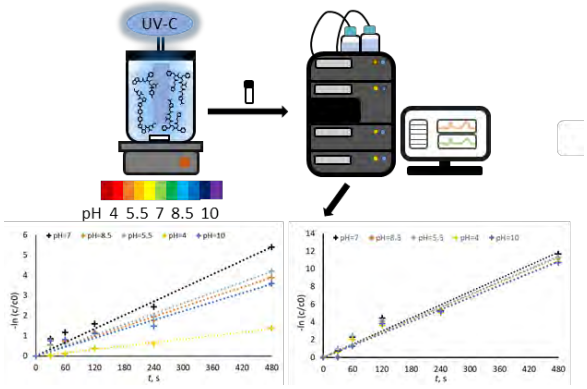
Luka Večenaj, Dora Lastovčić, Kristina Bule Možar, Matija Cvetnić, Dajana Kučić Grgić, Marinko Markić, Lidija Furač, Tomislav Bolanča, Šime Ukić†

Sveučilište u Zagrebu Fakultet kemijskog inženjerstva i tehnologije, Trg Marka Marulića 19, 10000 Zagreb, Hrvatska

Tijekom pandemije SARS-CoV-2 u okolišu se detektira nova skupina onečišćujućih tvari zbog povećane upotrebe antivirotika. Dostupno je malo informacija o njihovoj sudbini i ponašanju u okolišu te o procesima za njihovo učinkovito uklanjanje. Kao učinkoviti procesi uklanjanja predlažu se napredni oksidacijski procesi (AOP), među kojima su najčešće korišteni UV/H2O2 i Fentonovi procesi. Ovi su procesi uglavnom vrlo učinkoviti, ali energetski zahtjevni i zahtijevaju upotrebu potencijalno ekotoksičnih kemijskih reagensa. Stoga je prije ispitivanja učinkovitosti AOP-a potrebno ispitati razgradnju antivirotika pod utjecajem UV svjetlosti. UV-C inducirana oksidacija SARS-CoV-2 antivirotika provodila se pri valnoj duljini od 254 nm i u rasponu pH vrijednosti od 4 do 10. Iz dobivenih rezultata određene su brzine razgradnje i konstruirani grafovi ovisnosti negativnog logaritma omjera koncentracije antivirotika u određenom trenutku i početne koncentracije antivirotika o vremenu trajanja reakcije.

Ključne riječi: SARS-CoV-2, antivirotici, UV-C zračenje, razgradnja

Zahvala: Ovaj rad izrađen je u sklopu projekta „Okolišni aspekti SARS-CoV-2 antivirotika“ (EnASARS; IP-2022-10-2822) Hrvatske zaklade za znanost na Fakultetu kemijskog inženjerstva i tehnologije Sveučilišta u Zagrebu.



ANORGANSKI UGLJIK U TLU I NJEGOVA VAŽNOST ZA UBLAŽAVANJE KLIMATSKIH PROMJENA
SOIL INORGANIC CARBON AND ITS IMPORTANCE FOR CLIMATE CHANGE MITIGATION

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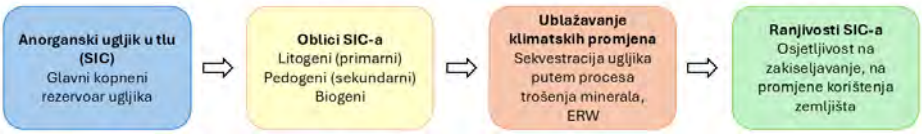
Tla predstavljaju jedan od najvećih kopnenih rezervoara ugljika, pri čemu se značajan dio ukupnih zaliha nalazi u obliku anorganskog ugljika u tlu (*Soil Inorganic Carbon, SIC*). Iako su istraživanja i klimatske politike tradicionalno usmjerene na organski ugljik u tlu (*Soil Organic Carbon, SOC*), sve je jasnije da SIC ima važnu, ali nedovoljno prepoznatu ulogu u regulaciji globalnog ciklusa ugljika i ublažavanju klimatskih promjena. Procjenjuje se da gornja dva metra tla globalno pohranjuju više od 2 300 PgC u obliku SIC-a, pri čemu su najveće zalihe koncentrirane u sušnim i polusušnim područjima.
SIC se javlja u tri glavna oblika: litogeni (primarni), biogeni i pedogeni (sekundarni) karbonati. Posebno su pedogeni karbonati značajni za ublažavanje klimatskih promjena jer predstavljaju aktivni mehanizam dugoročne sekvestracije atmosferskog CO_2 putem silikatnog trošenja. Proces pojačanog vremenskog trošenja stijena (*Enhanced Rock Weathering, ERW*) prepoznat je kao obećavajuća tehnologija negativnih emisija, kojom se ubrzava prirodno vezanje CO_2 u stabilne karbonatne oblike.
Međutim, zalihe SIC-a izrazito su osjetljive na antropogene utjecaje, osobito zakiseljavanje tla uzrokovano intenzivnom primjenom dušičnih gnojiva, što može dovesti do otapanja karbonata i ponovnog oslobađanja CO_2 u atmosferu. Također, promjene u korištenju zemljišta i hidrologiji utječu na stabilnost i raspodjelu anorganskog ugljika.
Integracija SIC-a u klimatske politike, sustave praćenja i tržišta ugljika nužna je za cjelovito upravljanje ugljikom u tlu. Uključivanje organske i anorganske komponente omogućuje preciznije procjene ponora ugljika te razvoj učinkovitijih strategija za postizanje ciljeva neto nulte emisije. Anorganski ugljik u tlu stoga predstavlja ključnu, ali još uvijek nedovoljno iskorištenu komponentu globalnih strategija ublažavanja klimatskih promjena.

