

**VOL. 1
NO. 1**

OCTOBER 2026.



ISSN 3126 - 4085

SCIENTIFIC/PROFESSIONAL JOURNAL

PHARMACY OF THE FUTURE

**JOURNAL OF THE FACULTY OF PHARMACY
UNIVERSITY OF TUZLA**

**TUZLA,
BOSNIA AND HERZEGOVINA**

EDITOR- IN-CHIEF: Dr.sc. Amra Džambić (Tuzla, BiH)

DEPUTY EDITORS: Mr.ph. Alen Hatkić (Tuzla, BiH)
Mr.ph. Lamija Kolarević (Tuzla, BiH)

SCIENTIFIC BOARD:

1. Dr.sc. Aida Smajlović (Tuzla, BiH)
2. Dr.sc. Adaleta Softić (Tuzla, BiH)
3. Dr.sc. Saša Pilipović (Sarajevo, BiH)
4. Dr.sc. Broza Šarić-Kundalić (Tuzla, BiH)
5. Dr.sc. Lejla Begić (Tuzla, BiH)
6. Dr.sc. Nahida Srabović (Tuzla, BiH)
7. Dr.sc. Alija Uzunović (Sarajevo, BiH)
8. Dr.sc. Midhat Jašić (Tuzla, BiH)
9. Dr.sc. Ermina Čilović Kozarević (Tuzla, BiH)
10. Dr.sc. Maida Šljivić-Husejnović (Tuzla, BiH)
11. Dr.sc. Esmeralda Dutović (Tuzla, BiH)
12. Dr.sc. Merima Ibišević (Tuzla, BiH)
13. Dr.sc. Dalila Haličević (Tuzla, BiH)

EDITORIAL BOARD:

1. Dr.sc. Jasmin Suljagić (Tuzla, BiH)
2. Dr.sc. Zorica Vujić (Beograd, Serbia)
3. Dr.sc. Nafija Serdarević (Sarajevo, BiH)
4. Dr.sc. Anđelka Lukić Račić (Banja Luka, BiH)
5. Dr.sc. Haris Nikšić (Sarajevo, BiH)
6. Dr.sc. Lana Lekić (Sarajevo, BiH)
7. Dr.sc. Tijana Kovačević (Banja Luka, BiH)
8. Dr.sc. Dušanka Krajnović (Belgrade, Serbia)
9. Dr.sc. Kemal Durić (Sarajevo, BiH)
10. Dr.sc. Ivana Nešić (Niš, Serbia)
11. Dr.sc. Žarko Gagić (Banja Luka, BiH)
12. Dr.sc. Veljko Krstonošić (Novi Sad, Serbia)
13. Dr.sc. Nataša Bubić Pajić (Banja Luka, BiH)
14. Dr.sc. Ana Šešelja Perišin (Split, Croatia)
15. Dr.sc. Relja Suručić (Banja Luka, BiH)
16. Dr.sc. Josipa Bukić (Split, Croatia)
17. Dr.sc. Martin Kondža (Mostar, BiH).

PUBLISHER: Faculty of Pharmacy, University of Tuzla
Urfeta Vejzagića 8, 75000 Tuzla
Bosnia and Herzegovina
<http://frmf.untz.ba>

Pharmacy of the Future is the official journal of the international scientific conference "Pharmacy of the Future", organized annually by the Faculty of Pharmacy, University of Tuzla

Prepress and Design: Bajrić Adela (Tuzla, Bosnia and Herzegovina)

According to the decision of the NNV of the Faculty of Pharmacy,
University of Tuzla, number: 02/13-1-8313-1-9.2/25.



CONTENTS

RIJEČ UREDNIKA	7
----------------------	---

ABSTRACTS

<i>Emina Ahmetović, Maida Šljivić Husejnović</i> THERAPEUTIC POSSIBILITIES AND HEALTH RISKS OF MINERAL WATER FROM THE CRNI GUBER SPRING IN SREBRENICA.....	10
---	----

<i>Demir Bjelošević, Tomislav Klapac, Maida Šljivić Husejnović</i> TOXICOLOGICAL RISK ASSESSMENT OF ARTIFICIAL SWEETENER INTAKE IN RELATION TO AGE, SEX, AND BMI IN THE POPULATION OF TUZLA CANTON.....	12
--	----

<i>Emina Borogovac, Halid Junuzović, Azra Suljić, Zerina Mujić, Maida Šljivić Husejnović</i> THE PHYSICOCHEMICAL ANALYSIS OF WELL WATER FROM KALESIJA AREA, BOSNIA AND HERZEGOVINA	14
--	----

<i>Amna Hasić, Alisa Karić, Amina Husejbašić, Inela Avdić, Selma Sejmenović, Ermina Cilović Kozarević, Merima Ibišević</i> ROLE OF PHARMACISTS IN THE TREATMENT OF ATOPIC DERMATITIS	16
--	----

<i>Amina Hasikić, Laura Divković, Ajla Džafić, Hedija Starčević, Samir Ćurić, Emina Ahmetović, Belkisa Djedović, Sumea Haušić, Lamija Kolarević, Merima Ibišević, Ermina Cilović Kozarević, Aida Smajlagić</i> EFFECT OF METHOD AND SOLVENT ON YIELD AND ANTIOXIDANT ACTIVITY OF POMEGRANATE PEEL EXTRACTS (LAT. <i>PUNICA GRANATUM L.</i>).....	17
--	----

<i>Faruk Kajtazović, Zerina Mujić, Šejla Haseljić, Merima Ibišević, Ermina Cilović Kozarević, Maida Šljivić Husejnović</i> CONTENT AND ASSESSMENT OF FLUORIDE INTAKE FROM BLACK AND GREEN TEA (<i>CAMELIA SINENSIS</i>) INFUSION.....	19
---	----

ORIGINAL SCIENTIFIC PAPERS

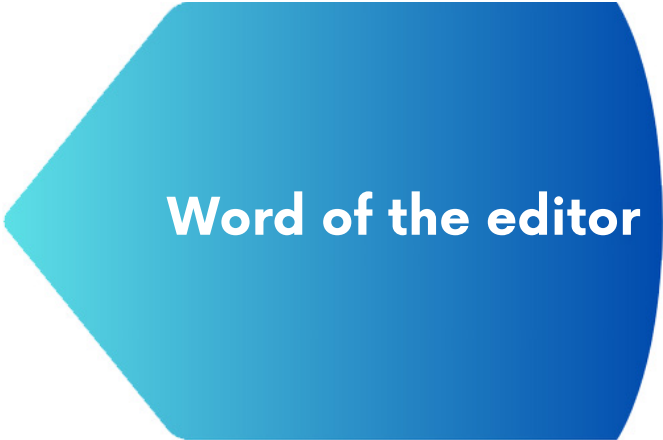
<i>Nadira Kunić, Enida Karić, Maida Šljivić Husejnović, Merima Ibišević</i> EVALUATION OF THE EFFICACY OF SKIN CLEANSING FORMULATIONS WITH THE TEA TREE ESSENTIAL OIL (<i>MELALEUCA ALTERNIFOLIA</i>).....	22
---	----

REVIEW PAPERS

<i>Mirha Terzić, Merima Ibišević</i> COSMETOVIGILANCE: REGULATORY OVERSIGHT OF COSMETIC PRODUCT SAFETY FROM RESEARCH TO MARKET	34
---	----

PROFESSIONAL PAPERS

<i>Martin Kondža</i> FIP'S GLOBAL FRAMEWORK FOR ETHICAL AND EFFECTIVE IMPLEMENTATION OF AI IN PHARMACY	46
--	----



Word of the editor

We are proud to introduce the inaugural issue of *Pharmacy of the Future*, an international, peer-reviewed journal written by pharmacists and for pharmacists. This publication is dedicated to navigating the critical intersection of advanced biomedical sciences, computational tools, and frontline pharmaceutical practice.

The global healthcare landscape is experiencing an irreversible transformation driven by breakthrough discoveries in the biomedical sciences. The traditional role of the pharmacist as a back-counter dispenser of mass-manufactured commercial products is rapidly becoming obsolete. Advanced robotics, automated dispensing hubs, and artificial intelligence are quickly absorbing routine administrative tasks. Rather than marginalizing our profession, this technological shift serves as a powerful catalyst. It liberates frontline pharmacists from mechanical workflows, allowing us to serve as the vital clinical translators of complex biomedicine directly to the patient.

This journal was established to serve as an academic blueprint and practical compass for the modern pharmacist. As the biomedical sciences introduce highly sophisticated, patient-specific therapies, the healthcare system requires an accessible expert to manage their selection, delivery, and monitoring. *Pharmacy of the Future* provides the empirical research, evidence-based case studies, and clinical data necessary to transform daily practice into a proactive, technology-enabled health hub.

This first edition establishes the foundational scientific pillars necessary to reshape our workflows across diverse global healthcare systems:

- **Artificial Intelligence in Pharmacy:** Evaluating machine learning models for predicting adverse drug events, AI-driven clinical decision support systems, and automated therapeutic optimization at the patient level.
- **Biochemistry and Medicinal Chemistry:** Investigating the clinical translation of novel small molecules, targeted macromolecular interactions, and the molecular mechanisms of drug resistance.
- **Bromatology and Nutraceuticals:** Analyzing food-drug interactions, the therapeutic efficacy of bioactive food compounds, and the pharmacist's role in guiding metabolic health and nutrition.

- **Pharmacognosy and Natural Products:** Documenting the isolation, standardization, and clinical efficacy of plant-derived therapeutics, bridging traditional knowledge with modern evidence-based pharmacy.
- **Pharmaceutical Technology:** Exploring advanced drug delivery systems, nanotechnology, 3D-printed personalized medications, and digital manufacturing workflows within clinical settings.
- **Toxicology and Safety:** Evaluating environmental toxins, mechanisms of cellular toxicity, and clinical protocols for managing adverse drug toxicities and poisoning.

This global professional evolution will inevitably face structural challenges, including legislative resistance, workplace burnout during systemic transitions, and fragmented health data systems. As a global community of practitioners, we must meet these hurdles with rigorous, undeniable evidence.

Editor-in-Chief

Pharmacy of the Future



ABSTRACTS

Emina Ahmetović¹
Maida Šljivić Husejnović²

THERAPEUTIC POSSIBILITIES AND HEALTH RISKS OF MINERAL WATER FROM THE CRNI GUBER SPRING IN SREBRENICA

ABSTRACT

Introduction: Mineral waters that originate from natural springs contain numerous minerals essential for the normal functioning of the human body. Long-term exploitation of ores from the Srebrenica basin has left behind numerous mining-shafts, tunnels, and pits, which contributed to the emergence of many mineral springs on the surface of the ground. The Crni Guber spring differs from other springs in Bosnia and Herzegovina due to its specific composition, particularly its high concentration of iron. In addition to iron, chemical analyses have confirmed the presence of other elements such as sodium, potassium, magnesium, strontium, barium, aluminum, manganese, zinc, lead, copper and arsenic. According to its chemical properties, there are similar springs in other parts of the world, but Guber water has a more complete mineral profile and contains less arsenic compared to others, which allows its use without dilution. The name Guber water derives from its use at the beginning of the 19th century in the treatment of skin diseases, especially leprosy, and today, in addition to skin disorders, it is also used in the treatment of anemia, gastrointestinal disorders, eye diseases, sinusitis and more.

Aim of the study: To review and analyze existing data on the use of Guber water through a historical and contemporary context, to investigate its chemical composition and possible effects on treatment outcomes, and to assess potential health risks and therapeutic benefits.

Materials and methods: A review of available literature, chemical analyses, clinical data, and previously published studies addressing the medicinal properties of Guber mineral water.

Results: Existing data suggest that Guber water may have a positive effect in the treatment of anemia and skin diseases; however, negative effects have also been reported, such as gastrointestinal disturbances and the potential risk of excessive iron intake.

Conclusion: Based on the obtained data, the goal is to provide recommendations and guidelines

1 Emina Ahmetović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina, E-mail: emina.ahmetovic@live.com

2 Maida Šljivić Husejnović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina

for the safe use of mineral water from the Crni Guber spring in Srebrenica, thereby contributing to the protection of human health and safety. Given the specific composition of this mineral water and the presence of the carcinogenic metal arsenic, improper or excessive use may lead to serious consequences, particularly, among vulnerable groups, such as patients with cardiovascular and renal diseases.

Keywords: *Guber water; mineral water; arsenic; iron*

Correspondent author: Emina Ahmetović

Phone: (+387) 62 583 387

E-mail: emina.ahmetovic@live.com

Demir Bjelošević¹
Tomislav Klapac²
Maida Šljivić-Husejnović³

TOXICOLOGICAL RISK ASSESSMENT OF ARTIFICIAL SWEETENER INTAKE IN RELATION TO AGE, SEX, AND BMI IN THE POPULATION OF TUZLA CANTON

ABSTRACT

Introduction: The number of obese individuals worldwide is steadily increasing. One of the approaches to reducing body weight is the consumption of non-alcoholic carbonated beverages sweetened with non-caloric artificial sweeteners. **Objective:** The aim of this study was to assess the intake of artificial sweeteners through selected non-alcoholic carbonated beverages in the population of Tuzla Canton, and to determine the relationship of intake with age, sex, and BMI, as well as to evaluate the health risk using deterministic and semi-probabilistic approaches. **Participants and Methods:** Participants from the Tuzla Canton area completed a questionnaire on the consumption of non-alcoholic carbonated beverages. The intake of artificial sweeteners was estimated based on the assumption that these beverages contained the maximum permitted concentrations of artificial sweeteners in accordance with the Rulebook on Food Additives of Bosnia and Herzegovina. Statistical analysis was performed using MS Office Excel (Microsoft) and Statistica (TIBCO Software). Monte Carlo simulations were conducted using IPSS (IBM), and, in order to achieve a more realistic estimation of intake, experimentally determined concentrations of artificial sweeteners in cola beverages available on the German market were applied.

