UDC 616.38-012-09-09-074:17.037.48
DOI https://doi.org/10.32782/health-2025.4.2

THE ROLE OF MYCOTOXINS IN HUMAN LIFE

Andrushchak Marharyta Olexandrivna,
Candidate of Medical Science,
Senior Lecturer at the Department of Infection Diseases
Bukovinian State Medical University
ORCID: 0000-0001-5003-9622

Boida Irina Yurieva,
student of 2 year medical faculty
Bukovinian State Medical University
ORCID: 0009-0008-1203-8037

Mycotoxins are low-molecular-weight secondary metabolites produced by molds (e.g., Aspergillus, Penicillium, Fusarium). Unlike antibiotics, mycotoxins serve no beneficial economic purpose; instead, they pose serious threats to animal and human health and compromise the safety of food and feed. Over 400 mycotoxins have been identified, with aflatoxin, fumonisin, deoxynivalenol, zearalenone, and ochratoxin A among the most studied. Even at low concentrations, these compounds can trigger acute or chronic diseases, affecting multiple organ systems and leading to immunosuppression, carcinogenesis, and reproductive toxicity. Assessment of exposure pathways, toxicodynamics, and prevention strategies is essential for safeguarding public health. Mycotoxins–secondary metabolites synthesized by filamentous fungi–have become a significant public health concern due to their presence in food and feed products. Globally, cereal crops, nuts, coffee, spices, and dairy are frequently contaminated with these compounds. The Food and Agriculture Organization (FAO) reports that approximately 36% of global crop diseases and losses are attributable to fungal toxins, resulting in economic damages exceeding US $15 billion annually.

These toxins exhibit diverse physicochemical properties: they are often thermostable, acid-resistant, lipid-soluble, and bioaccumulate within human and animal tissues. Their health impacts vary widely, ranging from acute illnesses–such as nausea, diarrhea, or central nervous system effects–to chronic outcomes like immunosuppression, hepatic and renal disorders, reproductive impairment, and carcinogenesis.

Despite ongoing research, gaps remain concerning the mechanisms of mycotoxin biosynthesis in fungi, synergistic interactions in co-contaminated foodstuffs, and the efficacy of detoxification methods. This review aims to assess major mycotoxins' toxicological profiles, elucidate human exposure pathways, and evaluate current strategies for mitigation within the context of infectious disease risk.

Key words: *mycotoxin biosynthesis, toxicological profiles, public health, detoxification methods.*

Маргарита Андрущак, Ірина Бойда. Різновиди мікотоксинів їхня роль в житті людини

Мікотоксини – це низькомолекулярні вторинні метаболіти, що виробляються пліснявими грибками (наприклад, Aspergillus, Penicillium, Fusarium). На відміну від антибіотиків, мікотоксини не мають корисної економічної цінності; навпаки, вони становлять серйозну загрозу для здоров'я тварин і людей та підривають безпеку харчових продуктів і кормів. Було ідентифіковано понад 400 мікотоксинів, серед яких найбільш дослідженими є афлатоксин, фумонізин, дезоксиніваленол, зеараленон та охратоксин А. Навіть у низьких концентраціях ці сполуки можуть викликати гострі або хронічні захворювання, впливаючи на багато органів і систем організму та призводячи до імуносупресії, канцерогенезу та репродуктивної токсичності. Оцінка шляхів експозиції, токсикодинаміки та стратегій профілактики є надзвичайно важливою для захисту здоров'я населення. Мікотоксини – вторинні метаболіти, що синтезуються грибами – стали серйозною проблемою для здоров'я населення через їхню присутність у продуктах харчування та кормах. У всьому світі зернові культури, горіхи, кава, спеції та молочні продукти часто забруднені цими сполуками. Продовольча та сільськогосподарська організація ООН (ФАО) повідомляє, що приблизно 36 % світових захворювань та втрат врожаю пов'язані з грибковими токсинами, що призводить до економічних збитків, які перевищують 15 млрд доларів США щорічно.

Ці токсини мають різноманітні фізико-хімічні властивості: вони часто є термостабільними, кислотостійкими, жиророзчинними та біо акумулюються в тканинах людини і тварин. Їхній вплив на здоров'я дуже різниться, від гострих захворювань, таких як нудота, діарея або центральна нервова система, до хронічних захворювань, таких як рак, інфекції та імунодефіцит.

