RESEARCH ARTICLE

Frontiers in Advanced Materials Research

DOI: 10.34256/famr2521

A Review: Potential of Application of Cold Plasma Technique in Detoxification of Aflatoxins

H.M.R. Hemanthika [a], A.B.G.C.J. De Silva [a], P.N.R.J. Amunugoda [a,*]

[a] Food Technology Section, Industrial Technology Institute, Sri Lanka
[*] Corresponding Author: neville@iti.lk

Received: 25-08-2025, Revised: 09-11-2025, Accepted: 17-11-2025, Published: 04-12-2025

Abstract: Aflatoxins pose a significant challenge to food safety with their high toxicity and widespread occurrence. Implementing effective strategies to mitigate their impact is essential while preserving the physical, chemical, nutritional, and sensory qualities of food. Cold plasma has emerged as an innovative approach for aflatoxin detoxification in food and animal feed, offering a solution that minimizes adverse effects on food properties. Exploring the diverse uses of cold plasma technology in aflatoxin detoxification across various food types is therefore critical. Additionally, scaling up and refining of existing cold plasma processes is vital for enhancing their efficiency and ensuring safe food production in the industry. This review focuses on the potential of cold plasma technology for aflatoxin detoxification and examines strategies for its optimization and industrial-scale implementation.

Keywords: Aflatoxin, Organoleptic properties, Detoxification, Cold Plasma Technology

1. Introduction

Ensuring safe and high-quality food is a crucial and complex challenge due to the presence of contaminants such as mycotoxins. Mycotoxins are harmful substances generated by specific fungi, including Aspergillus, Penicillium, and Fusarium, which can thrive on agricultural crops and food products.

These fungi have the potential to contaminate various agricultural commodities, such as grains, fruits, nuts, and spices [1]. Mycotoxins lead to various health problems in both humans and animals. They present both long-term and short-term dangers, having the potential to cause cancer, genetic mutations, birth defects, cell damage, nerve damage, kidney harm, immune system suppression, and hormonal imbalances.

The main mycotoxins frequently found in food and animal feed worldwide are aflatoxins (AFs), ochratoxin A (OTA), fumonisins, trichothecenes (including deoxynivalenol (DON) and (H)T-2 toxins), zearalenone (ZEN), and patulin [2-4].

There are six primary types of aflatoxins, which are Aflatoxin B1 (AFB1), Aflatoxin B2 (AFB2), Aflatoxin G1 (AFG1), Aflatoxin G2 (AFG2), Aflatoxin M1 (AFM1), and Aflatoxin M2 (AFM2). Among these, Aflatoxin B1 (AFB1) is the most toxic and widespread, known to be a strong carcinogen and associated with liver cancer in both humans and animals. Aflatoxin B2 (AFB2) is less harmful than AFB1, though it still poses a risk. Aflatoxin G1 (AFG1) and G2 (AFG2) are other toxic forms, though they are rarer [5]. Aflatoxin M1 (AFM1) is a metabolite of AFB1 found in the milk of animals that have consumed contaminated feed [6]. It is less toxic than AFB1 but still poses health risks. Due to the adverse health effects of aflatoxins, it is highly important to prevent contamination of food by aflatoxins and decontamination of aflatoxin-contaminated food and feedstuff. Pre-harvest and post-harvest practices are useful to prevent potential microbial contamination.

Pre-harvest strategies are primarily designed to prevent toxin production by inhibiting or eliminating fungal growth. These efforts emphasize good agricultural practices, such as effective pest management and the judicious application of fungicides. An innovative pre-harvest method involves the use of biocontrol techniques, where nontoxigenic strains of Aspergillus fungi, which do not produce aflatoxins, are introduced into crop fields. These benign strains establish themselves, outcompete, and replace the toxigenic strains, leading to a reduction in aflatoxin contamination [7].

Post-harvest, reducing aflatoxin contamination risk largely hinges on proper crop storage, ensuring the crops remain dry, as Aspergillus and many other fungi thrive in humid environments. While preventing fungal contamination is crucial to mitigating the impact of mycotoxins on human and animal health, current practices fall short, especially in less economically developed countries [8]. Although combining good agricultural practices with properly controlled storage conditions helps minimize mycotoxin contamination, these strategies alone cannot guarantee the complete elimination of mycotoxin-producing organisms.