Ključne riječi: anorganski ugljik u tlu, ublažavanje klimatskih promjena, pojačano vremensko trošenje stijena



10. susret mladih kemičara

10th Meeting of Young Chemists

ODREĐIVANJE NEUTRALIZACIJSKOG KAPACITETA ANTACIDA
DETERMINATION OF THE NEUTRALIZATION CAPACITY OF ANTACIDS

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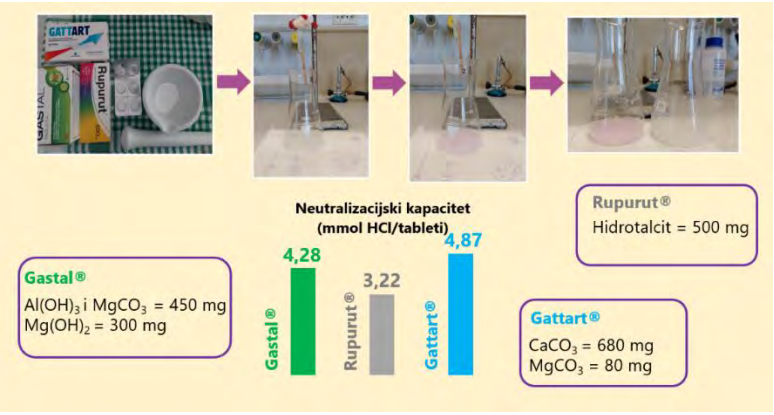
Antacidi su lijekovi koji se koriste za neutralizaciju želučane kiseline i ublažavanje simptoma žgaravice i hiperaciditeta. U ovom radu ispitan je neutralizacijski kapacitet različitih komercijalno dostupnih antacida: *Gastal*, *Rupurut* i *Gattart*. Antacidi se razlikuju prema sastavu i količini aktivnih tvari, poput magnezijeva hidroksida, aluminijeva hidroksida i kalcijeva karbonata, što može utjecati na njihov neutralizacijski kapacitet. Neutralizacijski kapacitet određen je metodom povratne acidobazne titracije, pri čemu je višak klorovodične kiseline titriran natrijevim hidroksidom uz fenolftalein kao indikator. Svi antacidi pokazali su dobru sposobnost neutralizacije kiseline te su uočene razlike u neutralizacijskom kapacitetu koje se mogu povezati sa sastavom, količinom aktivnih tvari i masom pojedine tablete.

Ključne riječi: klorovodična kiselina, antacidi, povratna acidobazna titracija, neutralizacijski kapacitet



BIORAZGRADIVI JEDNOKRATNI TANJUR OD BIOLOŠKOG OTPADNOG MATERIJALA
BIODEGRADABLE DISPOSABLE PLATE FROM BIOWASTE MATERIAL

Lina Borak, Tea Novak, Elena Spudić, Tamara Tkalec-Car, Petra Novak Mlinarić
Graditeljska, prirodoslovna i rudarska škola, Hallerova aleja 3, 42000 Varaždin, Hrvatska

U radu je istražena mogućnost izrade biorazgradivog jednokratnog tanjura primjenom bioplastike dobivene iz biološkog otpadnog materijala. Kao sirovine korišteni su kora naranče, talog kave i pšenične posije, s ciljem recikliranja organskog otpada i smanjenja uporabe konvencionalnih polimera. Težište istraživanja bilo je optimiranje sastava bioplastične smjese i određivanje odgovarajućeg omjera vezivne komponente i punila radi postizanja zadovoljavajućih uporabnih svojstava tanjura.
Vezivna masa pripravljena je zagrijavanjem škroba uz dodatak octa, pri čemu dolazi do djelomične hidrolize škroba. Dodatkom glicerola dobivena je elastična biopolimerna matrica kojoj su dodane posije kao punilo te usitnjena kora naranče i talog kave. Dobivena bioplastika korištena je za oblikovanje jednokratnog tanjura. Biorazgradivost materijala praćena je svakodnevnim vaganjem i promatranjem promjena strukture tijekom razgradnje u tlu. Nakon približno dva tjedna uočeni su gubitak čvrstoće, povećana prhkost i raspadanje materijala. Ispitivanje otpornosti na vodu pokazalo je omekšavanje materijala nakon jednog sata te gubitak oblika nakon tri sata bez potpunog otapanja. Rezultati potvrđuju potencijal primjene bioplastike iz organskog otpada za proizvodnju biorazgradivih jednokratnih proizvoda.