Results and Discussion: Higher intake of these sweeteners was recorded among younger individuals (<30 years), males, and those with higher BMI (>25), with a statistically significant difference observed between age categories. The estimated intakes of aspartame, acesulfame-K, and cyclamate were below the acceptable daily intake thresholds. The deterministic approach to risk assessment did not indicate an increased risk of exposure to these sweeteners, nor did the more realistic probabilistic approach.

1 Demir Bjelošević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagica 8, Tuzla 75000, B&H; Faculty of Food Technology Osijek, University of Osijek, Franje Kuhaca 18, Osijek 31 000, Croatia, E-mail: demir.bjelosevic@untz.ba

2 Tomislav Klapac, Faculty of Food Technology Osijek, University of Osijek, Franje Kuhaca 18, Osijek 31000, Croatia

3 Maida Šljivić-Husejnović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagica 8, Tuzla 75000, B&H

Conclusion: The population of Tuzla Canton consumes acceptable amounts of artificial sweeteners through non-alcoholic carbonated beverages and is not at an increased health risk.

Key words: *artificial sweeteners, risk assessment*

Corresponding author:

Mr ph Demir Bjelošević, Teaching Assistant

Phone: +38761952589

E-mail: demir.bjelosevic@untz.ba

Emina Borogovac¹
Halid Junuzović²
Azra Suljić³
Zerina Mujić⁴
Maida Šljivić Husejnović⁵

THE PHYSICOCHEMICAL ANALYSIS OF WELL WATER FROM KALESIJA AREA, BOSNIA AND HERZEGOVINA

ABSTRACT

Introduction: Water is a key resource for life and wells represent an alternative source compared to surface water and centralized water supply systems. However, well water can contain toxic contaminants, including heavy metals and inorganic anions, which represent a potential health risk.

Aim of the work: The aim of the study was to examine the physicochemical characteristics of well water, identify the contaminants present and assess its suitability for drinking.

Material and methods: In the spring of 2023, eighteen well water samples were collected from two localities in Kalesija Municipality (Vukovije Gornje and Rainci Donji). Analyzes included the determination of basic physicochemical parameters (organoleptic properties, alkalinity, pH value, electrical conductivity and density), potentiometric determination of fluoride content (F⁻) and spectrometric determination of heavy metal content (manganese (Mn), arsenic (As), lead (Pb) and cadmium (Cd)). All analyzes were performed in triplicate and the obtained results were statistically processed and interpreted in accordance with the valid drinking water quality standards.

Results with discussion: The samples from Vukovije Gornje well showed a lower pH value (6.45) compared to the national standard for drinking water. Also, all samples from this locality contained elevated concentrations of F⁻ (100.1-200 μmol/l). The concentrations of As, Mn and Cd in the water samples were below the detection limit. On the other hand, Pb was detected in all samples, with average concentrations of 0.04 ± 0.01 mg/l in Vukovije Gornje and 0.05 ± 0.01 mg/l in Rainci Donji. Other physicochemical parameters of water were within expected limits and did not indicate deviations from standard values.

-
- 1 Emina Borogovac, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina
 - 2 Halid Junuzović, Faculty of Technology, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina
 - 3 Azra Suljić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina
 - 4 Zerina Mujić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina, E-mail: zerina.mujić@untz.ba
 - 5 Maida Šljivić Husejnović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina

Conclusion: The results indicate that Pb is the most significant contaminant in well water with concentrations far exceeding international limits, while elevated concentrations of F⁻ were observed only in samples from well in Vukovije Gornje. These findings underscore the need for further comprehensive analyses to more precisely identify the sources of contamination and to assess potential health risks with the ultimate goal of protecting public health and ensuring the safety of the local water supply.

Keywords: *well water, analysis, lead, fluoride, contamination*

Corresponding author: Zerina Mujić, assistant

Phone: +38762198246

E-mail: zerina.mujic@untz.ba

Amna Hasić¹
Alisa Karić
Amina Husejbašić
Inela Avdić
Selma Sejmenović
Ermina Cilović Kozarević
Merima Ibišević

ROLE OF PHARMACISTS IN THE TREATMENT OF ATOPIC DERMATITIS

ABSTRACT

Atopic dermatitis (AD), also known as atopic eczema, is a chronic inflammatory, non-infectious skin condition frequently associated with atopic syndrome, including diseases such as bronchial asthma and allergic rhinitis. The etiology of the disease involves complex interactions between immunological, genetic, and environmental factors. Clinical manifestations include skin dryness and erythema, intense itching, and the presence of eczematous lesions.

The aim of this study is to explore and define the role of pharmacists in the management of atopic dermatitis. With appropriate therapeutic approaches, symptoms can be effectively controlled and exacerbations prevented. Pharmacists play a key role by counseling patients on the correct use of medications, educating them about daily skin care, identifying and avoiding triggers, and providing recommendations regarding diet and lifestyle. They also actively participate in monitoring therapy progress and adjusting treatment according to the individual needs of patients, thereby contributing to reduced hospitalizations and emergency interventions.

In addition to pharmacotherapeutic aspects, pharmacists provide significant emotional support through empathetic counseling and psychological assistance to patients coping with the challenges of this chronic disease. Through multidisciplinary collaboration and continuous education, pharmacists considerably contribute to improving the quality of life of individuals with atopic dermatitis.

Keywords: *atopic dermatitis, education, therapy, skin care, prevention*

Corresponding author: Amna Hasić
Phone: (+387) 60 30 49 120
E-mail: hasic.amna.online@gmail.com

¹ Amna Hasić, Faculty of Pharmacy, University of Tuzla,, Urfeta Vejzagića 8, 75000 Tuzla, Bosna i Hercegovina,
E-mail: hasic.amna.online@gmail.com

Amina Hasikić¹
Laura Divković²
Ajla Džafić³
Hedija Starčević⁴
Samir Ćurić⁵
Emina Ahmetović⁶
Belkisa Djedović⁷
Sumea Haušić⁸
Lamija Kolarević⁹
Merima Ibišević¹⁰
Ermina Cilović Kozarević¹¹
Aida Smajlagić¹²

EFFECT OF METHOD AND SOLVENT ON YIELD AND ANTIOXIDANT ACTIVITY OF POMEGRANATE PEEL EXTRACTS (lat. *Punica granatum L.*)

ABSTRACT

Introduction: Pomegranate peel (lat. *Punica granatum L.*) is recognized as a rich source of polyphenols with pronounced biological activity. Bioactive compounds, including ellagic acid, gallic acid, punicalin, ellagitannins, and flavonoids, show significant antioxidant effects, which are reflected in their ability to form complexes with metal ions and remove free radicals that lead to oxidative stress.

Aim of the study: To compare the efficiency of different extraction methods and solvents on the extraction yield and antioxidant activity of pomegranate peel extracts.

- 1 Amina Hasikić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
E-mail: amina.hasikic@untz.ba
- 2 Laura Divković, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 3 Ajla Džafić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 4 Hedija Starčević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 5 Samir Ćurić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 6 Emina Ahmetović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 7 Belkisa Djedović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 8 Sumea Haušić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 9 Lamija Kolarević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 10 Merima Ibišević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 11 Ermina Cilović Kozarević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 12 Aida Smajlagić, Department of Chemistry, Faculty of Natural Sciences and Mathematics, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina

Materials and methods: The extracts were obtained using three extraction methods: ultrasonic extraction, Soxhlet extraction, and traditional maceration. Methanol and 96% ethanol were used as extraction solvents. After solvent removal, dry extracts were obtained. The antioxidant activity of the extracts was determined using the DPPH method (2,2-diphenyl-1-picrylhydrazyl, DPPH). The results were expressed as IC₅₀ (µg/mL) values.

Results and discussion: The highest extraction yield was achieved by Soxhlet extraction with methanol as solvent (33.5%), and the lowest by maceration with 96% ethanol (7.33%). Methanol extracts showed higher yields, regardless of the extraction technique. However, the highest antioxidant activity was demonstrated for the ethanol extract obtained by ultrasonic extraction (IC₅₀ = 19.049 µg/mL), and the lowest for the ethanol extract obtained by Soxhlet extraction (IC₅₀ = 34.210 µg/mL). Although Soxhlet extraction yields the highest extraction yield, elevated temperatures lead to the thermal degradation of polyphenolic compounds, which correlates with a reduced antioxidant activity in the obtained extracts. Also, due to the toxicity of methanol, preference is given to ethanolic extracts. Ethanol, as a semipolar solvent, proved to be more efficient in extracting a large number of antioxidant compounds, especially partially polar compounds such as ellagic acid.

Conclusion: The obtained results indicate the importance of carefully selecting the extraction method and solvent to maximize the preservation of bioactive compounds. The combination of ultrasonic extraction and 96% ethanol proved to be the most effective and acceptable in terms of safety, efficiency, and future application in the cosmetic and pharmaceutical industry.

Keywords: *pomegranate peel, extraction, polyphenolic compounds, antioxidant activity*

Corresponding author: Amina Hasikić

Phone: (+387) 62 123 132

E-mail: amina.hasikic@untz.ba

Faruk Kajtazović¹
Zerina Mujić²
Šejla Haseljić³
Merima Ibišević⁴
Ermina Cilović Kozarević⁵
Maida Šljivić Husejnović⁶

CONTENT AND ASSESSMENT OF FLUORIDE INTAKE FROM BLACK AND GREEN TEA (*CAMELIA SINENSIS*) INFUSION

ABSTRACT

Fluorides are widely distributed in the environment, especially in water, soil, food and industrial products. Although the role in caries prevention is dominant, excessive intake of fluoride can cause serious health consequences, including dental and skeletal fluorosis. Black and green tea (*Camellia sinensis*) are recognized as notable dietary sources of fluoride due to its accumulation in tea leaves during growth. Considering the worldwide popularity of tea and the potential risk of exceeding the recommended fluoride intake, it is important to assess fluoride levels in tea infusions and the associated health risks.

The aim of this study was to determine fluoride content in black and green tea infusions from the local market using potentiometric analysis, and to evaluate estimated daily intake (EDI) and health risk (HQ) across different population groups. Twelve tea samples (5 black and 7 green) were analyzed. The mean fluoride concentration in black teas was 5.56 ± 1.94 mg/L, while in green teas it was 3.90 ± 2.09 mg/L. In three samples, fluoride concentration increased with longer infusion times, whereas in others it declined after prolonged extraction.

Deterministic risk assessment indicated that EDI from tea consumption did not exceed recommended values for adults, and HQ remained <1 in all cases, suggesting that consumption of black and green teas from the local market does not pose a significant health risk regarding fluoride exposure. The results confirmed that tea can be an important source of fluoride in the daily diet, but that moderate consumption does not exceed the maximum permissible daily values.

- 1 Faruk Kajtazović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina, E-mail: kajtazovicfaruk1@gmail.com
- 2 Zerina Mujić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 3 Šejla Haseljić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 4 Merima Ibišević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 5 Ermina Cilović Kozarević, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
- 6 Maida Šljivić Husejnović, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina

These findings will contribute to the understanding of the role of tea as a source of fluoride in the daily diet and highlight the need for continuous monitoring of tea quality in order to reduce potential health risks.

Keywords: *fluorides, black and green tea, infusion, risk assessment*

Corresponding author: Faruk Kajtazović

Phone: +387 62 948 946

E-mail: kajtazovicfaruk1@gmail.com



**ORIGINAL SCIENTIFIC
PAPERS**

Nadira Kunić¹
Enida Karić²
Maida Šljivić Husejnović³
Merima Ibišević⁴

EVALUATION OF THE EFFICACY OF SKIN CLEANSING FORMULATIONS WITH THE TEA TREE ESSENTIAL OIL (*Melaleuca alternifolia*)

ABSTRACT

Introduction: In the modern-day cosmetics industry, demand for natural and effective skin care product is constantly on the rise. Tea tree essential oil (*Melaleuca alternifolia*) is a rich source of terpenes including terpinen-4-ol, α -terpinolene, 1,8-cineole and α -terpinene, which show significant antimicrobial and antiseptic activity. This is attributed to their ability to disrupt the structural and functional integrity of microorganism cell membranes. This makes it one of the most promising ingredients in formulations for treating various dermatological conditions, such as acne, fungal infections, dandruff, superficial wounds, and skin irritations.

Study objective: To compare the efficacy of formulations with tea tree oil and their potential effects on blemish-prone skin.