Ключові слова: *біосинтез мікотоксинів, токсикологічні характеристики, громадське здоров'я, методи детоксикації.*

Purpose and objectives of the study. The purpose of this article is to summarise and systematically analyse current scientific data on the purpose of this article is to summarise and systematically analyse current scientific data on the role of mycotoxins in human life, with an assessment of current risks and prospects for further research.

To achieve this goal, the following objectives were set:

– To analyse current domestic and foreign scientific sources on the subject under study. To summarise data on the main mechanisms of action of mycotoxins.

– To characterise the possible consequences of the impact of mycotoxinson the human body.

– To identify current approaches to the prevention and control of mycotoxins.

Materials and methods. A review of the literature was conducted by searching for scientific publications in the international and national scientometric databases PubMed, Scopus, Web of Science, and Google Scholar. The analysis included publications published between 2014 and 2024 in peer-reviewed scientific journals, as well as official documents and recommendations from the WHO, FAO, and EFSA. The selection criteria were scientific relevance to the research topic, availability of the full text, and relevance of the data. Sources with insufficient evidence or duplicate publications were not included.

The urgency of the problem. In recent years, the study of mycotoxins of mold fungi has been carried out in different countries of the world. Research was conducted in the areas of studying the structure, properties, nature of contamination of plant raw materials, the mechanism of their influence on individual objects, the development of methods for their isolation, identification and quantitative determination, etc.. They develop only in the presence of air, form large mycelium and cover surfaces mainly in the form of fluffy plaques of various colors [1-3]. About 30,000 thousand species of mold fungi have been isolated from food and feed, of which more than 250 species are capable of producing dangerous toxins and are one of the risk factors and disruption of the most important systems of the human body. In addition, mycotoxins negatively affect the situation with food security and nutrition, since people's access to healthy food is limited. According to the Food and Agriculture Organization of the United Nations (FAO), annually about 36% of all plant and agricultural diseases in the world are caused by mycotoxins, while losses of agricultural products associated with their contamination exceed $15 billion. The reasons for the formation of mycotoxins by mold fungi have not yet been fully elucidated.

Research results and their discussion. The reasons for the formation of mycotoxins by mold fungi are not fully understood. It is believed that they are necessary for mold fungi to improve their vital activity, growth and development. The optimal temperature for toxin formation is in the range from 8–12°C to 27–30°C, air humidity – no more than 85%. By chemical structure, mycotoxins are aromatic polycyclic compounds. They contain various groups of chemicals: alkaloids, sterols, coumarins, peptides, anthraquinones, trichothecenes and other compounds. Most mycotoxins are crystalline substances that are well soluble in organic solvents, are quite resistant to the action of acids, are destroyed by alkalis with the formation of nontoxic or low-toxic compounds, resistant to heating, pasteurization, and cooking [3–4]. The degree of real danger of each mycotoxin depends on the biology and ecology of the producer fungus, the physicochemical properties of the mycotoxin and its toxicological characteristics (biotransformation, release, accumulation, acute and chronic toxicity), the features of its distribution in food products, hygienic regulation of the content of mycotoxins in food products, and preventive measures. It should be noted that the same type of mold fungi can produce several types of mycotoxins and several fungi can produce the same mycotoxin. The activity of mycotoxins in different strains of the same type of mold may differ, and the toxic component, which manifests itself in the inhibition of the synthesis of nucleic acids and protein compounds, may be acutely toxic, weakly toxic, or nontoxic at all. Mycotoxins can enter the human body with food products made from raw materials contaminated with them [4]. The sources of contamination of food products with mycotoxins are mainly cereals, legumes, oilseeds, affected by mold fungi at the stage of growth, harvesting, storage, sale and production of food products, concentrates, peanuts, nuts (pistachios, walnuts, almonds), coffee beans, cocoa beans, tea leaves, spices (most often red and black pepper, dried ginger), spices, dried fruits, etc. Varieties of cereals that grow in forests and mountains can also contain mycotoxins and pose a real risk of poisoning upon tactile contact or inhalation. From animal feed contaminated with mold fungi (hay, straw, moldy cereal grains, compound feeds, etc.), mycotoxins have the property of migrating into milk, meat, offal, eggs.