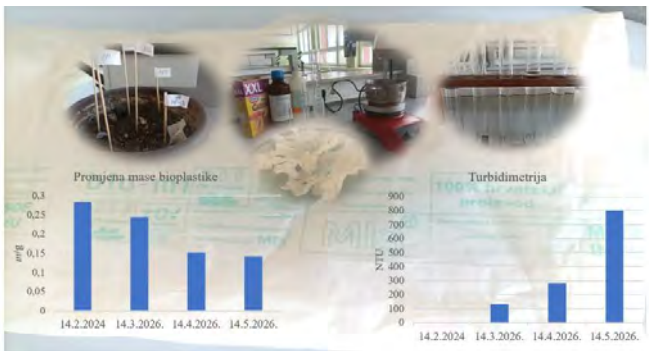
Ključne riječi: bioplastika, organski otpad, biorazgradivi tanjur, škrobni polimeri

BIOPLASTIKA NA BAZI KUKURUZNOG ŠKROBA KAO ODRŽIVA ALTERNATIVA KONVENCIONALNOJ PLASTICI
CORN STARCH BASED BIOPLASTIC AS A SUSTAINABLE ALTERNATIVE TO CONVENTIONAL PLASTIC

Ana Čiča, Anđela Dobrić, Đurđevka Pecikozić
Tehnička škola Nikole Tesle Vukovar, Blage Zadre 4, 32000 Vukovar, Hrvatska

Plastični otpad predstavlja značajan ekološki problem zbog svoje postojanosti u okolišu i nastanka mikroplastike koja je prisutna u vodi, tlu, prehrambenim proizvodima i hranidbenom lancu. Stoga razvoj i primjena biorazgradivih materijala imaju važnu ulogu u smanjenju onečišćenja okoliša. U ovom radu pripremljena je bioplastika na bazi kukuruznog škroba s ciljem ispitivanja njezine razgradivosti u usporedbi s polietilen-tereftalatom (PET), jednim od najčešće korištenih konvencionalnih plastičnih materijala. Bioplastika je izrađena od kukuruznog škroba uz dodatak vode, octene kiseline i glicerola, pri čemu je dobiven čvrst, savitljiv i homogen materijal. Razgradivost bioplastike i PET-a ispitivana je u vodi i tlu tijekom 90 dana, uz mjerenja u intervalima od 30 dana. Razgradnja u vodi praćena je mjerenjem mutnoće vode pomoću turbidimetra HACH 2100Q, a razgradnja u tlu praćenjem promjene mase uzoraka. Početna vrijednost mutnoće vode iznosila je 0,59 NTU. Nakon 90 dana kod uzorka PET-a zabilježena je zanemariva promjena mutnoće (0,22 NTU), dok su kod bioplastike izmjerene vrijednosti veće od 800 NTU, što ukazuje na znatno intenzivniju razgradnju materijala. Sličan trend potvrđen je i ispitivanjem u tlu, gdje nije uočena promjena mase uzorka PET-a, dok je masa bioplastike smanjena za 49,84 % u odnosu na početnu vrijednost. Dobiveni rezultati potvrđuju znatno veću biorazgradivost bioplastike na bazi kukuruznog škroba te njezin potencijal kao održive alternative konvencionalnim plastičnim materijalima.

Ključne riječi: bioplastika, kukuruzni škrob, razgradnja u okolišu, turbidimetrija



DVIJE STRANE ISTOG ZRCALA: OPTIČKA AKTIVNOST SAHAROZE I FRUKTOZE
THE DUAL NATURE OF OPTICAL ACTIVITY IN SUCROSE AND FRUCTOSE