It is evident that the current preventative measures are insufficient to eliminate all potential risks of aflatoxin contamination in feed and food commodities. Therefore, decontamination techniques are essential for controlling aflatoxin risk. These techniques can be categorized into three major types: physical, chemical, and biological decontamination. Traditional methods to address aflatoxin contamination often involve basic physical processes such as sorting and sieving, washing, milling, and thermal treatment. [9]. Aflatoxins can be degraded not only by chemicals, such as certain acids, alkalis, and oxidizing agents, but also by microorganisms and enzymes [10].

Physical decontamination methods such as High moisture thermal treatment (roasting, extrusion, cooking, High-pressure cooking, instant catapult steam explosion) UV light, near-infrared radiation, Gamma irradiation, Pulsed light treatment, pulsed electric field, Ultrasound, and Cold plasma technology are used in degradation of aflatoxins in food and feed materials [11].

Aflatoxin B1 is indeed quite stable under dry heating conditions below its decomposition point. When heated to the point of decomposition, it does emit acrid smoke, which is a result of the breakdown of its chemical structure [11].

The thermal stability of aflatoxin even at higher temperatures, and its resistance to complete inactivation by conventional processing methods indeed pose significant challenges for traditional food processing technologies [11]. Due to the adverse effects of heat treatments on the nutritional properties and quality of foods, the food industry is turning towards non-thermal technologies [12].

The development and implementation of highly efficient novel aflatoxin decontamination strategies will become increasingly critical for protecting both human and animal health. These advancements are essential not only for reducing contamination risks but also for ensuring the safety and quality of food and feed commodities from production to consumption.

2. Cold plasma Technology

Recent studies have shown that plasma technology can efficiently inactivate microbial pathogens, such as bacteria, fungi, and viruses, and degrade toxins. This innovative approach holds significant promise for enhancing safety and quality in various fields, including medical device sterilization, agricultural product treatment, and food preservation [13].

Plasma is an ionized gas with high energy levels, commonly known as the fourth state of matter. It comprises free electrons, charged ions, ultraviolet (UV) radiation, and various reactive neutral particles, such as Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS).

Based on the temperature generated during electrical discharges, plasma can be categorized as thermal and non-thermal plasma. Non-thermal plasma is also known as cold plasma. Cold plasma is produced by electrical discharges in gases under atmospheric pressure, functioning within a temperature range of 30 to 60°C [14]. Furthermore, it can be classified based on the system used for its generation, including Corona Discharge (CD), Dielectric Barrier Discharge (DBD), Atmospheric Pressure Plasma Jets (APPJ), and Radio Frequency Plasma (RFP) [15].

Recent advancements in cold atmospheric pressure plasma sources have enabled the precise tailoring of discharges to produce highly reactive species in high concentrations, while maintaining temperatures close to room temperature. These developments have significantly broadened the scope of biological applications, including improved methods for disinfection, sterilization, and mycotoxin degradation [13]. Extensive research has shown that CPT is capable of inactivating a wide range of microorganisms, including bacteria, fungi, and viruses. Multiple studies have confirmed its efficacy against different bacterial strains [16]. CPT has been proven to inactivate different fungal species [17]. Research indicates that Cold Plasma Technology can also inactivate viruses [18]. Moreover, Cold Plasma expertise can be applied to purify mycotoxins, particularly aflatoxins, making it a valuable tool for safeguarding food safety and quality. The temperature range of cold plasma is close to room temperature, which minimizes thermal damage to food quality [19]. These low temperatures are approachable to heat-sensitive food materials [20]. Additionally, Cold plasma equipment requires lower operating costs for maintenance and energy, making it a cost-effective option for food processing [21].

Aflatoxins are highly stable chemical compounds that cannot be eliminated by regular thermal processing techniques. Decomposition temperatures of aflatoxin are in the range of 237–306 ◦C [22]. Cold plasma has demonstrated significant effectiveness in degrading mycotoxins in various food products [13]. This technology offers a promising solution for addressing the limitations of traditional methods and improving food safety [21]. CPT can be utilized across a wide range of industries, including polymers and electronics [20]. In the agricultural and food sectors, CPT applications include: enhancing seed germination rates [23]; effectively decontaminating food products from microbial pathogens [20]; inactivating enzymes that could affect food quality[24]; degrading toxins such as mycotoxins[19]; modifying packaging materials to improve their properties [11]; removing pesticide residues from food surfaces [25]. CPT's versatility and effectiveness make it a promising technology for improving food safety and quality in various ways.