The source of mycotoxins entering the human body is also moldy products (baked goods, meat, sausage products, vegetables, fruits, jams, herbal teas,

etc.) [5]. In European countries, mycotoxins are often found in nuts, dried fruits, grain and meat products, and milk. According to expert research, mycotoxins are quite often found in baby food products and juices in PET packaging. The danger of mycotoxins is also that they are often not visible in food products, they do not change their color, smell, and are resistant to high and low temperatures. Toxins are absorbed very quickly in the human body. Studies by scientists have shown that most mycotoxins adapt in the small intestine. Symptoms of mycotoxicosis depend on the type of mycotoxin, its concentration, time of exposure, age, sex, general condition and sensitivity of the human body. The clinical picture of mycotoxicoses is quite diverse. In the human body, mycotoxins affect the cardiovascular, central nervous system, gastrointestinal tract, internal organs, skin, some of them affect the reproductive function and can cause mutations, abnormal intrauterine formation of the fetus. A clear relationship has been established between the content of mycotoxins in food products and the incidence of liver cancer in humans. The most dangerous for humans are mold fungi, mainly of the genera Aspergillus, Penicillium, Fusarium, which produce various mycotoxins [6]. These mycotoxins are characterized by nephrotoxic, neurotoxic, cardiotoxic, pulmonological, hepatotoxic, mutagenic effects. Substrates for fungi of the genus Penicillium are wheat, rye, oats, barley, rice, corn, sorghum, sunflower seeds, peanuts, various fruits and vegetables and products of their processing (compotes, juices, purees, jams), cheeses [5–6]. These mycotoxins cause inhibition of protein biosynthesis, have teratogenic, cytotoxic, immunosuppressive, carcinogenic, cardiotoxic, dermatotoxic effects, affect the central nervous system, hematopoietic organs, cause leukopenia, hemorrhagic syndrome, affect the skin and intestinal mucosa, causing diarrhea, and can cause hormonal disruption.

Mold fungi of the genus Fusarium, developing mainly on wheat, less often on rye, oats, barley, produce a mycotoxin – vomitoxin. A pale pink or pinkish-red coating appears on the grain and spikelets. When consuming bread obtained from flour made from grain infected with Fusarium graminearum, acute poisoning occurs, the symptoms of which are similar to intoxication ("drunken bread"), with mental disorders, excitement, euphoria, impaired coordination of movements, tremors in the limbs, dizziness, then weakness, drowsiness, depression, digestive disorders, bone marrow function is weakened and the number of leukocytes in the blood decreases. Poisoning occurs when consuming products made from infected grain crops (wheat, rye, barley, buckwheat, millet, and others) that have overwintered in the field. The most favorable conditions for the development of mold fungi are temperatures below 0°C, and toxin formation is from minus 1°C to plus 5°C [7]. The optimum temperature for the growth of the fungus ranges from 18°C to 27°C. The toxin is quite stable and remains active even during long-term (4–5 years) storage of grain. Alimentary-toxic aleukia is manifested by stomatitis, agranulocytosis, later – necrotic angina, hemorrhagic syndrome, sepsis. Zearalenone is a mycotoxin produced by the mold fungus Fusarium graminearum, has estrogenic and teratogenic properties, and also exhibits antibacterial activity against gram-positive bacteria [8].

The spores of the fungus live in the soil and mainly affect corn (the grains turn pink), as well as rice, sorghum, nuts, bananas, black pepper, spices. Zearalenone is often observed simultaneously with deoxynivalenol and other trichocenes and mycotoxins of fungi of the genus Fusarium and is a lactoneum of phenolic resorcinol acid. Studies are underway to confirm the involvement of zearalenone in the development of breast cancer. Fumonisins are a group of mycotoxins that are found in various products of plant origin (mainly cereals, corn, millet, sorghum). The most common and dangerous representative of fumonisins is fumonisin B1 [9–10].

Today, considerable attention is paid to the safety and quality of food products throughout the world. Consumption of food products of plant and animal origin contaminated with mold fungi is a threat to human health and can cause serious diseases. Despite the fact that in recent years, knowledge in the field of studying mycotoxins of mold fungi both in Ukraine and around the world has expanded significantly, the problem of their more detailed study remains relevant.