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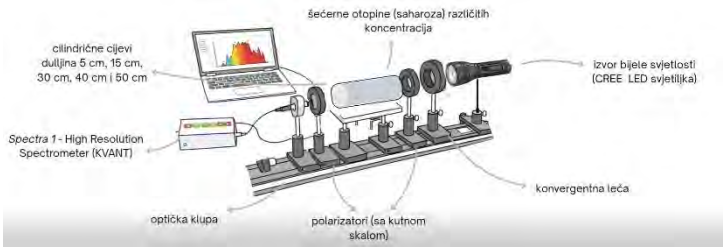
Kiralne molekule, poput šećera, zakreću ravninu linearno polarizirane svjetlosti. Smjer i intenzitet tog zakretanja ovise o molekularnoj strukturi, koncentraciji otopine, duljini optičkog puta i valnoj duljini svjetlosti. U ovom radu uspoređena je optička aktivnost saharoze ($C_{12}H_{22}O_{11}$) i fruktoze ($C_6H_{12}O_6$) – dvaju šećera koji, unatoč srodnoj molekularnoj građi, pokazuju različita optička ponašanja.
Mjerenja su provedena polarimetrom (CREE LED, dva polarizatora, kiveta, spektrometar). Ispitivane su četiri koncentracije (20-80 %) i pet duljina optičkog puta (0,5-6 dm) za oba šećera. Kut rotacije određen je za plavu (≈440 nm), zelenu (≈550 nm) i crvenu (≈660 nm). Rezultati potvrđuju Biotov zakon: kut rotacije linearno raste s koncentracijom ($\theta \propto c$) i duljinom puta ($\theta \propto L$). Potvrđena je i optička rotacijska disperzija – kut rotacije veći je za kraće valne duljine (plava > zelena > crvena), u skladu s Drudeovim modelom.
Ključna razlika između šećera očituje se u smjeru rotacije i specifičnoj rotaciji [α]. Saharoza zakreće udesno (dekstrorotatorna), [α] ≈ +66,5°, dok fruktoza zakreće ulijevo (levorotatorna), [α] ≈ -92,4°. Ova razlika posljedica je različite prostorne konfiguracije kiralnih centara. Suprotni predznaci rotacije izvrstan su primjer kako mikroskopska kiralnost određuje makroskopski optički odziv.
Usporedbom mjerenja pri istim koncentracijama i duljinama puta omogućena je izravna usporedba ponašanja dvaju šećera. Polarimetrija se može koristiti kao jednostavna analitička metoda za razlikovanje šećera. Optimizacijom parametara (c = 80%, L = 5 dm, $\lambda \approx 440$ nm) postignut je iznimno uzak propusni pojas od svega $\Delta\lambda \approx 11$ nm za saharozu, što postav čini funkcionalnim monokromatorom.

Ključne riječi: kiralnost, optička aktivnost, saharoza, fruktoza, polarimetrija



KOMPARATIVNA ANALIZA SADRŽAJA PROTEINA U KOMERCIJALNIM PROTEINSKIM NAPITCIMA I PREPARATIMA BIURETOVOM I KJELDAHLOVOM METODOM

COMPARATIVE ANALYSIS OF PROTEIN CONTENT IN COMMERCIAL PROTEIN DRINKS AND SUPPLEMENTS USING THE BIURET AND KJELDAHL METHODS

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Posljednjih godina svjedočimo iznimnom porastu popularnosti proteinskih napitaka i dodataka prehrani, posebice među mlađom populacijom i rekreacijskim sportašima. Taj trend rasta potrošnje motivirao je osmišljavanje ovog istraživanja, s ciljem da se aktualan društveni fenomen poveže s praktičnom kemijskom analizom. U radu je određen i uspoređen maseni udio proteina u komercijalnim proteinskim prašcima te gotovim mliječnim napitcima različitih okusa primjenom dviju analitičkih tehnika: spektrofotometrijske Biuretove metode i referentne Kjeldahlove metode. Kjeldahlovom metodom utvrđeni su maseni udjeli od 62,32 % i 62,69 % za praškaste uzorke, dok su u tekućim napitcima iznosili od 8,71 % do 9,40 %, što je u skladu s deklaracijama proizvoda i dopuštenim industrijskim tolerancijama. Biuretova metoda dala je sustavno više vrijednosti za napitke (10,24 % – 11,44 %), dok je kod jednog uzorka u prahu podcijenila udio (54,40 %). Razlike u rezultatima pripisuju se optičkim i kemijskim interferencijama dodanih aroma i boja u napitcima te nepotpunoj topljivosti pojedinih praškastih uzoraka. Provedeno istraživanje potvrđuje opravdanost statusa Kjeldahlove metode kao zlatnog standarda u analizi hrane.