3. Application of Cold Plasma Technology in Detoxification of Aflatoxin

A growing number of studies have shown the potential for cold plasma-treated food products, such as flour [26], peanuts [27] and wheat [28]. Cold plasma has also been demonstrated as a potential alternative approach to aflatoxin decontamination [8]. Cold plasma technology has proven effective in rapidly detoxifying aflatoxins under ambient temperature and pressure conditions [19]. For example, a study employed dielectric barrier discharge (DBD) N_2-plasma to break down aflatoxins on dehulled hazelnuts [29]. Their results demonstrated that around 70% of AFB_1, AFB_2, and total aflatoxins were effectively detoxified after just 12 minutes of exposure to a 1150 W plasma treatment. The study also revealed that AFB_1 and AFG_1 were exhibited greater sensitivity to N_2-plasma treatment compared to AFB_2 and AFG_2, respectively. Additionally, researchers [30] observed that the effectiveness of N_2-plasma in detoxifying AFB_1 depended on both processing duration and plasma frequency. The results indicated that 15 minutes of N_2-plasma treatment at 1.5 kpps reduced AFB_1 by over 90% and successfully eliminated its toxicity to HepG2 cells [31].

The investigation explored the effects of carrier gas type and relative humidity on AFB_1 breakdown triggered by high voltage atmospheric cold plasma (HVACP). The carrier gases studied included air and a modified atmosphere consisting of 65% O_2, 30% CO_2, and 5% N_2. The relative humidity levels tested were 5%, 40%, and 80%. [32]. The optimal outcome was obtained by running the plasma in a modified atmosphere with 40% relative humidity (RH), resulting in the removal of 88.3% of AFB_1 in corn within 5 minutes. For peanut samples, 5 minutes of treatment with an agitated atmospheric pressure plasma jet (APPJ) led to a 38% reduction in total aflatoxin levels, without adversely affecting the chemical quality of the peanut oil [27].

Previous research assessed the impact of Corona Discharge Plasma Jet (CDPJ) treatment on the degradation of AFB_1 on glass slides and contaminated food samples [33]. Thirty minutes of CDPJ treatment resulted in a 95% reduction in AFB_1 concentration on glass slides. However, AFB_1 levels in rice and wheat were reduced by 56.6% and 45.7%, respectively. The authors suggested that the variation in AFB_1 degradation between the glass slides and food samples could be attributed to chemical interactions between AFB_1 and the food matrix, which may resist the degradation of the toxin.

The effectiveness of aflatoxin degradation using cold plasma largely depends on various factors, including the plasma system employed, operating conditions (such as working gas, moisture, and energy input), exposure duration, and the specific type of food product. The investigation into the effects of microwave-powered cold plasma treatments on reducing microorganisms in red pepper powder, including Aspergillus flavus and Bacillus cereus spores, revealed significant results. Using nitrogen-based CPT at 900 W and 667 Pa for 20 minutes, the A. flavus count decreased by 2.5 ± 0.3 log spores per gram. The study concluded that the microwave-powered cold plasma system is effective in inhibiting A. flavus in red pepper powder [34].

A study assessed the decontamination efficacy of cold atmospheric pressure plasma against six of the most common mycotoxins found in foods and feedstuffs. According to the results, a concentration reduction of up to 66% was achieved in maize for both aflatoxin B_1 and fumonisin B_1. In the case of maize samples, the final concentrations in spiked grains exposed were 1.25 ng/g for AFB_1 and 259 ng/g for FB_1. After 10 minutes of plasma exposure, AFB_1 and FB_1 were reduced by 65% and 64%, respectively [8]. Microwave argon plasma at atmospheric pressure was shown to be sufficient for complete AFB_1 degradation on a glass substrate after just 5 seconds [35]. Radio frequency plasma at 300W demonstrated an 88% reduction in AFB_1 after 10 minutes [36]. On hazelnuts, under conditions of (1000 W, 12 minutes), a reduction in the concentration of total aflatoxins and AFB_1 of over 70% was obtained. Aflatoxins B_2 and G_1 were more sensitive to plasma treatments compared to aflatoxins B_1 and G_2, respectively [29]. Aflatoxin B_1 was more sensitive compared to aflatoxin G_1. At the highest power and for the longest exposure time, the maximum temperature increment was 28.9°C [29].

Cold atmospheric plasma shows promise as a method for aflatoxin detoxification in food. It is effective in significantly reducing aflatoxin levels while potentially maintaining the organoleptic characteristics of the food [29]. Cold plasma is a versatile technology that can be scaled and tailored to different food types and mycotoxins. It offers the potential to be a costefficient and sustainable solution, needing less energy than many alternative methods. Research so far has shown that cold plasma can break down mycotoxins on the surface of foods like peanuts without causing major changes to their nutritional value or sensory qualities, while producing degradation by products that are proven to be less harmful [27].