Materials and methods: The antimicrobial activity of the formulations was tested using Kirby-Bauer disk diffusion method. The analysis utilized six reference bacterial strains, including four Gram-positive strains (*Listeria monocytogenes* WDCM 00021, *Staphylococcus aureus* WDCM 00034, *Enterococcus faecalis* WDCM 00087 and *Bacillus subtilis* WDCM 00003) and two Gram-negative strains (*Escherichia coli* WDCM 00012 and *Klebsiella pneumoniae* WDCM 00097). Additionally, the effect on sebum secretion in volunteer participants was evaluated using a Sebumeter SM 815.

Results and discussion: The results of the microbiological tests showed sensitivity in three out of six tested bacterial strains, with the formation of distinct zones of inhibition. Formulation testing indicated satisfactory physicochemical stability and good tolerability during regular application on the skin. The bioengineering method proved to significantly reduce the amount of sebum after using the formulation, which further confirms its effectiveness in treating oily and problematic skin.

1 Nadira Kunić, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Herzegovina, E-mail: kunic.nadira@gmail.com

2 Enida Karić, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Herzegovina

3 Maida Šljivić Husejnović, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Herzegovina

4 Merima Ibišević, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Herzegovina

Conclusion: The obtained results indicate the potential application of these preparations as a natural alternative in the everyday care of skin prone to imperfections.

Keywords: essential tea tree oil, Melaleuca alternifolia, skin, antimicrobial activity, skin bio-engineering, natural cosmetics

Corresponding author: Nadira Kunić

Phone: (+387) 64 4260 537

E-mail: kunic.nadira@gmail.com

Nadira Kunić⁵
Enida Karić⁶
Maida Šljivić Husejnović⁷
Merima Ibišević⁸

EVALUATION OF THE EFFICACY OF SKIN CLEANSING FORMULATIONS WITH THE TEA TREE ESSENTIAL OIL (*Melaleuca alternifolia*)

ABSTRACT

Acne is the most common benign dermatosis caused by inflammatory changes in the pilosebaceous unit. It primarily occurs during adolescence, manifesting as lesions most frequently on the face, neck, arms, and back. Key causative factors include increased sebum production, pore clogging due to retention hyperkeratosis, the normal activity of skin microorganisms (*Cutibacterium acnes* and *Staphylococcus aureus*), and inflammation.

Sebum is a fatty substance produced by the activity of sebaceous glands located throughout the body, with the highest concentration in the facial and scalp areas. Physiologically, sebum serves to protect and hydrate human skin, thereby maintaining its homeostasis. Excessive production (influenced by numerous factors) can lead to issues such as oily skin and scalp, excessive shine and the appearance of acne.

Facial cleansing foams and gels are suitable formulations for cleansing oily and acne-prone skin. A particular advantage of their use lies in gentle skin cleansing without excessive drying or irritation. Tea tree essential oil (TTO), containing monoterpene and sesquiterpene components and their associated alcohols, exhibits antimicrobial, antiseptic, and anti-inflammatory activities, and helps reduce skin irritation. These properties make it one of the most promising components in formulations intended for treatment of various dermatological conditions, such as acne, fungal infections, dandruff, superficial wounds, and skin irritations.

5 Nadira Kunić, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Hercegovina, E-mail: kunic.nadira@gmail.com

6 Enida Karić, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Hercegovina

7 Maida Šljivić Husejnović, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Hercegovina

8 Merima Ibišević, Faculty of Pharmacy, University of Tuzla, Dr. Tihomila Markovića 1, 75 000 Tuzla, Bosnia i Hercegovina

This study explores the effectiveness of tea tree oil as an active component in formulations for cleansing oily and problematic skin, the stability of the developed formulations, their antimicrobial activity, alongside *in vivo* testing on volunteers. Measurements of skin sebum production, before and after use of formulations, were performed using the MPA 6 bioengineering device.

Key words: *tea tree oil, Melaleuca alternifolia, skin care, antimicrobial activity, skin bioengineering, natural cosmetics*

Corresponding author: Nadira Kunić

Phone: (+387) 64 4260 537

E-mail: kunic.nadira@gmail.com

INTRODUCTION

Australian Tea Tree (*Melaleuca alternifolia*) is a large shrub or a small tree in the myrtle family, *Myrtaceae*, 5 to 7 meters in height, endemic to Australia. The narrow, needle-like leaves of the tea tree contain glands that produce essential oil, which is obtained from the plant material through the process of steam distillation.

Tea tree oil has been proven to contain terpene hydrocarbons, primarily represented by monoterpenes, sesquiterpenes, and their associated alcohols [1]. Key components of the oil, such as terpinen-4-ol and 1,8-cineole, greatly contribute to its antibacterial, antiviral and antifungal properties. α -pinene i β -pinene contribute to its antiseptic properties, while limonene gives the tea tree oil its characteristic fresh and citrus scent.

The mechanism of antimicrobial activity of tea tree oil is based on disrupting the integrity and function of the cell membrane, leading to the loss of intracellular material, the inability to maintain homeostasis, and the inhibition of cellular respiration in microorganisms. This activity occurs as a result of the action of primarily the terpinen-4-ol component, but also through complex interactions with various other components, such as 1,8-cineole, α -terpinene, γ -terpinene, terpinolene, and others. [2]

Cutibacterium acnes, the microorganism responsible for the development of acne, metabolizes sebum lipids into free fatty acids, thereby triggering an inflammatory process by releasing IL-1 β from monocytes and promoting perifollicular inflammation. Studies on the effect of tea tree oil and its components have concluded that terpenes have the ability to reduce the expression of IL-1 β , IL-6 and TNF- α , both in specific macrophage cell lines and in *in vivo* models, such as Swiss mice and other rodents. [3]



Figure 1: Australian Tea Tree (*Melaleuca alternifolia*)

In cosmetology, numerous studies have been conducted on the effects of tea tree oil and its application in the treatment of skin conditions, such as acne, fungal infections, wounds, and irritations. Tea tree oil is frequently used in cosmetic formulations for the treatment of oily and acne-prone skin.

Various dermocosmetic formulations are used in the treatment of oily skin, with particular importance given to foams and gels. Foams and gels easily reach all parts of the skin, including hair-covered areas. [4] Due to their gentle cleansing action, they deeply clean the skin and remove excess sebum without disrupting its natural moisture or leaving a feeling of tightness after use.

The aim of this study is to examine the efficacy of tea tree oil as an active component in formulations for cleansing oily and problematic facial skin, the stability of the developed formulations, their antimicrobial activity, as well as *in vivo* testing on volunteers.

MATERIALS AND METHODS

All raw materials used in the research were obtained from the companies *Volimo prirodno*

(Volimo prirodno d.o.o., Mostar, Bosna and Hercegovina) and *BM Logistic* (BM Logistic d.o.o., Sarajevo, Bosna and Hercegovina). The efficacy of the formulations was then tested using the MPA 6 skin bioengineering device (Courage+Khazaka), with a sebumeter SM 815.

Formulating the tea tree oil-based cleansing foam

The production of the facial cleansing foam began by mixing the appropriate amounts of lavender hydrolate, glycerin, and preservative (*Geogard 221*) at room temperature ($22\pm 2^{\circ}\text{C}$). The surfactants (*Coco-glucoside* and *Cocamidopropyl betaine*) were added to the mixture, ensuring the proper dissolution of tea tree oil, which was then added and blended with the rest of the ingredients to achieve a uniform solution. The quantities of raw materials used in the formulation of the tea tree oil-based cleansing foam are detailed in the *Table 1*.

Table 1: Quantities of raw materials used in the formulation of tea tree oil-based cleansing foam

Components	Amount (g)
Lavander hydrolate	74.0
Coco-glucoside	15.0
Vegetable glycerin	5.0
Cocamidopropyl betaine	5.0
Tea tree oil	0.5
Geogard 221	0.5

Formulating the tea tree oil-based cleansing gel

The production of the facial cleansing gel was done in three phases. Phase A began by mixing the appropriate amounts of distilled water and glycerin. The gelling agent (*Xanthan gum*) is then gradually added to the solution with continuous stirring until a gel is formed. Once formed, the gel is left to rest for 10 – 15 minutes, to allow for complete thickening.

Phase B introduces surfactants to the fully formed gel, combining the two gently, manually stirring to prevent the formation of foam.

In phase C, in a separate beaker, the solubilizer (*Polysorbate 20*) and tea tree oil are mixed. Once the two ingredients have combined, glycerin, panthenol, and *Geogard 221* are added and thoroughly mixed. Phase C is then combined with the prepared gel until a uniform product is achieved. The quantities of raw materials used in the formulation of the tea tree oil-based cleansing gel are detailed in the *Table 2*.

Table 2: Quantities of raw materials used in the formulation of tea tree oil-based cleansing gel

Phase	Components	Amount (g)
A	Distilled water	63.0
A	Vegetable glycerin	5.0
A	Xantan Gum	0.5
B	Coco-glucoside	15.0
B	Cocamidopropyl betaine	10.0
C	Tea tree oil	0.5
C	Polysorbate 20	2.0
C	Panthenol	3.0
C	Geogard 221	1.0

Testing the pH value of tea tree oil-based cleansing foam and gel

Immediately after the preparation of the formulations, the pH value of the tested cleansing foam and gel samples were determined potentiometrically at room temperature ($22\pm 2^{\circ}\text{C}$). The cleansing foam and gel were stored at room temperature during their testing. The recommended pH range for cosmetic skin cleansing products is between 3.0 and 9.0. [5]

Testing the effectiveness of tea tree oil-based cleansing foam and gel on sebum levels

The study was approved by the Ethical Committee for Scientific Research University of Tuzla (03/8-2943-2.2/26). It was conducted at the Faculty of Pharmacy, University of Tuzla, following the use of tea tree oil-based formulations on volunteers.

Participants and procedure

The study involved 12 participants, men and women aged between 20 and 27 years, with normal to oily skin type and acne-prone skin. All participants were volunteers who had previously signed and informed consent, containing details on objectives and procedures of the research. Each participant was verbally instructed on how to use the formulation, as well as the scheduled skin parameter measurement appointments.

The verbal instructions included the regular application of the cleansing formulations twice per day, in the morning and in the evening. The participants were instructed to clean their faces using only provided formulations and rinse with lukewarm water, with no additional skincare or cosmetic product applications after.

Sebum measurement procedure

Sebum levels on the facial skin surface were measured using the Sebumeter® SM 815. The probe employs a transparent synthetic film that absorbs sebum (lipids) on the skin's surface. By utilizing a photometer to measure light transmission through the tape before and after skin contact, sebum levels are calculated. The results of measured sebum are displayed in $\mu\text{g}/\text{cm}^2$. [6]

A cartridge containing a matte tape is pressed against the measuring surface of the face and left for 15 seconds. The probe is then inserted back into the device, and the amount of lipids is determined by measuring the transparency of the plastic tape using a photodetector.

In addition to objective assessment of sebum level, participants were asked to share their personal experiences using the cleansing foam and gel. This included their subjective perceptions and any potential side effects, such as irritation, itching, redness, and others. The measurements and reports were collected during a four-week long study.

Determining the antimicrobial activity of tea tree oil-based cleansing foam and gel

The antimicrobial activity of the tea tree oil-based cleansing foam and gel formulation samples was evaluated by determining the susceptibility of bacteria to formulated products. In total, six bacterial strains were tested: *Listeria monocytogenes* WDCM 00021, *Staphylococcus aureus* WDCM 00034, *Enterococcus faecalis* WDCM 00087, *Bacillus subtilis* WDCM 00003, *Escherichia coli* WDCM 00012 and *Klebsiella pneumoniae* WDCM 00097. The study utilized Kirby-Bauer disk diffusion method, in which sample formulations were prepared and applied to a solid nutrient medium. The samples were then incubated for 24 hours at a temperature of 37°C. [7]

RESULTS AND DISCUSION

Determination of pH value

Table 3: pH value of tea-tree oil-based cleansing foam and gel sample

Formulation	pH value
Cleansing foam	6.0
Cleansing gel	6.0

Immediately post-production, the pH value of cleansing foam was measured at 6.0, which is within allowed range for products intended for use on the face.

pH value of the cleansing gel immediately after the production was also measured at 6.0, as presented in Table 3.

Results of the antimicrobial activity of cleansing foam and gel

After the incubation period of 24 hours, three out of six tested bacterial strains showed antibacterial activity. The most distinct response to the formulations was recorded against *Klebsiella pneumoniae* strain, with the zone of inhibition measured at 30 mm, for both cleansing foam and gel, indicating certain antibacterial activity of the formulations. For the *Listeria monocytogenes* strain, zones of inhibition were measured at 16 mm (foam) and 21 mm (gel), which can be described as moderate to certain antimicrobial activity. In the case of *Staphylococcus aureus* strain, the zones of inhibition were 15 mm (foam), while a slightly smaller zone was recorded for the gel, meaning weak activity or no antimicrobial activity. [8][9]

No clear zones of inhibition were observed for the strains *Bacillus subtilis*, *Enterococcus faecalis*, and *Escherichia coli*, indicating a lack of antimicrobial activity against these strains at the applied concentration of the formulations.