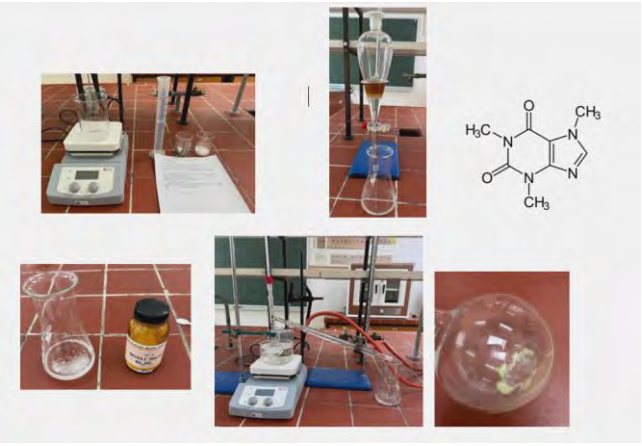
Ključne riječi: proteinski napitci, dodaci prehrani, Biuretova metoda, Kjeldahlova metoda, kontrola kvalitete hrane

IZOLACIJA KOFEINA I ODREĐIVANJE KONCENTRACIJE U RAZNIM NAPITCIMA
ISOLATION AND QUANTIFICATION OF CAFFEINE IN VARIOUS BEVERAGES

Andrej Lisica, Lana Rehnicer, Zorica Majić, Suzana Čurić
Tehnička škola i prirodoslovna gimnazija Ruđera Boškovića Osijek, Vukovarska cesta 209, 31000 Osijek, Hrvatska

Kofein je prirodni alkaloid prisutan u kavi, čaju, energetskim i gaziranim pićima, poznat po svom stimulativnom učinku na središnji živčani sustav. Izolacija kofeina najčešće se provodi ekstrakcijom pomoću organskih otapala, pri čemu se iskorištava njegova topljivost u nepolarnim otapalima poput diklorometana ili kloroforma. Za određivanje koncentracije kofeina koriste se metode UV/VIS spektrofotometrije. Dobiveni rezultati omogućuju usporedbu količine kofeina u različitim vrstama napitaka. U ovom radu opisana je izolacija kofeina iz tri vrste čaja te su određeni njegovi maseni udjeli u pojedinoj vrsti. Korištena metoda za izolaciju je ekstrakcija na osnovi različite topljivosti između dvaju otapala, a maseni udjeli kofeina određeni su gravimetrijski. Potom su apsorbancije i masene koncentracije određene pomoću UV/VIS spektrofotometrije.

Ključne riječi: kofein, čaj, ekstrakcija, gravimetrija, UV-Vis spektrofotometrija



KOMPARATIVNA ANALIZA SADRŽAJA POLIFENOLNIH SPOJEVA I ANTIOKSIDATIVNE AKTIVNOSTI EKSTRAKATA PTIČJE GRAHORICE (*Vicia cracca* L.)

COMPARATIVE ANALYSIS OF POLYPHENOL COMPOUNDS CONTENT AND ANTIOXIDATIVE ACTIVITY OF BIRD VETCH (*Vicia cracca* L.) EXTRACTS

Lana Memišević, Lana Bećirović, Ismar Mujagić, Lana Cvijić, Emir Horozić
Katolički školski centar »Sveti Franjo« Opća gimnazija Tuzla, Klosterska 10, 75 000 Tuzla, Bosna i Hercegovina

Vicia cracca L. (ptičja grahorica) višegodišnja je biljka iz porodice Fabaceae, rasprostranjena na različitim staništima umjerenoga klimatskog pojasa. Bogata je brojnim sekundarnim metabolitima, među kojima se ističu flavonoidi i fenolni spojevi. U ovom radu ispitan je sadržaj polifenolnih spojeva te antioksidativna aktivnost vodenih, etanolnih i acetonskih ekstrakata ptičje grahorice pripremljenih metodom maceracije. Biljni materijal prikupljen je na dva lokaliteta u široj okolici grada Tuzle.

Sadržaj ukupnih polifenola određen je spektrofotometrijski primjenom Folin–Ciocalteu reagensa (FCR), dok je antioksidativna aktivnost procijenjena metodom inhibicije DPPH radikala te određivanjem redukcijske sposobnosti ekstrakata FRAP metodom. Dobiveni rezultati pokazali su da vodeni ekstrakti ptičje grahorice sadrže najveću količinu polifenolnih spojeva te istodobno iskazuju najizraženiju antioksidativnu aktivnost. Nasuprot tome, aceton se pokazao najmanje učinkovitim ekstrakcijskim sredstvom, pri čemu su zabilježene vrlo niske koncentracije polifenola i slaba antioksidativna aktivnost ekstrakata.

U odnosu na geografsko podrijetlo uzoraka nisu utvrđene značajne razlike u rezultatima provedenih analiza. Dobiveni nalazi pridonose boljem razumijevanju biološkog značaja ove biljne vrste te njezina potencijala kao prirodnog izvora bioaktivnih spojeva na području tuzlanske regije.