The permissible norms of the content of mycotoxins of mold fungi in food products are given, which determine their safety for consumption. It has been established that one and the same type of mold fungi can produce several types of mycotoxins and several fungi can produce the same mycotoxin. The activity of mycotoxins in different strains of one type of mold may differ, and the toxic component, which manifests itself in the inhibition of the synthesis of nucleic acids and protein compounds, may be acutely toxic, weakly toxic or not toxic at all. The problem of mycotoxins is becoming increasingly important

Studies by scientists have shown that most mycotoxins adapt in the small intestine. Symptoms of mycotoxicosis depend on the type of mycotoxin, its concentration, time of exposure, age, sex, general condition and sensitivity of the human body. The clin-

ical picture of mycotoxicoses is quite diverse. In the human body, mycotoxins affect the cardiovascular, central nervous system, gastrointestinal tract, internal organs, skin, some of them affect the reproductive function and can cause mutations, abnormal intrauterine formation of the fetus. A clear relationship has been established between the content of mycotoxins in food products and the incidence of liver cancer in humans. The most dangerous for humans are mold fungi, mainly of the genera Aspergillus, Penicillium, Fusarium, which produce various mycotoxins [6–7]. When grown on natural substrates such as cereals, rice, corn, legumes, nuts, peanuts, fruits, vegetables, cheeses, and spices, fungi of the genus.It has been proven that even small doses of the toxin have carcinogenic properties and can cause the development of esophageal and intestinal cancer. The microscopic mold fungi Claviceps purpurea and Claviceps paspali secrete ergotoxine and serotonin, which affect spikelets of wheat and rye and enter the human body with products made from infected grain. Manifestations of poisoning are convulsions, spasms of smooth muscles, mental disorders, and vision [7]. In the prevention of mycotoxicoses, the main measures to prevent contamination of food products and raw materials with micromycetes are measures to prevent contamination of food products and raw materials with micromycetes. Moldy products cannot be used for food. In everyday life, one should pay attention to the shelf life of a food product before consumption, as well as the absence of foreign odors, the presence of mold, and proper storage. The group of problem products without visible mold and with no odor includes peanuts, lentils, nuts in their shells, peach and apricot kernels, and almonds. Measures to comply with the rules for storing grain and food products are aimed at preventing moisture in products, the development of mold, improving agricultural culture, and implementing scientifically based agrotechnological measures. In the USA and France, chemical detoxification of feed with ammonia at elevated pressure and temperature is used to reduce the content of aflatoxins in products to a safe level, and in India, treatment with hydrogen peroxide [10–11].To destroy mycotoxins produced by fungi of the genus Aspergillus, disinfection with ammonia or calcium hydroxide or extraction with organic solvents is used in feed. It is also possible to treat feed with hot water and salt. Sometimes it is advisable to remove aflatoxins by extraction with water, organic solvents (dimethyl ether, bentonite), a mixture of organic solvent and water (acetone:hexane:water). Treatment with oxidant solutions is also used; strong acids (the method is not suitable for food products), bases in combination with high temperatures. Hydrosulfites, which are used for preserving fruit juices, jams, dried fruits, destroy aflatoxins B1 and G1. Biological detoxification of aflatoxins and other mycotoxins by some types of microorganisms is promising. Biological methods of aflatoxin prevention also consist in breeding plant varieties resistant to aspergillus. Mechanical methods of decontamination and detoxification of products contaminated with aflatoxins involve the physical removal of contaminated material, namely: substandard, moldy corn kernels, peanuts, nut kernels, fruits, etc. Electronic colorimetric sorters have been developed to remove damaged grains, however, the optimal effect is achieved when this method is combined with subsequent manual sorting [7]. Physical methods include high heat treatment, irradiation with solar and UV rays, which allows destroying up to 70% of aflatoxins. Such destruction increases with increasing pressure and temperature, as well as the volume of water relative to the product. Breeding work is being carried out with agricultural crops to select combinations to resist pathogenic mold fungi at the genetic level. The only evidence of the presence of a specific fungal toxin in food products and raw materials is chemical and physical identification (Table 1) [12].

Table 1

Mycotoxin	Producing Fungi	Toxic Effects	Contaminated Products
Aflatoxins	*Aspergillus flavus*, *A. parasiticus*	Hepatotoxicity, carcinogenicity, immunosuppression	Corn, peanuts, tree nuts, spices
Ochratoxin A	*Aspergillus ochraceus*, *Penicillium verrucosum*	Nephrotoxicity, carcinogenicity, neurotoxicity	Cereals, coffee, dried fruits, wine
Patulin	*Penicillium expansum*	Gastrointestinal toxicity, genotoxicity	Apples, apple juice
Zearalenone	*Fusarium graminearum*, *F. culmorum*	Estrogenic effects, reproductive disorders	Corn, wheat, barley, rice
Deoxynivalenol (DON)	*Fusarium graminearum*	Vomiting, immunosuppression	Wheat, corn, barley, oats
Fumonisins	*Fusarium verticillioides*, *F. proliferatum*	Neural tube defects, hepatotoxicity, nephrotoxicity	Corn, maize-based products
T-2 toxin	*Fusarium sporotrichioides*	Skin irritation, immunosuppression, GI hemorrhage	Cereal grains, oats, barley