Table 4: Measurements of zones of inhibition for tea tree oil-based cleansing foam and gel

Bacterial strain	Gel	Foam
	Zone of inhibition (mm)	Zone of inhibition (mm)
<i>Listeria monocytogenes</i>	21	16
<i>Staphylococcus aureus</i>	-	15
<i>Enterococcus faecalis</i>	-	-
<i>Bacillus subtilis</i>	-	-
<i>Klebsiella pneumoniae</i>	30	30
<i>Escherichia coli</i>	-	-

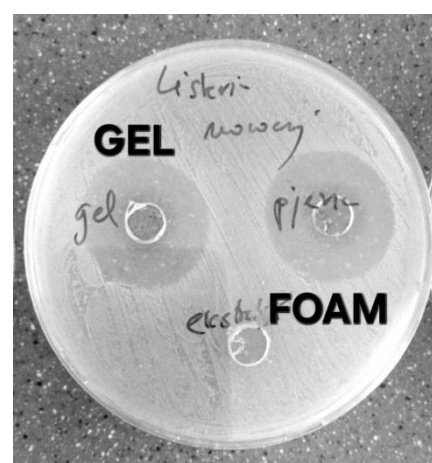
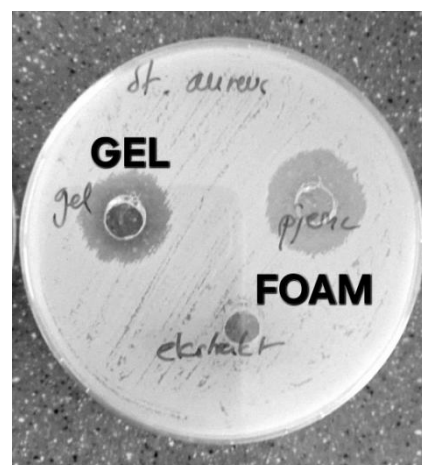
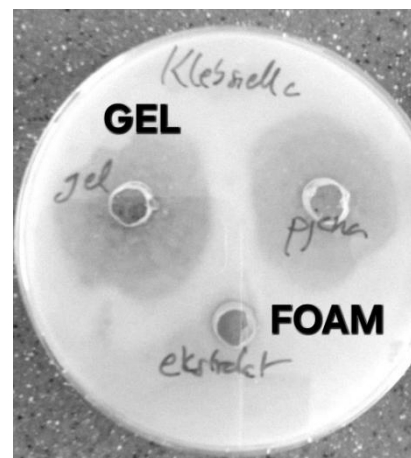


Figure 2: Plates with cleansing foam and gel after the incubation

Measurement of skin sebum levels

The percentage results of sebum level measurements are displayed in Table 5.

Upon application of the cleansing foam and gel, a universal decrease in sebum levels was observed across all study participants. The sebum level before the usage of cleansing foam or gel ranged from 58 $\mu\text{g}/\text{cm}^2$ to 216 $\mu\text{g}/\text{cm}^2$, and after their use, it ranged from 5 $\mu\text{g}/\text{cm}^2$ to 46 $\mu\text{g}/\text{cm}^2$.

The fluctuations in results may be attributed to external and physiological factors, such as individual sebum levels, skin type and hormonal imbalances, stress, or inconsistent application of the product.

Table 5: Percentage results of measured facial sebum levels

Participant	Sebum level before cleansing	Sebum level after cleansing the skin with water	Sebum level after cleansing
<i>Foam</i>			
1.	58	44	5
2.	112	84	21
3.	103	45	16
4.	129	75	46
5.	85	20	13
6.	100	23	12
<i>Gel</i>			
7.	97	36	26
8.	157	35	19
9.	102	85	41
10.	216	80	10
11.	119	45	32
12.	123	44	18

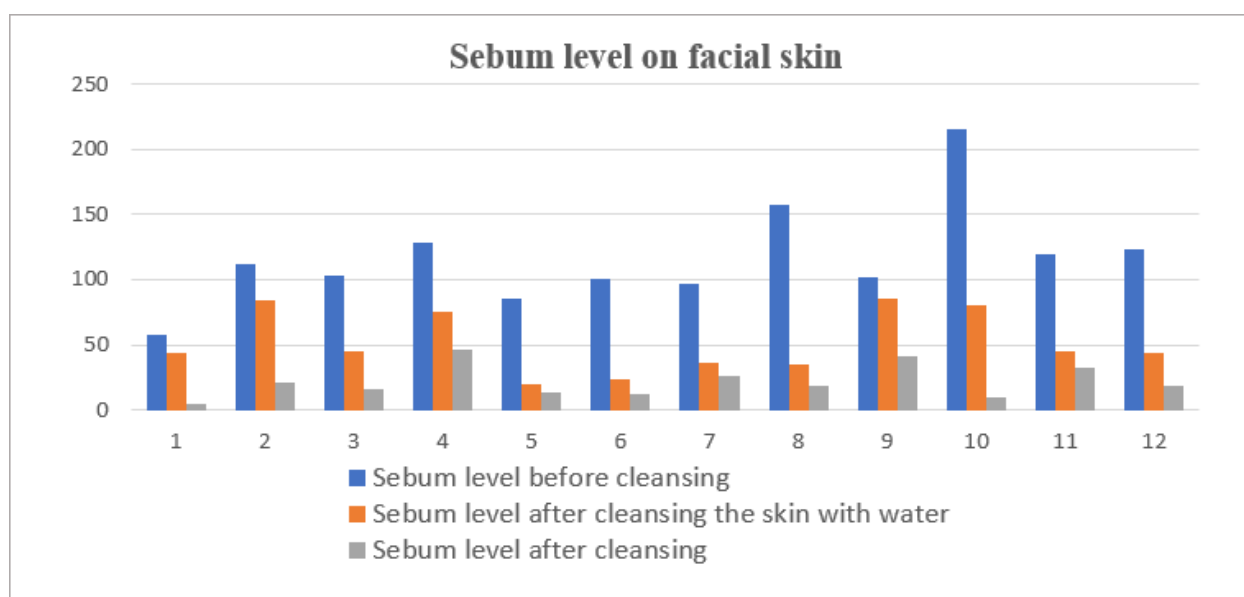


Figure 3: Sebum levels on volunteers' facial skin

In addition to objective sebum level measurements, participants provided subjective feedback via a survey. Notably, 87.5% of the volunteers reported that the formulations improved their overall skin condition. Following the application of the cleansing foam or gel, volunteers described feelings of cleanliness and freshness, while facial sebum levels decreased.

Table 7: Skin condition after cleansing foam and gel application (subjective feeling)

Characteristics		%
Reduced appearance of oily skin	Yes	87.5
	No	12.5
Side effects	Irritation and/or itchiness	12.5
	No side effects	87.5

Consistent with previous research on tea tree oil, our findings align with the claim that tea tree oil effectively lowers sebum production. A study by Nurzynska-Wierdak et al. suggests that a combination of essential oils, such as tea tree oil, with more conventional treatment may contribute to the reduction of *C. acnes*, *S. epidermidis*, and *S. aureus*, as well as lesions and sebum secretion in the populations diagnosed with various forms of acne. A study by Mazzarello et al. shows that 3% tea tree oil cream reduces facial sebum levels more than 3% erythromycin cream after 15 days. [10][11]

No significant difference was recorded in the results of the measured sebum levels depending on the type of cleansing product used (foam or gel). The reduction in sebum levels may be attributed to the activity of tea tree oil as an active ingredient in the formulations, while the choice of formulation type is left to the user, according to their skin type and/or individual preference.

CONCLUSIONS

The inclusion of tea tree oil as the active agent in the cleansing foam and gel formulations was instrumental in substantially decreasing facial skin sebum levels. Parallel to the reduction in oiliness was a perceptible improvement in skin appearance. These results indicate that tea tree oil-based foams and gels provide an effective solution for regulating oily and problematic skin while simultaneously improving overall skin appearance. This study highlights tea tree oil's potential as a pivotal component in dermatological products aimed at sebum control.

REFERENCES

1. Carson CF, Hammer KA, Riley TV. *Melaleuca alternifolia* (Tea Tree) oil: a review of antimicrobial and other medicinal properties. *Clin Microbiol Rev.* 2006 Jan;19(1):50-62. doi: 10.1128/CMR.19.1.50-62.2006. PMID: 16418522; PMCID: PMC1360273.
2. Brun P., Bernabè G., Filippini R., Piovan A. In Vitro Antimicrobial Activities of Commercially Available Tea Tree (*Melaleuca alternifolia*) Essential Oils. *Curr. Microbiol.* 2019;76:108–116. doi: 10.1007/s00284-018-1594-x
3. Miguel M.G. Antioxidant and Anti-Inflammatory Activities of Essential Oils: A Short Review. *Molecules.* 2010;15:9252–9287. doi: 10.3390/molecules15129252.
4. R. Porter, “MSD Manual for Physicians”, 2019.
5. D. Vasiljević, S. Savić, Lj. Đorđević, D. Krajišnik, “Priručnik iz Kozmetologije - drugo izdanje”, Beograd, 2009.
6. Courage+Khazaka. Sebumeter® SM 815; Manual Instruction; Courage+Khazaka: Köln, Germany, 2016
7. Bauer AW, Kirby WM, Sherris JC, Turck M. Antibiotic susceptibility testing by

- a standardized single disk method. *Am J Clin Pathol.* 1966 Apr;45(4):493-6. PMID: 5325707.
8. Halilović, Aida & Hodžić, Snježana & Hercegovac, Amela & Osmanović, Sanida & Husejnagic, Darja & Mešikić, Emina & Hadzic-Hasanovic, Vildana & Sanida, Bektić. (2017). Antimikrobna svojstva ekstrakta ploda i lista borovnice, brusnice i aronije.
 9. Pirvu, Lucia & Hlevca, Cristina & Nicu, Alina & Corina, Bubueanu. (2014). Comparative Studies on Analytical, Antioxidant, and Antimicrobial Activities of a Series of Vegetal Extracts Prepared from Eight Plant Species Growing in Romania. *JPC - Journal of Planar Chromatography - Modern TLC.* 27. 346-356. 10.1556/JPC.27.2014.5.4.
 10. Mazzarello V., Donadu M.G., Ferrari M., Piga G., Usai D., Zanetti S., Sotgiu M.A. Treatment of Acne with a Combination of Propolis, Tea Tree Oil, and Aloe Vera Compared to Erythromycin Cream: Two Double-Blind Investigations. *Clin. Pharmacol.* 2018;10:175–181. doi: 10.2147/CPAA.S180474.
 11. Nurzyńska-Wierdak R, Pietrasik D, Walasek-Janusz M. Essential Oils in the Treatment of Various Types of Acne—A Review. *Plants.* 2023; 12(1):90. <https://doi.org/10.3390/plants12010090>



Mirha Terzić¹
Merima Ibišević²

COSMETOVIGILANCE: REGULATORY OVERSIGHT OF COSMETIC PRODUCT SAFETY FROM RESEARCH TO MARKET

SUMMARY

Cosmetovigilance encompasses regulatory and surveillance activities within the framework of public health with the aim of ensuring the safety of cosmetic products at all stages of their life cycle, from initial research to market distribution and subsequent monitoring. Given the increasing global consumption of cosmetic products and the continuous introduction of new substances and formulations, the existence of an effective cosmetovigilance system plays a crucial role in risk prevention and consumer health protection. The basis of the regulatory framework in the European Union is Regulation (EC) No. 1223/2009, which defines the obligations of manufacturers and distributors, requirements for safety assessment, reporting of adverse reactions and post-market monitoring. At the level of Bosnia and Herzegovina, the implementation of EU regulations and the development of national mechanisms for reporting adverse reactions represent a challenge due to limited resources and the lack of specialized databases.

This review paper analyzes the legal and regulatory framework, key stages of the cosmetovigilance process, including pre-market safety assessment, reporting of adverse reactions and product withdrawal, and highlights the importance of the Safety Gate rapid alert system (formerly known as RAPEX). Special emphasis is placed on the role of pharmacists in educating consumers, reporting adverse reactions and improving professional practice.

Key words: *cosmetic vigilance, safety of cosmetic products, regulatory framework, postmarket surveillance*

Corresponding author: Mirha Terzić
E-mail: terzic.mirha@gmail.com

1 Mirha Terzić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina
2 Mirha Terzić, Faculty of Pharmacy, University of Tuzla, Urfeta Vejzagića 8, 75 000 Tuzla, Bosnia and Herzegovina,
E-mail: terzic.mirha@gmail.com

INTRODUCTION

Cosmetovigilance is a multidisciplinary regulatory and surveillance framework aimed at the systematic identification, assessment, documentation, and prevention of adverse effects associated with the use of cosmetic products (Basketter and White, 2015). The concept of cosmetovigilance encompasses product safety monitoring, pharmacovigilance principles adapted to the cosmetics industry, and risk assessment based on clinical, toxicological, and experimental studies. Cosmetovigilance is founded on the principle of proactive consumer protection, with the objective of ensuring the continuous safety of cosmetic products throughout their entire life cycle (Halepović Đečević and Kaliterna, 2019).

Historically, the concept emerged in response to an increased incidence of dermatological and systemic reactions associated with cosmetic products. The first formal regulatory frameworks in Europe were introduced in the second half of the 20th century, within the context of harmonizing standards and implementing stricter requirements regarding product composition and labeling. The adoption of Regulation (EC) No. 1223/2009 significantly redefined the regulatory framework, emphasizing the obligation for the proactive reporting and documentation of adverse effects (Basketter and White, 2015).