Ključne riječi: ekstrakcija, prirodni antioksidansi, slobodni radikali, polifenolni spojevi

BALNEOLOŠKA SVOJSTVA GEOTERMALNIH IZVORA U VUKOVARU
BALNEOLOGICAL PROPERTIES OF GEOTHERMAL SOURCES IN VUKOVAR

Antonija Milić[1], Elvira Kovač – Andrić[2], Sanja Pavlović Šijanović[1], Nikolina Filipović[2], Davor Šijanović[1], Stjepan Šarić[2], Erika Bainrauch[1], Ema Kumer[1], Nina Štrus[1], Anamarija Glavaš[1], Laura Kerek[1], Lea Samardžić

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Geotermalni izvori na području Vukovara predstavljaju jedinstven hidrogeološki sustav s povišenim udjelom mineralnih tvari i stabilnom termalnom dinamikom, što ih čini važnim predmetom balneoloških istraživanja. U sklopu ovog rada provedena je detaljna fizikalno-kemijska analiza geotermalnih voda u analitičkom laboratoriju Odjela za kemiju, s naglaskom na parametre poput temperature, električne vodljivosti, pH vrijednosti, ukupne mineralizacije, udjela karbonata, sulfata i kationa poput Ca^{2+}, Mg^{2+} i Na^{+}. Dobiveni rezultati uspoređeni su s dostupnim literaturnim podacima te klasifikacijom ljekovitih voda. [1] Poseban segment rada usmjeren je na edukaciju najmlađih kroz praktične demonstracije i laboratorijske vježbe koje približavaju koncept geotermalne energije, hidrogeologije i balneologije. Učenici su, kroz jednostavne analitičke postupke (mjerenje pH, određivanje tvrdoće i provodljivosti), imali priliku razumjeti ulogu geotermalnih sustava u prirodi i njihovu zdravstvenu, gospodarsku i ekološku važnost. Ovakav edukacijski pristup doprinosi razvoju znanstvene pismenosti i poticanju interesa za prirodne znanosti, a istovremeno podiže svijest o zaštiti i održivom korištenju geotermalnih resursa. Rezultati istraživanja ukazuju na to da geotermalne vode Vukovara imaju potencijal za primjenu u balneoterapiji, turizmu i budućim energetskim projektima, dok edukativni pristup doprinosi razvoju znanstvene pismenosti i poticanju interesa mladih za prirodne znanosti.

Ključne riječi: geotermalne vode, Vukovar, balneologija, fizikalno-kemijska analiza, edukacija

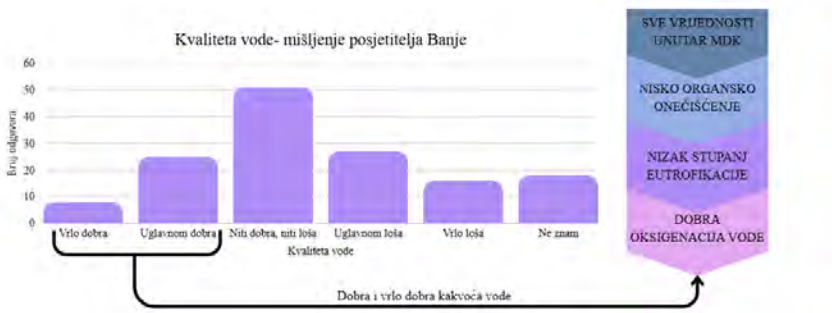
[1] M. Novak, *Balneologija i primjena mineralnih voda*, Sveučilišna naklada, Zagreb, 2020.

KAKVOĆA VODE JEZERA BANJA: USPOREDBA PERCEPCIJE I KEMIJSKIH POKAZATELJA
WATER QUALITY OF BANJA LAKES: COMPARISON OF PERCEPTION AND CHEMICAL INDICATORS

Lucija Vidaković, Maja Dubovicki
Gimnazija M. A. Reljkovića, Trg bana J. Šokčevića 1, 32100 Vinkovci, Hrvatska

Jezera Banja u Vinkovcima predstavljaju antropogeno-prirodni vodeni sustav nastao eksploatacijom gline i izviranjem podzemnih voda. Cilj rada bio je analizirati kemijske pokazatelje kakvoće vode te ih usporediti s percepcijom posjetitelja.
Polazište istraživanja bila je anketa među stanovnicima Vinkovaca, čiji su rezultati pokazali da dio ispitanika kvalitetu vode procjenjuje kao srednju ili lošiju. To je potaknulo provedbu kemijske analize radi objektivne procjene.
Uzorci vode analizirani su određivanjem ključnih fizikalno-kemijskih parametara (pH, KPK, BPK_5, dušik, fosfor i metali). Svi rezultati nalaze se unutar propisanih granica. Niske vrijednosti KPK i BPK_5 ukazuju na mali udio organskog onečišćenja, a niske koncentracije hranjivih tvari na nizak stupanj eutrofikacije. Metali su prisutni u tragovima i potječu iz geološke podloge.
Usporedba rezultata pokazuje nesklad između percepcije i stvarnog stanja vode, što se može objasniti vizualnim karakteristikama poput suspendiranih čestica i algi.
Zaključno, voda jezera Banja može se klasificirati kao dobra do vrlo dobra, što potvrđuje važnost kombiniranja anketnih i analitičkih metoda u procjeni kakvoće voda.