4. Mode of action of cold plasma to degrade

In contrast to conventional methods, CPT has the potential to reduce aflatoxin contamination by either preventing their production at the source or converting the toxins into less harmful or non-toxic substances. However, the exact mechanisms through which CPT facilitates aflatoxin detoxification and interferes with their biosynthesis are not fully understood, which presents significant challenges to its broad commercial adoption. According to available experimental data, it is proposed that CPT detoxifies aflatoxins by damaging or oxidizing fungal cell structures, disrupting cellular components and metabolism, ultimately resulting in fungal death [37].

5. Scale Up of Cold Plasma Technology

While commercial plasma equipment specifically designed for the food industry is uncommon, a range of plasma technologies from other sectors is increasingly emerging in the market. These are primarily utilized in areas such as medical applications, environmental protection, electronics, and material preparation or modification [38]. Expanding cold plasma technology for industrial use requires careful attention to factors that ensure its effectiveness, efficiency, and cost-effectiveness. Its broad applicability in the food industry is expected to drive demand, thanks to its ability to improve food safety, quality, and shelf life.

6. Conclusion

Cold plasma operates through non-thermal mechanisms and eliminates the need for chemical additives, thereby preventing heat-related damage and the accumulation of chemical residues. This feature harmonizes with numerous ecological and environmental standards, positioning cold plasma as an excellent choice for sustainable and eco-friendly applications. However, further research is essential to identify the specific active particles and their effective doses for CPT applications, to pinpoint the points at which CPT interferes with aflatoxin biosynthesis, and to assess its effects on the nutritional value and sensory qualities of various food types. Additionally, since there is limited evidence confirming that the degradation products are less toxic than AFB1, further studies are needed to evaluate their toxicity from cellular, physiological, and molecular perspectives.

References

[1] CAST (Council for Agriculture Science and Technology) (2003) Mycotoxins Risks in Plant, Animal, and Human Systems. Task Force Report 139, CAST, Ames.

[2] J.W. Bennett, M. Klich, Mycotoxins. Clinical Microbiology Reviews, 16, (2003) 497-516. https://doi.org/10.1128/CMR.16.3.497-516.2003

[3] S. Marin, A.J. Ramos, G. Cano-Sancho, V. Sanchis, 2013. Mycotoxins: Occurrence, toxicology, and exposure assessment. Food and chemical toxicology, 60, (2013) 218-237. https://doi.org/10.1016/j.fct.2013.07.047

[4] E. Wielogorska, Y. Ahmed, J. Meneely, W.G. Graham, C.T. Elliott, B.F. Gilmore, A holistic study to understand the detoxification of mycotoxins in maize and impact on its molecular integrity using cold atmospheric plasma treatment. Food chemistry, 301, (2019) 125281. https://doi.org/10.1016/j.foodchem.2019.125281

[5] A. Kumar, H. Pathak, S. Bhadauria, J. Sudan, Aflatoxin contamination in food crops: causes, detection, and management: a review. Food Production, Processing and Nutrition, 3(1), (2021) 17. https://doi.org/10.1186/s43014-021-00064-y

[6] Y. Liu, F. Wu, Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. Environmental health perspectives, 118(6), (2010) 818. https://doi.org/10.1289/ehp.0901388

[7] L.A. Senghor, A. Ortega-Beltran, J. Atehnkeng, K.A. Callicott, P.J. Cotty, R. Bandyopadhyay, The atoxigenic biocontrol product Aflasafe SN01 is a valuable tool to mitigate aflatoxin contamination of both maize and groundnut cultivated in Senegal. Plant Disease, 104(2), (2020) 510-520. https://doi.org/10.1094/PDIS-03-19-0575-RE

[8] E. Wielogorska, M. Mooney, M. Eskola, C.N. Ezekiel, M. Stranska, R. Krska, C. Elliott, Occurrence and human-health impacts of mycotoxins in Somalia. Journal of agricultural and food chemistry, 67(7), (2019) 2052-2060. https://doi.org/10.1021/acs.jafc.8b05141