Conclusion. 1. The determination of mycotoxins is particularly important for food manufacturers and suppliers, as it allows to determine the contamination of food with mold fungi, avoid the spread of mycotoxins, improve or change storage conditions. To prevent harm to human health, the content of mycotoxins in food should be as low as possible. In most countries of the world, maximum permissible standards for the content of mycotoxins in raw materials, food products, feed, which are specified in regulatory documents, and exceeding them is the cause of serious diseases.

BIBLIOGRAPHY

1. Habschied, K., Kanižai Šarić, G., Krstanović, V., & Mastanjević, K. Mycotoxins–Biomonitoring and Human Exposure. *Toxins*. 2021. № 13(2). P. 113. https://doi.org/10.3390/toxins13020113

2. El-Sherbeny, E. M. Mycotoxins: Review on types, toxicity, conventional and updating techniques of detection and counteraction in feeds and foods of animals and human. *Egyptian Journal of Animal Health*. 2024. № 4(2). P. 96-109. https://doi.org/10.21608/ejah.2024.346750

3. Kościelecka, K., Kuć, A., Kubik-Machura, D., Męcik-Kronenberg, T., Włodarek, J., & Radko, L.. Endocrine Effect of Some Mycotoxins on Humans: A Clinical Review of the Ways to Mitigate the Action of Mycotoxins*. Toxins.* 2023. №15(9). P. 515. https://doi.org/10.3390/toxins15090515

4. Lázaro, Á., Vila-Donat, P., & Manyes, L. . Emerging mycotoxins and preventive strategies related to gut microbiota changes: probiotics, prebiotics, and postbiotics – a systematic review. *Food & Function.* 2024. № 15. P. 8998-9023. https://doi.org/10.1039/D4FO01705F

5. Dietz, L. Dietary Mycotoxins: An Overview on Toxicokinetics, Toxicodynamics, Toxicity, Epidemiology, Detection, and Their Mitigation with Special Emphasis on Aflatoxicosis in Humans and Animals. *Toxins* 2024. № 16(11)P. 83. https://doi.org/10.3390/toxins16110483

6. Lázaro, Á., Vila-Donat, P., Manyes, L. Applications of Mycotoxin Biomarkers in Human Biomonitoring for Exposome-Health Studies: Past, Present, and Future. *Exposure and Health.* 2024. № 16. P. 837-859. https://doi.org/10.1007/s12403-023-00595-4

7. Awuchi, C. G., Nwozo, S., Salihu, M., Odongo, G. A., Sarvarian, M., & Okpala, C. O. R.. Mycotoxins' Toxicities – From Consumer Health Safety Concerns, to Mitigation/Treatment Strategies: A Perspective Review. *Journal of Chemical Health Risks*. 2022. № 12(3). P. 151-161 https://doi.org/10.22034/jchr.2022.1939170.1399

8. Shekhar R., Raghavendra V.B., Rachitha P. . *A comprehensive review of mycotoxins, their toxicity, and innovative detoxification methods.* Toxicology Reports. 2025. № 14. P. 101-105. DOI:10.1016/j.toxrep.2025.101952

9. Li, K., Cai, H., Luo, B., Duan, S., Yang, J., Zhang, N., He, Y., Wu, A., & Liu, H. Recent Progress of Mycotoxin in Various Food Products–Human Exposure and Health Risk Assessment. *Foods* 2025. № 14(5), P. 865. https://doi.org/10.3390/foods14050865

10. El-Sherbeny E. M. Mycotoxins: Review on types, toxicity, conventional and updating techniques of detection and counteraction in feeds and foods of animals and humans. *Egyptian Journal of Animal Health.* 2024. № 4(2), 96–109. DOI:10.21608/ejah.2024.346750.

11. Gopal T., Sugumar V., Wagdevi P., Pereira D. J., Tharannum S. *A* Systematic Review on Mycotoxins in Food and Environment: Occurrence, distribution, Impact on human health and Prevention. *International Journal of Environmental Sciences.* 2025. № 11(21s), P. 2134–2140. DOI:10.64252/bw6b8h02.