Ključne riječi: kakvoća vode, kemijska analiza, KPK, BPK_5, eutrofikacija



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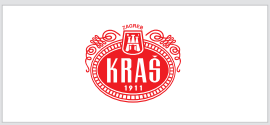
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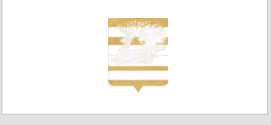


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Od svakodnevne laboratorijske analize do razvoja novih materijala, Anton Paar pruža rješenja za mjerenje gustoće i viskoznosti, određivanje reoloških svojstava, karakterizaciju čestica te analizu specifične površine i poroznosti.

Pomažemo vam odabrati odgovarajuće mjerno rješenje i podržavamo vaš rad kroz instalaciju, edukaciju i servis.

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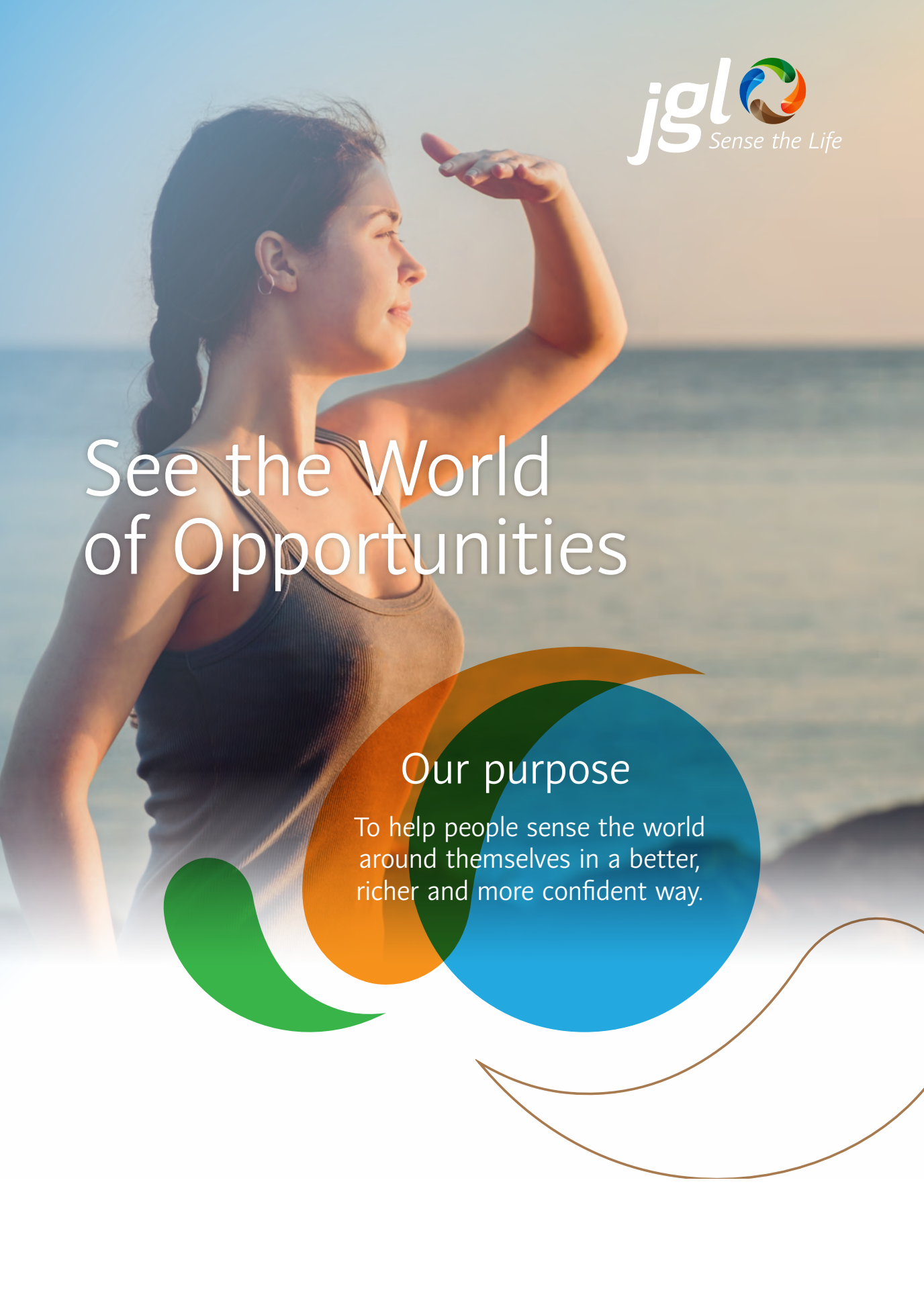
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Shimadzu je vodeći svjetski proizvođač analitičkih i mjernih instrumenata. Nudimo sofisticirana i optimalna rješenja neophodna za istraživanje, razvoj i kontrolu kvalitete.