[9] H. Marshall, J.P. Meneely, B. Quinn, Y. Zhao, P. Bourke, B.F. Gilmore, G. Zhang, C.T. Elliott, Novel decontamination approaches and their potential application for post-harvest aflatoxin control. Trends in Food Science & Technology,106, (2020) 489-496. https://doi.org/10.1016/j.tifs.2020.11.001

[10] C. Boudergue, C. Burel, S. Dragacci, M.C. Favrot, J.M. Fremy, C. Massimi, P. Prigent, P. Debongnie, L. Pussemier, H. Boudra, D. Morgavi, Review of mycotoxin-detoxifying agents used as feed additives: mode of action, efficacy and feed/food safety. EFSA Supporting Publications, 6(9), (2009) 22E. https://doi.org/10.2903/sp.efsa.2009.EN-22

[11] S.K. Pankaj, H. Shi, K.M. Keener, A review of novel physical and chemical decontamination technologies for aflatoxin in food. Trends in food science & technology,71, (2018) 73-83. https://doi.org/10.1016/j.tifs.2017.11.007

[12] O.P. Chauhan, L.E. Unni, Pulsed electric field (PEF) processing of foods and its combination with electron beam processing. Electron beam pasteurization and

complementary food processing technologies, (2015) 157-184. https://doi.org/10.1533/9781782421085.2.157

[13] A. Sakudo, Y. Yagyu, T. Onodera, Disinfection and sterilization using plasma technology: Fundamentals and future perspectives for biological applications. International journal of molecular sciences,20(20), (2019) 5216. https://doi.org/10.3390/ijms20205216

[14] C. Hertwig, N. Meneses, A. Mathys, Cold atmospheric pressure plasma and low energy electron beam as alternative nonthermal decontamination technologies for dry food surfaces: A review. Trends in Food Science & Technology, 77, (2018) 131-142. https://doi.org/10.1016/j.tifs.2018.05.011

[15] A. Fridman, A. Chirokov, A. Gutsol, Non-thermal atmospheric pressure discharges. Journal of Physics D: Applied Physics, 38(2), (2005) R1-R24. https://doi.org/10.1088/0022-3727/38/2/R01

[16] O.F. Nwabor, H. Onyeaka, T. Miri, K. Obileke, C. Anumudu, A. Hart, A cold plasma technology for ensuring the microbiological safety and quality of foods. Food Engineering Reviews, 14(4), (2022) 535-554. https://doi.org/10.1007/s12393-022-09316-0

[17] N.N. Misra, S.K. Pankaj, A. Segat, K., Ishikawa, Cold plasma interactions with enzymes in foods and model systems. Trends in Food Science & Technology, 55, (2016) 39-47. https://doi.org/10.1016/j.tifs.2016.07.001

[18] Y. Guo, L. Zhao, Q. Ma, C. Ji, Novel strategies for degradation of aflatoxins in food and feed: A review. Food Research International, 140, (2021) 109878. https://doi.org/10.1016/j.foodres.2020.109878

[19] M. Gavahian, Y.H. Chu, C. Jo, Prospective applications of cold plasma for processing poultry products: Benefits, effects on quality attributes, and limitations. Comprehensive Reviews in Food Science and Food Safety, 18(4), (2019) 1292-1309. https://doi.org/10.1111/1541-4337.12460

[20] F.G.C. Ekezie, D.W. Sun, J.H. Cheng, A review on recent advances in cold plasma technology for the food industry: Current applications and future trends. Trends in food science & technology, 69, (2017) 46-58. https://doi.org/10.1016/j.tifs.2017.08.007

[21] S. Harikrishna, P.P. Anil, R. Shams, K.K. Dash, Cold plasma as an emerging nonthermal technology for food processing: A comprehensive review. Journal of Agriculture and Food Research, 14, (2023) 100747. https://doi.org/10.1016/j.jafr.2023.100747

[22] I.Y. Rustom, Aflatoxin in food and feed: occurrence, legislation and inactivation by physical methods. Food chemistry, 59(1), (1997) 57-67. https://doi.org/10.1016/S0308-8146(96)00096-9

[23] M. Darmanin, A. Frohling, S. Bubler, J. Durek, S. Neugart, M. Schreiner, R. Blundell, R. Gatt, O. Schluter, V.P. Valdramidis, Aqueous and gaseous plasma applications for the treatment of mung bean seeds. Scientific Reports, 11(1), (2021) 19681. https://doi.org/10.1038/s41598-021-97823-1

[24] Y. Han, J.H. Cheng, D.W., Sun, Activities and conformation changes of food enzymes induced by cold plasma: A review. Critical reviews in food science and nutrition, 59(5), (2019) 794-811. https://doi.org/10.1080/10408398.2018.1555131