12. Cordero-Mendoza D. D., Hernández-Ceruelos M. C. A., et al. Exposure to Mycotoxins and Its Importance in Public Health. *European Journal of Nutrition & Food Safety* 2023. №15(10). P. 21–28.

REFERENCES

1. Habschied, K., Kanižai Šarić, G., Krstanović, V., & Mastanjević, K. (2021). *Mycotoxins–Biomonitoring and Human Exposure.* Toxins, 13(2), 113. https://doi.org/10.3390/toxins13020113 (mdpi.com)

2. El-Sherbeny, E. M. (2024). *Mycotoxins: Review on types, toxicity, conventional and updating techniques of detection and counteraction in feeds and foods of animals and human.* Egyptian Journal of Animal Health, 4(2), 96-109. https://doi.org/10.21608/ejah.2024.346750 (journals.ekb.eg)

3. Kościelecka, K., Kuć, A., Kubik-Machura, D., Męcik-Kronenberg, T., Włodarek, J., & Radko, L. (2023). *Endocrine Effect of Some Mycotoxins on Humans: A Clinical Review of the Ways to Mitigate the Action of Mycotoxins.* Toxins, 15(9), 515. https://doi.org/10.3390/toxins15090515 (mdpi.com)

4. Lázaro, Á., Vila-Donat, P., & Manyes, L. (2024). Emerging mycotoxins and preventive strategies related to gut microbiota changes: probiotics, prebiotics, and postbiotics – a systematic review. *Food & Function, 15*, 8998-9023. https://doi.org/10.1039/D4FO01705F (RSC Publishing)

5. Dietz, L. (2024). *Dietary Mycotoxins: An Overview on Toxicokinetics, Toxicodynamics, Toxicity, Epidemiology, Detection, and Their Mitigation with Special Emphasis on Aflatoxicosis in Humans and Animals.* Toxins, 16(11), 483. https://doi.org/10.3390/toxins16110483 (mdpi.com)

6. Lázaro, Á., Vila-Donat, P., Manyes, L. (2024). *Applications of Mycotoxin Biomarkers in Human Biomonitoring for Exposome-Health Studies: Past, Present, and Future.* Exposure and Health, 16, 837-859. https://doi.org/10.1007/s12403-023-00595-4 (SpringerLink)

7. Awuchi, C. G., Nwozo, S., Salihu, M., Odongo, G. A., Sarvarian, M., & Okpala, C. O. R. (2022). *Mycotoxins' Toxicities – From Consumer Health Safety Concerns, to Mitigation/Treatment Strategies: A Perspective Review.* Journal of Chemical Health Risks, 12(3). https://doi.org/10.22034/jchr.2022.1939170.1399 (jchr.org)

8. Shekhar R., Raghavendra V.B., Rachitha P. (2025). *A comprehensive review of mycotoxins, their toxicity, and innovative detoxification methods.* Toxicology Reports, 14:101952, 2025. DOI:10.1016/j.toxrep.2025.101952

9. Li, K., Cai, H., Luo, B., Duan, S., Yang, J., Zhang, N., He, Y., Wu, A., & Liu, H. (2025). *Recent Progress of Mycotoxin in Various Food Products–Human Exposure and Health Risk Assessment.* Foods, 14(5), 865. https://doi.org/10.3390/foods14050865

10. El-Sherbeny E. M. *Mycotoxins: Review on types, toxicity, conventional and updating techniques of detection and counteraction in feeds and foods of animals and humans.* Egyptian Journal of Animal Health, 4(2), 96–109 (2024). DOI:10.21608/ejah.2024.346750.

11. Gopal T., Sugumar V., Wagdevi P., Pereira D. J., Tharannum S. (2025) *A Systematic Review on Mycotoxins in Food and Environment: Occurrence, distribution, Impact on human health and Prevention. International Journal of Environmental Sciences,* 11(21s), 2134–2140. DOI:10.64252/bw6b8h02.

12. Cordero-Mendoza D. D., Hernández-Ceruelos M. C. A., et al. (2023) *Exposure to Mycotoxins and Its Importance in Public Health. European Journal of Nutrition & Food Safety*, 15(10), 21–28.

Дата першого надходження статті до видання: 10.11.2025
Дата прийняття статті до друку після рецензування: 11.12.2025
Дата публікації (оприлюднення) статті: 31.12.2025