Naša rješenja!

Sustavi za plinsku kromatografiju (GC) osiguravaju pouzdanu i osjetljivu analizu hlapljivih spojeva sadržanih u uzorku.

Masena spektrometrija s induktivno spregnutom plazmom (ICP-MS) je tehnika u kojoj se induktivno spregnuta plazma koristi kao ionizacijski izvor, a detekcija se vrši masenom spektrometrijom.

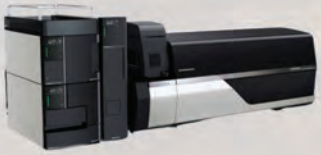
Spektrofotometri mjere intenzitet svjetlosti koju apsorbiraju ili emitiraju kemijske tvari.

Analizatori ukupnog organskog ugljika (TOC) mjere ukupnu količinu organskog ugljika u vodi, plinovima i čvrstim tvarima. Zadovoljavaju raznolik raspon potreba u područjima kao što su istraživanje okoliša, kontrola kvalitete i upravljanje procesima.

Sustavi za tekućinsku kromatografiju (LC) uspješno razdvaja tvari na osnovi razmještanja između čvrste stacionarne faze i tekuće mobilne faze.

Sustavi za plinsku kromatografiju - masenu spektrometriju (GC/MS) omogućuju brzu identifikaciju nepoznatih komponenti i preciznu kvantitativnu analizu, čak i za komponente u tragovima.

Sustavi za visoko učinkovitu tekućinsku kromatografiju (HPLC) podržavaju širok raspon aplikacija, uključujući analizu hrane, lijekova te uzoraka iz okoliša.



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Kroz kvalitetan servis, brz odziv i stručnu aplikativnu podršku gradimo dugoročno povjerenje i visoku razinu zadovoljstva korisnika.

Neprestano ulažemo u znanje – pohađamo stručne edukacije i organiziramo treninge kako bismo svojim korisnicima osigurali najnovija rješenja i najbolju podršku.

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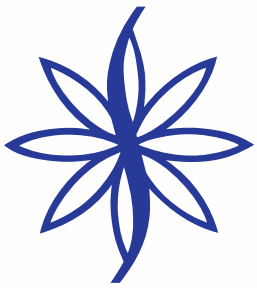

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Osiguravamo vrhunsku laboratorijsku podršku kroz distribuciju visokokvalitetnih proizvoda renomiranih svjetskih proizvođača. Svojim znanjem, iskustvom i kvalitetnim rješenjima podupiremo laboratorije u znanosti, industriji, medicini i dijagnostici.

Naš asortiman uključuje:

- Kemikalije i reagense za sve laboratorijske primjene
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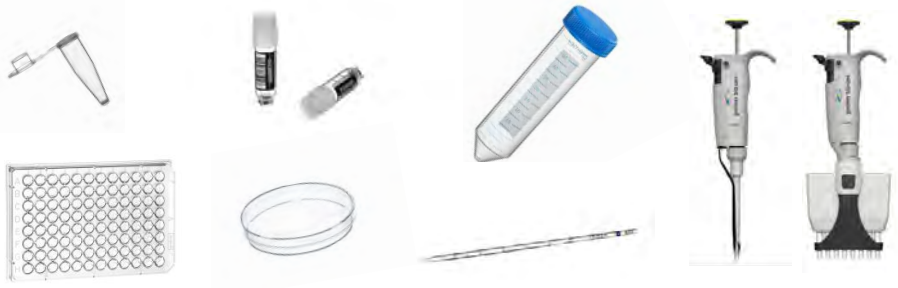

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II. skup laboratorijskih tehničara

9. – 11. rujna 2026., Vukovar

- **Predavanje:**
  Digitalna tranzicija u laboratoriju: virtualni asistent laboratorijskog tehničara
- **Radionica:**
  Kratki vodič za upravljanje stresom na radnom mjestu
- **Interaktivni kviz:**
  Pokažite svoje laboratorijsko znanje i vještine
- **Panel rasprava:**
  Kemijski tehničar nekad i sad, sličnosti, razlike i izazovi
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