Integrating cosmetovigilance into industrial practice requires:

- the structured implementation of reporting procedures,
- systematic data validation,
- product safety assessments both pre- and post-market authorization.

Systematic surveillance enables regulatory authorities to make evidence-based decisions, including recommendations for amendments to the legislative framework. In addition, cosmetovigilance ensures continuous monitoring

of trends related to the use of new ingredients, innovative formulations, and emerging manufacturing technologies. Risk assessment is based on the principles of pharmacoepidemiology, *in vitro* and *in vivo* toxicological studies, and clinical monitoring of adverse effects (De Groot, 2020).

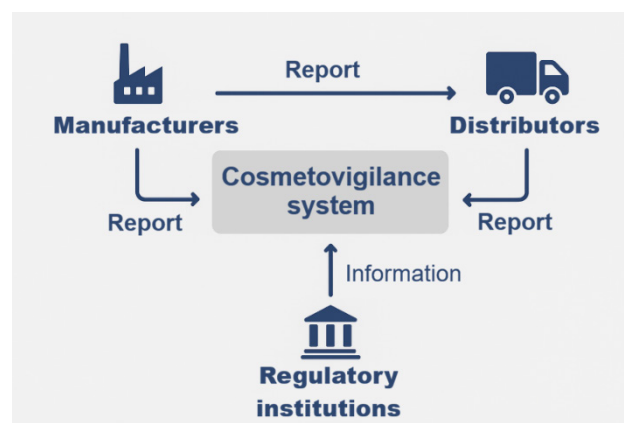


Figure 1. Scheme of the cosmetovigilance system

FRAMEWORK FOR REGULATING THE SAFETY OF COSMETIC PRODUCTS IN THE EU AND BIH

Cosmetovigilance is an integral component of the regulatory oversight of cosmetic product safety, aimed at the systematic protection of public health, the minimization of consumer risk, and the continuous improvement of standards within the cosmetics industry (European Journal of Dermatology, 2021). The regulation of cosmetic products within the markets of the European Union and Bosnia and Herzegovina is based on formally defined legal acts and regulations that establish obligations and standards for all actors involved in production, distribution, and control processes, thereby ensuring compliance with consumer protection principles and international norms.

Regulation (EC) No. 1223/2009 of the European Parliament and of the Council constitutes the primary legal framework governing the placement of cosmetic products on the Union

market, establishing high standards of safety and accountability. Its main objective is to provide an effective mechanism for the protection of consumer health, including requirements for risk assessment, toxicological evaluation, and assessment of skin compatibility (Moretti and Velo, 2008).

Core requirements include the performance of comprehensive product safety assessments prior to market placement, detailed ingredient labeling in accordance with the INCI nomenclature, strict adherence to prohibitions and restrictions on the use of specific substances, and the maintenance of technical documentation and clinical data (Cosmeservice Editorial Team, 2024). All economic operators placing products on the market are required to maintain a Product Safety Report, which must be made available to competent regulatory authorities upon request. The Regulation further establishes the obligation for systematic monitoring and documentation of adverse reactions following market placement, forming the basis of a functional cosmetovigilance system. Within the cosmetovigilance framework, each stakeholder has clearly defined functional responsibilities:

- 1) Manufacturers bear primary responsibility for product safety and quality assurance, including risk assessment, toxicological evaluation, maintenance of technical and regulatory documentation, and timely reporting of adverse effects.
- 2) Distributors are responsible for preserving product integrity throughout logistics and supply chain processes and ensuring that products placed on the market comply with applicable legal requirements.
- 3) Regulatory authorities monitor compliance with legislation, conduct inspections and market surveillance, evaluate safety documentation, and analyze reports of adverse reactions, thereby contributing to the prevention of harmful effects and the protection of public health.

The efficient functioning of this three-tier system enables alignment with international standards and good practice principles, thereby ensuring a high level of consumer protection and maintaining trust in the cosmetics industry.

Table 1. Comparative overview of cosmetic product safety assessment requirements in Bosnia and Herzegovina and under EU Regulation (EC) No. 1223/2009

Type of examination	Mandatory in Bosnia and Herzegovina	Mandatory in the EU	The purpose of the examination
Microbiological tests	Yes	Yes	Checking the presence of pathogenic microorganisms (<i>S. aureus</i> , <i>P. aeruginosa</i> , <i>Candida albicans</i> , <i>E. coli</i>) and the total number of bacteria, molds and yeasts.
Chemical testing for heavy metals (Pb, Cd, Hg, As)	Yes	Yes	It ensures that the concentrations of toxic metals are below the limits that can endanger health.
pH value	Yes	Yes	Checks that the pH of the product does not damage the skin or mucous membranes.
Prohibited and restricted substances	Partially (only if suspected or declared)	Fully	Control of the presence of ingredients prohibited in cosmetics or restricted in concentration (e.g. parabens, certain dyes, UV filters).
Product safety assessment (Safety Assessment)	No	Yes	Expert toxicological assessment of all ingredients and finished formula by a qualified safety assessor.

Product Stability Test	No	Yes	Checking chemical, physical and microbiological stability throughout the entire shelf life.
Packaging compatibility test	No	Yes	Checking whether the packaging releases harmful substances or changes the product formulation.
Dermatological testing (Patch test)	No	Yes (if the product goes on the skin)	Checks for potential irritation or allergic reactions on the skin.
Eye Irritation Test (for eye products)	No	Yes	Assessment of eye irritation risk.
Product Claim Evaluation	No	Yes	Scientific evidence that the product actually has the declared effect (e.g. „reduces wrinkles by 30%“).
UV light impact test (photo-stability)	No	Yes (for products with UV filters)	Checking that UV filters remain stable in light and heat.

Note: The comparison is based on the requirements of Regulation (EC) No. 1223/2009 and publicly available information on cosmetic product control and testing practices currently applied in Bosnia and Herzegovina. Since Bosnia and Herzegovina has not fully harmonized its cosmetic product legislation with the EU Cosmetics Regulation, some requirements presented in the table may not be explicitly regulated through a single legal act but are derived from existing regulatory and market surveillance practices.

The information presented in Table 1 should be interpreted as a comparative overview of the scope of safety assessment requirements rather than a direct article-by-article legal comparison between the regulatory systems of Bosnia and Herzegovina and the European Union. Based on currently applied cosmetic product control and testing practices in Bosnia and Herzegovina, microbiological testing, heavy metal analysis and pH determination represent the core elements of routine product evaluation, while additional testing may be performed depending on the product category, composition or specific regulatory concerns. In contrast, the EU regulatory framework requires a comprehensive Cosmetic Product Safety Report (CPSR), including toxicological assessment, stability testing, packaging compatibility evaluation, claim substantiation and other safety-related requirements. Consequently, the scope of pre-market safety evaluation in Bosnia and Herzegovina may be more limited compared with the comprehensive assessment required under Regulation (EC) No. 1223/2009.

RESPONSIBILITY IN ENSURING THE SAFETY OF COSMETIC PRODUCTS

According to Article 2 of Regulation (EC) No. 1223/2009, a cosmetic product is defined as any substance or mixture intended to be applied to various external parts of the human body, including the skin, hair, nails, lips, teeth, oral mucosa, or external genital organs, with the purpose of cleaning, perfuming, changing appearance, correcting body odours, protecting, or maintaining them in good condition (Jocić et al., 2011). Since cosmetic products must not alter or interfere with the normal physiological functions of the human body, their safety and efficacy are not subject to prior approval by national regulatory authorities before being placed on the market. Instead, the identification and assessment of adverse effects are primarily the responsibility of the manufacturer, who is legally required to demonstrate product safety and ingredient safety prior to distribution, as well as to systematically collect and evaluate reports of potential adverse effects during the post-marketing phase (Mehta et al., 2024).

Article 4 of the Regulation introduces the concept of the “responsible person”, who is legally accountable for ensuring that each cosmetic product placed on the market complies fully with the requirements of the Regulation (Renner et al., 2017). The responsible person may be the manufacturer, importer, or distributor, depending on the supply chain structure (e.g., production within or outside the EU, or marketing under a different brand name). Their key responsibility is to ensure product safety and regulatory compliance. The product safety assessment is performed prior to market placement and is conducted by qualified experts such as pharmacists, toxicologists, or medical professionals, in accordance with Good Laboratory Practice (GLP) principles. The Cosmetic Product Safety Report forms an integral part of the technical documentation defined in Annex I of the Regulation and must be retained for 10 years following the last batch placed on the market. This report must be made available at all times to competent national authorities, whereas consumers have access only to summary information. Before placing a product on the market, the responsible person is required to submit all relevant product information electronically to the European Commission, including data on the presence of nanomaterials where applicable.

REPORTING AND EVALUATION OF SERIOUS ADVERSE EFFECTS OF COSMETIC PRODUCTS

In situations where there is a serious risk to human health, the responsible person is required to take all appropriate measures to identify, manage, and mitigate such risk, including preventing the placing of the product on the market or withdrawing products already made available on the market. To support the implementation of Article 23 of Regulation (EC) No. 1223/2009, which represents a key instrument of the cosmetovigilance system within the European Union and EEA Member States, the European

Commission established in August 2012 a harmonised guideline for the reporting of serious undesirable effects associated with cosmetic products. An adverse reaction is defined as any harmful effect on human health resulting from the normal or reasonably foreseeable use of a cosmetic product. A serious adverse reaction is defined as an effect that results in temporary or permanent functional impairment, disability, hospitalisation, congenital anomalies, immediate life-threatening conditions, or death. Final risk assessment is performed on a case-by-case basis in order to determine the probable causal relationship between a specific cosmetic product (or its mode of use) and the observed adverse effect, since such risks cannot be generalised to the entire population.

For the evaluation of causality between cosmetic product use and serious undesirable effects, a reproducible, harmonised, and standardised methodology has been developed, enabling assessment of the causal relationship between a specific product and reported clinical and/or paraclinical manifestations (Toklu et al., 2019; Vigan and Castelain, 2014). This method is based on six criteria grouped into two main categories, used to calculate both a chronological and a semiological score. It is applied individually to each product, independently of potential interactions with other products. By combining the results in a decision matrix, the strength of the causal association can be classified into five categories: very likely, likely, unclear association, unlikely association, and excluded. The chronological score is based on the temporal relationship between product use and symptom onset, classified as consistent, partially consistent, unknown, or inconsistent. The semiological score is derived from the characteristics of the adverse effects, the results of specific investigations, and data related to re-exposure or repeated use of the product.

Reporting of serious undesirable effects (SUE) is carried out using three standardised forms. Form

A is used by the responsible person or distributor to report cases to the competent authorities. Form B is completed by the competent authority to provide a case summary and facilitate regulatory review; its transmission is mandatory when the initial report originates from a distributor. Form C is used for transmitting reports submitted by healthcare professionals or consumers to other competent authorities or responsible persons. Reports of serious undesirable effects must be transmitted within 20 calendar days from the date on which the responsible person or the competent

authority first receives the information. Following evaluation of post-marketing surveillance data, corrective and preventive measures proportional to the severity and frequency of the reported effects may be implemented. These may include changes in product use instructions, additional labelling or warnings, reformulation, recall, or withdrawal of the product from the market. All competent authorities within the EU must be notified in a timely manner when such measures are taken.

QUESTIONNAIRE FOR REPORTING ADVERSE EFFECTS OF COSMETIC PRODUCTS

Product name: _____
 Production name: _____

Last name: _____
 File number: _____
 First name: _____
 Address: _____
 Tel.: _____
 E-mail address: _____

Please complete the following questionnaire so that we can investigate the situation you experienced:
 Note: You must check the box for each question item.

1. What date did you start using the product?
 Day: _____ Month: _____ Year: _____

2. On what date did the first skin reaction appear?
 Day: _____ Month: _____ Year: _____

3. Which part of the body is affected?

Head	☐ Yes	☐ No	Axillary region	R	L	☐ Yes	☐ No
Face	☐ Yes	☐ No	Hands	R	L	☐ Yes	☐ No
Neck	☐ Yes	☐ No	Legs	R	L	☐ Yes	☐ No
Back	☐ Yes	☐ No	Fists	R	L	☐ Yes	☐ No
Stomach	☐ Yes	☐ No	Feet	R	L	☐ Yes	☐ No

4. Do you experience:

Seals or redness ☐ Yes ☐ No
 Itching ☐ Yes ☐ No
 Stinging ☐ Yes ☐ No

5. Has there been a sensation of this type before? ☐ Yes ☐ No
 • If the answer is yes, was the reaction caused by using the same product ☐ Yes ☐ No

6. Has the product been discontinued? ☐ Yes ☐ No

7. How long has the product been used? _____

8. Have you seen a doctor? ☐ Yes ☐ No
 • If so, do you give permission for your doctor to provide our consultant with information about this incident? ☐ Yes ☐ No
 • Please provide your doctor's contact information (address, phone): _____

9. Has the adverse reaction been eliminated? ☐ Yes ☐ No
 • If the answer is yes:
 - How long did it take for the adverse reaction to go away? _____
 - Was any therapy used? ☐ Yes ☐ No
 (specify what was used): _____
 • If the answer is negative, we will contact you again within two weeks, with your permission, to determine the outcome of the reaction.