[25] A.A. Zhang, P.P. Sutar, Q. Bian, X.M. Fang, J.B. Ni, H.W. Xiao, Pesticide residue elimination for fruits and vegetables: The mechanisms, applications, and future trends of thermal and non-thermal technologies. Journal of Future Foods, 2(3), (2022) 223-240. https://doi.org/10.1016/j.jfutfo.2022.06.004

[26] M. Menkovska, K. Dimitrov, M. Mangova, Effect of cold plasma on wheat flour and bread making quality, Macedonian Journal of Animal Science, 4(1), (2014) 27–30,

[27] B.M. Iqdiam, M.O. Abuagela, Z. Boz, S.M. Marshall, R. Goodrich-Schneider, C.A. Sims, M.R. Marshall, A.J. MacIntosh, B.A. Welt, Effects of atmospheric pressure plasma jet treatment on aflatoxin level, physiochemical quality, and sensory attributes of peanuts. Journal of Food Processing and Preservation, 44(1), (2020) e14305. https://doi.org/10.1111/jfpp.14305

[28] N. Bahrami, D. Bayliss, G. Chope, S. Penson, T. Perehinec, I.D. Fisk, Cold plasma: A new technology to modify wheat flour functionality. Food chemistry, 202, (2016) 247-253. https://doi.org/10.1016/j.foodchem.2016.01.113

[29] I. Siciliano, D. Spadaro, A. Prelle, D. Vallauri, M.C. Cavallero, A. Garibaldi, M.L. Gullino, Use of cold atmospheric plasma to detoxify hazelnuts from aflatoxins. Toxins,8(5), (2016) 125. https://doi.org/10.3390/toxins8050125

[30] A. Sakudo, Y. Toyokawa, T. Misawa, Y. Imanishi, Degradation and detoxification of aflatoxin B1 using nitrogen gas plasma generated by a static induction thyristor as a pulsed power supply. Food Control, 73, (2017) 619-626. https://doi.org/10.1016/j.foodcont.2016.09.014

[31] Y. Guo, L.L. Breeden, W. Fan, L.P. Zhao, D.L. Eaton, and H. Zarbl, Analysis of cellular responses to aflatoxin B1 in yeast expressing human cytochrome P450 1A2 using cDNA microarrays. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 593(1-2), (2006) 121-142. https://doi.org/10.1016/j.mrfmmm.2005.07.001

[32] H. Shi, B. Cooper, R.L. Stroshine, K.E. Ileleji, K.M. Keener, Structures of degradation products and degradation pathways of aflatoxin B1 by high-voltage atmospheric cold plasma (HVACP) treatment. Journal of agricultural and food chemistry, 65(30), (2017) 6222-6230. https://doi.org/10.1021/acs.jafc.7b01604

[33] S. Choi, P. Puligundla, C. Mok, Effect of corona discharge plasma on microbial decontamination of dried squid shreds including physico-chemical and sensory evaluation. LWT, 75, (2017) 323-328. https://doi.org/10.1016/j.lwt.2016.08.063

[34] J. Eun kim, D. Un Lee, S.C. Min, Microbial decontamination of red pepper powder by cold plasma, Food Microbiology, 38, (2014) 128–136. https://doi.org/10.1016/j.fm.2013.08.019

[35] B.J. Park, K. Takatori, Y. Sugita-Konishi, I.H. Kim, M.H. Lee, D.W. Han, K.H. Chung, S.O. Hyun, J.C. Park, Degradation of mycotoxins using microwave-induced argon plasma

at atmospheric pressure. Surface and Coatings Technology, 201(9-11), (2007) 5733-5737. https://doi.org/10.1016/j.surfcoat.2006.07.092

[36] Ivana Sremački, Lei Wang, Andrea Jurov, Martina Modic, Uroš Cvelbar, Christophe Leys, Anton Nikiforov, Radio-frequency plasma in combination with aerosol injection for biomedical applications, International Symposium on Plasma Chemistry (ISPC24), 2019.

[37] Y. Wu, J.H. Cheng, D.W. Sun, Blocking and degradation of aflatoxins by cold plasma treatments: Applications and mechanisms. Trends in Food Science & Technology,109, (2021) 647-661. https://doi.org/10.1016/j.tifs.2021.01.053

Conflict of interest: The Authors have no conflicts of interest to declare that they are relevant to the content of this article.