Figure 2. Example of a standardized questionnaire for reporting adverse reactions to cosmetic products – part I (Mirković et al., 2013)

As agreed, we are contacting you again to check your allergy re-evaluation report and would be grateful if you could kindly answer the following questions:

Has the adverse reaction been resolved? YES NO

IF THE ANSWER IS YES:

- How long did it take for the adverse reaction to go away? _____
- Recovery after treatment/therapy? YES NO

If so, please specify therapy: _____

Thank you for answering our question.

If the consumer is not available by phone, send a standard letter with question 9.

The completed questionnaire is submitted to the consulting physician (Questionnaire + contact form + letter with the consumer's response).

Figure 3. Example of a standardized questionnaire for reporting adverse reactions to cosmetic products – part II (Mirković et al., 2013)

PRACTICAL EXAMPLES OF REGULATORY INTERVENTIONS AND WARNINGS

Butylphenyl methylpropional (also known as Lilial; 2-(4-tert-butylbenzyl)propionaldehyde; p-tert-butyl- α -methylhydrocinnamic aldehyde) is a synthetic fragrance ingredient that has been widely used in cosmetic products, including perfumes, shower gels, and deodorants. However, due to concerns regarding its potential adverse effects on human health, particularly reproductive toxicity, its use has been prohibited in the European Union. On 1 March 2022, under Regulation (EU) 2021/1902, Lilial was officially listed in Annex II of Regulation (EC) No. 1223/2009 (substances prohibited in cosmetic products), thereby banning its use in cosmetics. This regulatory decision was based on its classification as a substance associated with serious health effects, including potential reproductive toxicity.

According to reports from the RQA Group, the number of cosmetic product recalls in the European Union remains high, with record levels observed in 2024. Cosmetic products account for a significant proportion of notifications within the EU Safety Gate system, with an average of

more than 32,000 units recalled per product. The Sedgwick Recall Index similarly indicates that product recall activity in both the EU and the United Kingdom reached unprecedented levels in 2024, suggesting increased regulatory scrutiny of cosmetic product safety (RQA Group, 2024; Sedgwick, 2024).

THE ROLE OF PHARMACISTS IN THE COSMETOVIGILANCE SYSTEM AND CONSUMER EDUCATION

Consumer education regarding the presence of potential allergens in cosmetic products represents a fundamental component of preventive strategies aimed at protecting skin health (Mirković et al., 2013). Contemporary consumers are exposed to a wide range of products whose formulations often contain numerous chemical substances, some of which may act as allergens. Timely identification of potentially harmful ingredients requires not only careful reading of product declarations but also an adequate understanding of their biological effects. The INCI (International Nomenclature of Cosmetic Ingredients) system standardises ingredient nomenclature and enables the international

identification of cosmetic substances. Consumers who are familiar with INCI terminology are better equipped to make informed and safer product choices. Consumer education should therefore include the identification of common allergenic substances, such as parabens, sulphates, formaldehyde-releasing preservatives, fragrances, and colourants. Clearly presented, legible, and accessible product labelling in a language understandable to local consumers is essential for reducing the risk of allergic reactions.

The pharmacist in this function acts as an educator and advisor. Through professional guidance to consumers, pharmacists can clarify the meaning of ingredient names, point out risky components, and direct consumers towards products that are appropriate for their skin type or known allergies. In addition to individual counseling, pharmacists have a role in promoting awareness of cosmetic tolerance testing, especially in people with sensitive skin, which significantly contributes to the prevention of adverse reactions (Toklu and Mensah, 2016).

CURRENT CHALLENGES AND PROSPECTS OF COSMETOVIGILANCE DEVELOPMENT

The development of cosmetovigilance faces a range of challenges arising from the rapid expansion of the cosmetics industry, the introduction of novel technologies, and the growing demand for enhanced consumer protection. Market globalisation, product diversification, and increasing digitalisation raise important questions regarding the efficiency of existing regulatory frameworks, the interoperability of reporting systems, and the preparedness of institutions to ensure timely responses. Digitalisation represents a key factor in strengthening cosmetovigilance by enabling faster and more accurate exchange of information on adverse reactions. The implementation

of electronic reporting platforms improves accessibility and usability for both consumers and professionals, reduces administrative burden, and accelerates data transmission to competent authorities (Mehta et al., 2024).

The emergence of personalised cosmetics, based on genetic, epigenetic, and microbiome profiles of consumers, presents a significant challenge to existing regulatory models. Traditional approaches, which rely on universal safety standards, are increasingly limited in the context of individualised formulations and bespoke products. Regulatory authorities face the challenge of ensuring adequate quality control and safety assessment, particularly with regard to product stability, skin interactions, and potential immunological responses. This necessitates the development of new evaluation guidelines for personalised formulations, including validated methodologies and enhanced transparency regarding raw material sourcing (Mehta et al., 2024). In this context, further regulatory harmonisation at the EU and international level remains essential in order to ensure consistent standards and minimise regulatory uncertainty. The use of nanomaterials and other innovative ingredients in cosmetic products offers several advantages, including improved delivery of active substances, prolonged efficacy, and enhanced formulation stability. However, these technologies also raise new concerns regarding toxicity, biodistribution, and potential cumulative effects associated with long-term use. At present, significant gaps remain in standardised testing methods for evaluating the safety of nanomaterials in cosmetics, which complicates regulatory decision-making. Future developments are expected to focus on the implementation of advanced *in vitro* and *in silico* methods for predicting adverse effects, as well as the establishment of comprehensive databases of safety profiles for emerging materials.

CONCLUSION

Effective cosmetovigilance represents a critical component of consumer protection, encompassing continuous monitoring and analysis of adverse reactions throughout the cosmetic product life cycle. EU regulatory standards, particularly Regulation (EC) No. 1223/2009, establish a high level of safety accountability; however, their effective implementation in Bosnia and Herzegovina remains limited by resource constraints and the absence of coordinated national databases. The role of pharmacists as educators and intermediaries within the cosmetovigilance system further underscores the importance of professional expertise in identifying potentially harmful substances and empowering consumers through the interpretation of INCI labelling. Digitalisation of cosmetovigilance, particularly through electronic reporting and data exchange systems, offers significant potential to enhance the speed, accuracy, and reliability of post-market surveillance. In this context, the future development of cosmetovigilance requires adaptive regulatory models capable of addressing emerging challenges associated with cosmetic personalisation and innovative materials, including nanomaterials, through the application of advanced in vitro and in silico assessment methods.

LITERATURE

1. Basketter, D. A., & White, I. R. (2015). *Skin sensitization and allergens in cosmetic products: Regulatory challenges*. Toxicology Letters, 238(2), 91–96.
2. Cosmeservice Editorial Team. (2024). *Regulation 2023/1545 changes the allergen list*. Cosmeservice News. <https://www.cosmeservice.com>
3. De Groot, A. C. (2020). *Cosmetics and skin allergies (2nd ed.)*. CRC Press.
4. European Economic Community. (1976). *EU Cosmetics Directive 76/768/EEC*. Official Journal of the European Communities.
5. European Journal of Dermatology. (2021). *Surveillance of dermo-cosmetic products: A global cosmetovigilance system to optimise product development and consumer safety*. European Journal of Dermatology, 31(4).
6. Halepović Đečević, E., & Kaliterna, D. (2019). *Applied cosmetics [Primijenjena kozmetika] (2nd ed.)*. Medicinska naklada.
7. Jocić, D., Primorac, M., Vuleta, G., & Milić, J. (2011). *Safety of cosmetic products – regulatory aspects [Bezbednost kozmetičkih proizvoda – regulatorni aspekti]*. Arhiv za farmaciju, 61(5), 478–500.
8. MDSS Cosmetics. (n.d.). *Ban of lilial*. MDSS News. <https://mdssc cosmetics.com/ban-of-lilial>
9. Mehta, G., Tyagi, D. R., Sachdeva, M., Tripathi, R., & Tyagi, H. (2024). *An observational study on cosmetics use-related adverse effects: Cosmetovigilance need of the day*. Drug Research, 74(4), 164–170. <https://doi.org/10.1055/a-2251-6655>
10. Mirković, I., Vuleta, G., & Savić, S. (2013). *Cosmetovigilance – establishing a system for monitoring adverse effects of cosmetic products [Kozmetovigilanca – uspostavljanje sistema praćenja neželjenih efekata kozmetičkih preparata]*. Arhiv za farmaciju, 63(4), 375–386.
11. Moretti, U., & Velo, G. (2008). *Cosmetovigilance: The 'beautiful' risk*. Drug Safety, 31(5), 437–439. <https://doi.org/10.2165/00002018-200831050-00012>
12. Moretti, U., & Velo, G. (2009). *Cosmetovigilance: The beautiful risk*. University of Verona - Clinical Pharmacology Unit.
13. Obelis Group. (n.d.). *Lilial and zinc pyrithione banned in the EU*. Obelis

- News. <https://www.obelis.net/news/lilial-and-zinc-pyrithione-banned-in-the-eu>
14. Renner, G., Audebert, F., Burfeindt, J., Calvet, B., Caratas-Perifan, M., Leal, M. E., Gorni, R., Long, A., Meredith, E., O'Sullivan, Ú., Paye, M., Perriere, C., & Schlotmann, K. (2017). *Cosmetics Europe guidelines on the management of undesirable effects and reporting of serious undesirable effects from cosmetics in the European Union*. *Cosmetics*, 4(1), 1. <https://doi.org/10.3390/cosmetics4010001>
 15. RQA Group. (2024). *Product recall report 2024 is out now*. RQA Group News. <https://www.rqa-group.com/product-recall-report-2024-is-out-now>
 16. Sedgwick. (2024). *European product recalls reached unprecedented high in 2024*. Sedgwick News. <https://www.sedgwick.com/en-gb/press-release/european-product-recalls-reached-unprecedented-high-in-2024>
 17. Toklu, H. Z., & Mensah, E. (2016). *Why do we need pharmacists in pharmacovigilance systems?* *Online Journal of Public Health Informatics*, 8(2), e193. <https://doi.org/10.5210/ojphi.v8i2.6802>
 18. Toklu, H. Z., Antigua, A., Lewis, V., Reynolds, M., & Jones, J. (2019). *Cosmetovigilance: A review of the current literature*. *Journal of Family Medicine and Primary Care*, 8(5), 1540-1545. https://doi.org/10.4103/jfmmpc.jfmmpc_447_18
 19. Vigan, M., & Castelain, F. (2014). *Cosmetovigilance: Definition, regulation and use "in practice."* *European Journal of Dermatology*, 24(6), 643-649.



**PROFESSIONAL
PAPERS**

Martin Kondža¹

FIP's GLOBAL FRAMEWORK FOR ETHICAL AND EFFECTIVE IMPLEMENTATION OF AI IN PHARMACY

ABSTRACT

The rapid evolution of artificial intelligence (AI) is transforming healthcare, including the role of pharmacists in clinical, community, and industrial settings. In response to this paradigm shift, the International Pharmaceutical Federation (FIP) developed the Artificial Intelligence Toolkit for Pharmacy (March 2025), a comprehensive guide to support pharmacists in understanding, adopting, and ethically applying AI technologies in practice. This lecture will introduce key elements of the Toolkit, including the classification of AI tools (predictive vs. generative), practical use cases (e.g., clinical decision support, risk prediction, personalised therapy), and the implications of AI for data privacy, algorithmic bias, regulatory compliance, and digital workforce development. Particular emphasis will be placed on ethical deployment strategies, transparency standards (e.g., model cards), and how pharmacists can become competent and confident end-users of AI. The lecture will also explore the FIP Development Goal 20 on Digital Health, highlighting its relevance to national and institutional strategies for pharmacy education and practice. Through real-world examples and global recommendations, this session aims to equip pharmacists and decision-makers with actionable knowledge to responsibly integrate AI in a way that enhances care quality without compromising professional judgement.

Keywords: *FIP, AI, pharmacy, guide, model cards*

Corresponding author: Martin Kondža, PhD,
Assistant Professor

Phone: +387 36 312 791

E-mail: martin.kondza@farf.sum.ba

¹ Martin Kondža, Faculty of Pharmacy, University of Mostar, Matice hrvatske bb, 88000 Mostar, Bosnia and Herzegovina; Faculty of Food and Technology, Josip Juraj Strossmayer University of Osijek, Franje Kuhača 18, 31000 Osijek, Croatia, E-mail: martin.kondza@farf.sum.ba

1. INTRODUCTION

Artificial intelligence (AI) has rapidly evolved from a theoretical concept into one of the key drivers of transformation in modern healthcare systems. Advances in machine learning, natural language processing, and data analytics have enabled the development of tools that support clinical decision-making, optimise therapeutic strategies, predict disease risk, and improve the organisational efficiency of healthcare institutions. Healthcare organisations are increasingly relying on AI to process large volumes of clinical and real-world data that exceed the capabilities of traditional analytical approaches [1,2]. This technological shift is not only reshaping medical practice but also redefining interdisciplinary collaboration, digital competency requirements, and the professional responsibilities of healthcare practitioners. As AI continues to evolve, its integration into routine clinical workflows raises important issues related to safety, transparency, ethical use, and the preservation of human oversight in patient care. Within this rapidly evolving digital environment, the professional role of pharmacists is undergoing significant transformation. Although traditionally focused on medication dispensing and pharmaceutical counselling, contemporary practice increasingly incorporates advanced digital tools that support personalised therapy, pharmacovigilance, risk assessment, and data-driven decision-making. The emergence of AI platforms places pharmacists in a strategic position as interpreters of algorithm-generated information, intermediaries between technology and patients, and guardians of medication safety. Consequently, new competencies are emerging that integrate clinical expertise with digital literacy, ethical awareness, and an understanding of the limitations of algorithms [3]. The transition towards digital health ecosystems requires pharmacists to move beyond being passive users of technology and become informed and critical end-users capable of evaluating AI outputs, recognising potential biases, and maintaining

professional judgement in complex therapeutic situations.

In response to the growing impact of artificial intelligence on pharmacy practice, the International Pharmaceutical Federation (FIP) developed the *Artificial Intelligence Toolkit for Pharmacy* in March 2025 [4], a structured framework designed to guide the profession through this paradigm shift. The Toolkit aims to bridge the gap between technological innovation and everyday pharmacy practice by providing practical guidance for the classification, evaluation, and responsible implementation of AI solutions [4]. Particular attention is given to challenges related to ethical use, data privacy, algorithmic transparency, regulatory compliance, and workforce readiness for digital transformation. By offering globally applicable recommendations, real-world examples, and strategic alignment with digital health initiatives, the Toolkit seeks to empower pharmacists to harness artificial intelligence in ways that enhance the quality of care while preserving professional integrity and public trust.

2. ARTIFICIAL INTELLIGENCE IN PHARMACY PRACTICE

2.1. Fundamental Concepts of Artificial Intelligence in Healthcare

Artificial intelligence in healthcare encompasses a range of computational methods and algorithms that enable the analysis of large volumes of data to identify patterns, generate predictive assessments, and support professional decision-making. Key concepts include machine learning, deep learning, and natural language processing, which allow systems to learn from historical data and continuously improve their performance [5]. In pharmacy practice, AI is applied to the interpretation of laboratory findings, the assessment of drug interactions, the optimisation of therapeutic regimens, and the monitoring of

medication safety through pharmacovigilance. It is important to emphasise that artificial intelligence does not replace pharmacists' clinical judgement but rather serves as a tool that provides additional insights and support for evidence-based decision-making. Understanding these fundamental concepts enables pharmacists to critically evaluate AI systems, including their strengths, limitations, and potential risks.

Within the field of artificial intelligence, it is particularly important to distinguish between predictive and generative tools, as they have different functions and implications for pharmacy practice. Predictive models rely on the analysis of existing data to estimate the likelihood of specific outcomes, such as the risk of adverse effects, patient adherence, or treatment success. Such systems are commonly integrated into clinical information systems and decision-support tools [6]. In contrast, generative AI tools create new content, including text summaries, educational materials, or therapeutic recommendations, by leveraging complex language models and patterns learned from large datasets. Although generative tools may enhance efficiency and accelerate access to information, they require additional caution because of the potential for inaccurate or biased outputs [7]. Pharmacists must therefore understand how to interpret the outputs of both types of systems and recognise when further verification or clinical validation is required.

2.2. Areas of Application in Clinical, Community, and Industrial Pharmacy

The application of artificial intelligence spans various sectors of pharmacy, each presenting specific opportunities and challenges. In clinical pharmacy, AI is used to analyse treatment protocols, identify potential drug interactions, and personalise therapy based on patients' genetic and clinical characteristics. In community pharmacy practice, AI can enhance patient counselling through digital risk assessment tools,

automated inventory management, and support for pharmacists in everyday clinical decision-making. In the pharmaceutical industry, AI is employed in drug discovery, optimisation of manufacturing processes, and the analysis of real-world data to improve drug safety profiles [8]. The integration of artificial intelligence across these three domains contributes to a more efficient healthcare system; however, it also requires clearly defined ethical standards, regulatory frameworks, and continuous professional development to ensure the responsible and safe use of the technology.

The effectiveness of artificial intelligence in pharmacy practice largely depends on the quality, completeness, and representativeness of the data used to train AI models. Inadequate or biased datasets may lead to inaccurate recommendations, with potentially direct consequences for patient safety and therapeutic outcomes. Therefore, it is essential for pharmacists to understand the basic principles of data governance, including source validation, terminology standardisation, and the monitoring of algorithm performance over time [6]. Continuous assessment of data quality, together with transparency regarding how models generate their outputs, has become an important component of professional responsibility in the digital era. In this context, pharmacists are increasingly involved in multidisciplinary teams that evaluate the clinical relevance of AI tools before their implementation in practice.

The implementation of artificial intelligence extends beyond technological innovation and also involves the adaptation of workflows and organisational structures. In clinical settings, AI systems can automate routine tasks such as analysing treatment protocols and screening for drug interactions, thereby allowing pharmacists to devote more time to direct patient care and multidisciplinary collaboration [8]. In the community pharmacy sector, digital assistants and inventory management systems contribute to improved operational efficiency, while in

industrial pharmacy, algorithms accelerate the research and development of new molecules. However, successful integration requires appropriate staff training, clearly defined protocols for use, and continuous evaluation of the impact of these technologies on the quality of care. Pharmacists play an essential role in determining when AI tools serve as valuable complements to professional practice and when decisions should rely primarily on clinical expertise and individual patient assessment

2.3. Future Trends and Competency Development in Artificial Intelligence

As artificial intelligence continues to evolve, its application in pharmacy practice is expected to expand further, encompassing advanced systems for personalised therapy, digital twins, and

the integration of real-world data into clinical decision-making [9]. These developments necessitate the acquisition of new competencies that extend beyond traditional pharmacy curricula, including an understanding of the fundamental principles of algorithmic decision-making, the interpretation of model outputs, and the recognition of ethical implications associated with AI technologies. Continuous professional development and interdisciplinary collaboration with data scientists, clinicians, and regulatory authorities are becoming essential prerequisites for the responsible use of artificial intelligence. Consequently, the role of pharmacists is gradually evolving towards that of digitally competent healthcare professionals who actively contribute to shaping future healthcare technologies and the standards governing their implementation.

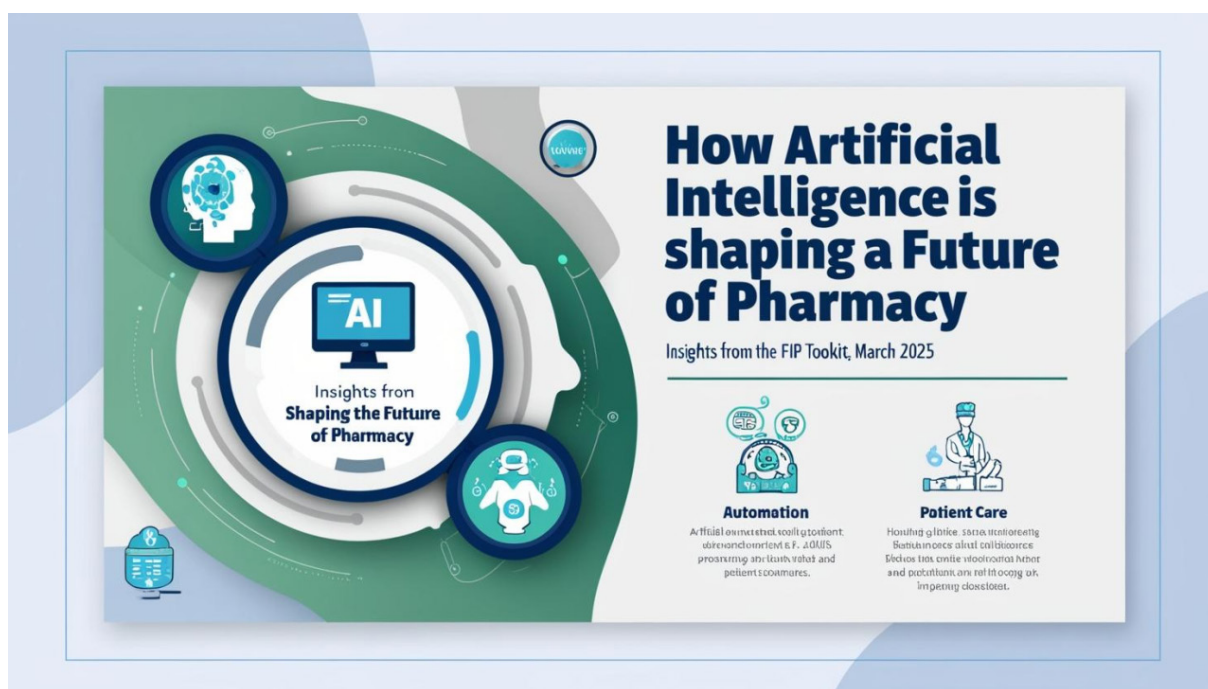


Figure 1. How AI contributes to pharmacy [4]

Artificial intelligence is emerging as a major driver of transformation in pharmacy practice across clinical, community, and industrial settings, enabling more efficient decision-making, personalised therapy, and the optimisation of workflows. Nevertheless, its value largely depends on data quality, algorithmic transparency, and well-defined ethical and regulatory frameworks. Successful implementation requires continuous professional development of pharmacists, the acquisition of new digital competencies, and active participation in multidisciplinary teams. Looking ahead, AI tools are expected to become increasingly integrated into routine practice, with pharmacists playing a pivotal role in ensuring the responsible, safe, and clinically appropriate use of these technologies to improve therapeutic outcomes and the overall quality of healthcare.

3. OVERVIEW OF THE TOOLKIT

3.1. Purpose and Concept of the Toolkit

The FIP Artificial Intelligence Toolkit for Pharmacy was developed to provide a systematic and practice-oriented framework to help pharmacists understand, evaluate, and responsibly implement artificial intelligence in everyday practice. The Toolkit is designed to bridge the gap between rapid technological advances and the practical needs of the pharmacy profession, with particular emphasis on ethical use, patient safety, and the preservation of professional autonomy. Its underlying concept is based on the recognition that artificial intelligence should not be viewed merely as a technological solution, but rather as an integral component of the digital transformation of healthcare that requires clearly defined competencies, transparency standards, and regulatory compliance. The Toolkit provides a structured overview of different types of AI tools, guidance for their evaluation, and recommendations for strengthening digital capabilities within the pharmacy workforce [4].

The Toolkit comprises several interconnected components addressing the classification of AI systems, the assessment of their reliability, data governance, and the ethical dimensions of their application. Particular attention is devoted to distinguishing between predictive and generative models, as well as to understanding their specific strengths and limitations in pharmacy practice. The document includes recommendations aimed at enhancing algorithmic transparency, for example through the use of model cards, and emphasises the need for continuous risk assessment and ongoing evaluation of data quality. In addition to technical guidance, the Toolkit provides strategic recommendations regarding pharmacy education, the development of digital competencies, and alignment with international regulatory frameworks [4]. Emphasis is placed on practical examples and use cases that enable pharmacists to better understand how AI can be integrated into diverse professional settings.

3.2. The Role of Pharmacists as End-Users of AI Technologies

One of the central emphases of the Toolkit is to empower pharmacists as competent and responsible end-users of artificial intelligence. Rather than assuming a passive role as technology users, pharmacists are encouraged to actively participate in the evaluation of AI solutions, the interpretation of their outputs, and the identification of potential algorithmic limitations. This includes understanding the fundamental principles underlying AI models, critically assessing AI-generated recommendations, and maintaining professional judgement when making therapeutic decisions. The Toolkit also highlights the importance of interdisciplinary collaboration with information technology specialists, clinicians, and regulatory authorities to ensure the safe and ethical implementation of AI technologies. Through this approach, pharmacists become key stakeholders in the digital transformation of healthcare, responsible not only for the use of AI tools but also for

safeguarding patients' interests and maintaining trust in the healthcare system.

Artificial intelligence is increasingly being used as a clinical decision-support tool, providing pharmacists with access to analyses that integrate information on medication therapy, laboratory findings, comorbidities, and potential drug interactions. AI systems can identify risks associated with specific therapeutic combinations, suggest dose optimisation strategies, and alert healthcare professionals to clinically significant changes in treatment [10]. In hospital and clinical settings, such tools contribute to process standardisation and reduce the likelihood of errors, particularly in complex cases involving polypharmacy. It is important to emphasise that AI does not make final decisions; rather, it provides an additional layer of analytical support that enables pharmacists to exercise more informed and safer professional judgement.

3.3. Risk Prediction and Pharmacovigilance

One of the most important applications of artificial intelligence is the analysis of safety data and the enhancement of pharmacovigilance. Machine learning algorithms can analyse large datasets derived from electronic health records, spontaneous adverse event reports, and real-world data sources to identify patterns indicative of potential safety signals. This facilitates the earlier detection of adverse drug reactions and enables the assessment of risks associated with specific therapies or patient populations [11,12]. Pharmacists play a pivotal role in interpreting these findings, evaluating their clinical relevance, and making informed decisions regarding subsequent actions in medication safety management. The integration of AI into pharmacovigilance contributes to more systematic monitoring of therapeutic outcomes and enhances the efficiency of both regulatory and clinical processes.

3.4. Personalised Therapy and Pharmacogenomics

The development of artificial intelligence has significantly accelerated advances in personalised medicine, particularly in the field of pharmacogenomics, where genetic variations influencing drug metabolism and therapeutic response are analysed. AI systems can integrate genetic data, clinical parameters, and lifestyle information to recommend therapeutic strategies tailored to the individual characteristics of each patient. Such an approach enables more precise dose selection, reduces the risk of adverse drug reactions, and improves treatment effectiveness [13]. In this context, the role of pharmacists includes the interpretation of pharmacogenomic findings, communication with patients and other healthcare professionals, and ensuring that AI-generated recommendations are applied in accordance with clinical guidelines and ethical standards.

3.5. Real-World Applications

Artificial intelligence is already being applied across various areas of pharmacy practice through numerous real-world use cases. In hospital settings, AI is used to analyse treatment protocols and predict the risk of adverse events, whereas community pharmacies employ digital tools to optimise inventory management and enhance patient counselling. In the pharmaceutical industry, algorithms are being utilised to accelerate drug development, identify novel therapeutic targets, and analyse data generated from clinical trials [14]. These examples demonstrate that artificial intelligence is not merely a concept for the future but has already become an important component of contemporary pharmacy practice. Nevertheless, successful implementation requires continuous professional education, well-defined regulatory frameworks, and the active involvement of pharmacists in evaluating both the benefits and potential risks associated with these technologies.

4. ETHICAL, REGULATORY, AND PROFESSIONAL CHALLENGES

4.1. Data Privacy and Information Security

The application of artificial intelligence in pharmacy inevitably involves the processing of large volumes of sensitive health data, raising important concerns regarding data privacy and information security. Pharmacists are increasingly interacting with digital platforms that collect and analyse information related to medication therapy, genetic characteristics, and patient outcomes, making it essential to ensure compliance with applicable data protection legislation and ethical standards of healthcare practice. Transparent data governance, access control mechanisms, and information encryption constitute fundamental components of the secure use of AI systems [15]. At the same time, it is important to promote awareness of responsible data sharing, particularly in the context of international research collaborations and digital health ecosystems, where a balance must be maintained between fostering innovation and preserving patient trust.

4.2. Algorithmic Bias and Model Transparency (Model Cards)

One of the key ethical challenges associated with artificial intelligence is algorithmic bias, which may arise from inadequate or unrepresentative datasets used during model development. Such bias can result in unequal therapeutic recommendations or inaccurate risk assessments for specific patient populations. To mitigate these risks, increasing emphasis is being placed on the transparency of AI systems, including the documentation of their limitations, methodologies, and intended applications through standardised tools such as model cards [16]. These documents enable healthcare professionals, including pharmacists, to better understand how a model operates, recognise its

strengths and limitations, and identify situations in which additional human oversight is required. Continuous monitoring of model performance and ongoing evaluation are essential prerequisites for the responsible implementation of AI technologies.

The introduction of artificial intelligence into pharmacy practice requires alignment with existing regulatory frameworks governing medical products, digital health, and patient protection. As healthcare professionals, pharmacists have a responsibility to understand the regulatory requirements associated with the use of AI tools, including the assessment of their clinical validity and safety prior to implementation. Regulatory authorities are increasingly emphasising the need to document decisions supported by AI systems and to clearly define the boundaries of responsibility between technology developers and end-users. In this context, pharmacists act as key intermediaries, ensuring that technological innovations are implemented in accordance with professional standards, legal requirements, and the principles of good pharmacy practice.

The growing availability of AI tools has also sparked discussions regarding their impact on pharmacists' professional autonomy and clinical judgement. Although artificial intelligence has the potential to improve efficiency and provide valuable analytical insights, there is a risk of excessive reliance on algorithm-generated recommendations, which may compromise critical thinking or lead to insufficient consideration of individual patient needs. Maintaining an appropriate balance between technological support and human expertise has therefore become a key issue in contemporary pharmacy practice [17]. Pharmacists must develop competencies that enable them to understand the context in which AI systems operate, recognise their limitations, and make final decisions grounded in clinical experience, ethical principles, and responsibility towards patients.

4.3. The Context of FIP Development Goal 20: Digital Health

FIP Development Goal 20 focuses on advancing digital health as a key component of contemporary pharmaceutical systems and professional competencies. This goal emphasises the need to integrate digital technologies, including artificial intelligence, telehealth, and data analytics, into pharmacy education and everyday practice. Strategic priorities include strengthening the digital literacy of healthcare professionals, fostering innovation, and ensuring the ethical and safe implementation of emerging technologies. FIP recognises that digital health represents not only technological progress but also a transformation in the delivery of healthcare, with pharmacists playing an important role in improving access to therapy, promoting personalised approaches to treatment, and facilitating the management of health data. The development of digital competencies is regarded as a fundamental prerequisite for the future sustainability of the pharmacy profession within the global healthcare landscape [18].

The implementation of FIP Development Goal 20 is closely linked to national digital health strategies and healthcare reforms aimed at improving efficiency, interoperability, and the quality of care. At the institutional level, faculties of pharmacy and healthcare organisations are increasingly integrating digital tools into curricula, research activities, and clinical practice in response to evolving workforce demands and technological advancements. Alignment with international guidelines facilitates the standardisation of competencies and promotes collaboration across different healthcare systems. In this context, the development of national policies supporting the digital transformation of pharmacy represents an important step towards creating a sustainable and innovative healthcare environment, with pharmacists playing an active role in shaping and implementing these strategies [19].

The adoption of digital health and artificial intelligence is bringing significant changes to the education of future pharmacists and to continuing professional development. Pharmacy curricula are increasingly focused on fostering digital competencies, understanding the principles underlying algorithms, developing data analytics skills, and addressing the ethical aspects of technology use. Such an approach enables pharmacists to become active participants in digital transformation rather than merely users of technological solutions. In practice, the acquisition of these new skills contributes to more effective medication management, improved communication with patients through digital platforms, and more systematic monitoring of therapeutic outcomes. In the long term, the integration of digital health into pharmacy education and professional practice reinforces the role of pharmacists as key stakeholders in an innovative, personalised, and data-driven healthcare system.

5. CONCLUSION

The rapid development of artificial intelligence represents one of the most significant transformations in contemporary healthcare, with the pharmacy profession positioned at the forefront of this digital transition. The integration of AI tools into clinical, community, and industrial pharmacy creates new opportunities to enhance the quality of care, optimise therapeutic decision-making, and advance personalised approaches to treatment. At the same time, these developments bring a range of ethical, regulatory, and professional challenges that require a systematic understanding of the technology, critical evaluation, and clearly defined standards for its responsible use.

The FIP Artificial Intelligence Toolkit for Pharmacy represents an important step towards a structured approach to implementing artificial

intelligence in pharmacy practice, providing pharmacists with guidance for the evaluation of AI systems, the development of digital competencies, and the preservation of professional autonomy. The strong emphasis placed on transparency, data protection, and the recognition of algorithmic limitations underscores that technology must remain in the service of patients and informed professional judgement. In this context, FIP Development Goal 20 on Digital Health further highlights the need to integrate digital skills into pharmacy education and continuing professional development. Artificial intelligence should not be viewed as a replacement for pharmacists, but rather as a tool capable of significantly enhancing professional practice when applied responsibly, ethically, and in accordance with established regulatory frameworks. The future evolution of the pharmacy profession will depend on its ability to adapt to emerging technologies, strengthen interdisciplinary collaboration, and actively contribute to shaping the digital future of healthcare while maintaining patient trust and ensuring the continued delivery of high-quality care.

REFERENCES

1. Inglada Galiana L, Corral Gudino L, Miramontes González P. Ethics and artificial intelligence. *Rev Clin Esp (Barc)*. 2024 Mar;224(3):178-186. doi: 10.1016/j.rceng.2024.02.003. Epub 2024 Feb 12. PMID: 38355097.
2. Keskinbora KH. Medical ethics considerations on artificial intelligence. *J Clin Neurosci*. 2019 Jun;64:277-282. doi: 10.1016/j.jocn.2019.03.001. Epub 2019 Mar 14. PMID: 30878282.
3. Ranchon F, Chanoine S, Lambert-Lacroix S, Bosson JL, Moreau-Gaudry A, Bedouch P. Development of artificial intelligence powered apps and tools for clinical pharmacy services: A systematic review. *Int J Med Inform*. 2023 Apr;172:104983. doi: 10.1016/j.ijmedinf.2022.104983. Epub 2022 Dec 30. PMID: 36724730.
4. <https://www.fip.org/file/6202>
5. Jarab AS, Abu Heshmeh SR, Al Meslamani AZ. Artificial intelligence (AI) in pharmacy: an overview of innovations. *J Med Econ*. 2023 Jan-Dec;26(1):1261-1265. doi: 10.1080/13696998.2023.2265245. Epub 2023 Oct 12. PMID: 37772743.
6. Abdel Aziz MH, Rowe C, Southwood R, Nogid A, Berman S, Gustafson K. A scoping review of artificial intelligence within pharmacy education. *Am J Pharm Educ*. 2024 Jan;88(1):100615. doi: 10.1016/j.ajpe.2023.100615. Epub 2023 Oct 30. PMID: 37914030.
7. Roosan D, Padua P, Khan R, Khan H, Verzosa C, Wu Y. Effectiveness of ChatGPT in clinical pharmacy and the role of artificial intelligence in medication therapy management. *J Am Pharm Assoc (2003)*. 2024 Mar-Apr;64(2):422-428.e8. doi: 10.1016/j.japh.2023.11.023. Epub 2023 Dec 2. PMID: 38049066.
8. Jessica H, Britney R, Sarira ED, Parisa A, Joe Z, Betty B C. Applications of artificial intelligence in current pharmacy practice: A scoping review. *Res Social Adm Pharm*. 2025 Mar;21(3):134-141. doi: 10.1016/j.sapharm.2024.12.007. Epub 2024 Dec 17. PMID: 39730225.
9. Salas M, Petracek J, Yalamanchili P, Aimer O, Kasthuril D, Dhingra S, Junaid T, Bostic T. The Use of Artificial Intelligence in Pharmacovigilance: A Systematic Review of the Literature. *Pharmaceut Med*. 2022 Oct;36(5):295-306. doi: 10.1007/s40290-022-00441-z. Epub 2022 Jul 29. PMID: 35904529. yqsr4fx
10. Patil RS, Kulkarni SB, Gaikwad VL. Artificial intelligence in pharmaceutical regulatory affairs. *Drug Discov Today*. 2023 Sep;28(9):103700. doi: 10.1016/j.

- drudis.2023.103700. Epub 2023 Jul 12. PMID: 37442291.
11. Nelson SD. Artificial intelligence and the future of pharmacy. *Am J Health Syst Pharm.* 2024 Feb 8;81(4):83-84. doi: 10.1093/ajhp/zzad316. PMID: 38141260.
 12. Smoke S. Artificial intelligence in pharmacy: A guide for clinicians. *Am J Health Syst Pharm.* 2024 Jul 8;81(14):641-646. doi: 10.1093/ajhp/zzxae051. PMID: 38394361.
 13. Sahu A, Mishra J, Kushwaha N. Artificial Intelligence (AI) in Drugs and Pharmaceuticals. *Comb Chem High Throughput Screen.* 2022;25(11):1818-1837. doi: 10.2174/1386207325666211207153943. PMID: 34875986.
 14. Cain J, Malcom DR, Aungst TD. The Role of Artificial Intelligence in the Future of Pharmacy Education. *Am J Pharm Educ.* 2023 Oct;87(10):100135. doi: 10.1016/j.ajpe.2023.100135. Epub 2023 May 26. PMID: 37852692.
 15. Weidmann AE. Artificial intelligence in academic writing and clinical pharmacy education: consequences and opportunities. *Int J Clin Pharm.* 2024 Jun;46(3):751-754. doi: 10.1007/s11096-024-01705-1. Epub 2024 Mar 12. PMID: 38472596; PMCID: PMC11133206.
 16. Cheema B, Hourmozdi J, Kline A, Ahmad F, Khera R. Artificial Intelligence in the Management of Heart Failure. *J Card Fail.* 2025 Oct;31(10):1561-1573. doi: 10.1016/j.cardfail.2025.02.020. Epub 2025 May 7. PMID: 40345521.
 17. González-Pérez Y, Montero Delgado A, Martinez Sesmero JM. [Translated article] Introducing artificial intelligence to hospital pharmacy departments. *Farm Hosp.* 2024 Jul;48 Suppl 1:TS35-TS44. English, Spanish. doi: 10.1016/j.farma.2024.04.001. PMID: 39097375.
 18. Knobloch J, Cozart K, Halford Z, Hilaire M, Richter LM, Arnoldi J. Students' perception of the use of artificial intelligence (AI) in pharmacy school. *Curr Pharm Teach Learn.* 2024 Dec;16(12):102181. doi: 10.1016/j.cptl.2024.102181. Epub 2024 Sep 4. PMID: 39236450.
 19. <https://developmentgoals.fip.org/>

