Magna Scientia Advanced Biology and Pharmacy

eISSN: 2582-8363

Cross Ref DOI: 10.30574/msabp

Journal homepage: https://magnascientiapub.com/journals/msabp/

(REVIEW ARTICLE)

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Mycotoxins: Their presence in food and relationship with nanoparticles

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Magna Scientia Advanced Biology and Pharmacy, 2024, 12(01), 060–067

Publication history: Received on 25 April 2024; revised on 07 June 2024; accepted on 10 June 2024

Article DOI: https://doi.org/10.30574/msabp.2024.12.1.0037

Abstract

Mycotoxins are toxic compounds that are produced by certain fungi species; these compounds are found in many food products and may have detrimental effects on the health of human beings and livestock. Mycotoxins spoilage in food triggers both short-term and long-term effects including upset stomachs, liver, kidney, and neurological disorders. Typically used inspection methods for determination of mycotoxins in foods are cumbersome, tedious, and can sometimes give out inaccurate results. Therefore, there is a need for improvement in the approaches used for early detection of mycotoxins and the control of mycotoxin contamination in foods. As for the fourth direction, we can pinpoint nanotechnology for the detection of mycotoxin and their prevention as a promising field of study. When manipulated for use in food, the small size, geometry and surface characteristics of nanoparticles can be used to improve the detection and elimination of mycotoxins in foods. To date, implementation of nanoparticles in food safety is rather limited; however, the potentials of the technology have been highlighted by the existing studies. For instance, some current research has ascertained that nanoparticles are capable of adsorbing mycotoxins so that these toxins are easily separated from the food products. Also, nanoparticles can also be applied for the purpose of degrading or neutralizing mycotoxin.

Keywords: Mycotoxins; Nanoparticles; Fungi; Foods; Contamination; Aflatoxins

1. Introduction

1.1. Introduction to Mycotoxins and Nanoparticals

Mycotoxins are toxic compounds, which can be produced by specific fungal species or molds, as the general public usually calls them. They are commonly found in diverse habitats including terrestrial and aquatic habitats, food and soil, and the ingestion or inhalation of the spores poses serious health risks to human beings. Mycotoxins are toxic metabolites produced by fungi that may enter into the food chain and therefore cause risks to the quality and safety of food [1, 2]. Now, it is high time to learn more about mycotoxins – Familiarize your with the potential health effects of naturally occurring toxins thanks to scientific findings and research. Thus, the work aimed to establish the correlation between mycotoxins and nanoparticles and their impact on the quality and safety of foods [3][4].

In this research and analysis, it has been realized that the mycotoxins and nanoparticles bear some relationship. In this process, we have discovered that these particles can alter the toxicity and the rate of absorption of mycotoxins; a situation that may pose other health risks and challenges (5).

The study between mycotoxins and nanoparticles is one of the most researched fields, given that both elements have severe impacts on the health of a human being; within this paper, we look deeper into both to further understand their effects. Enhancing the understanding of such connections may also be useful in developing new policy strategies in managing food safety and quality as well as population health.

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The present review is focused on the analysis of molecular methods for detection of mycotoxins in food products, including those containing nanoparticles. Because of that, employing complicated techniques and technologies such as spectroscopy and nanotechnology, it is possible to quantify the mycotoxin production with more sensitivity and selectivity(6).

Furthermore, this review aims to also evaluate the impact of nanoparticles regarding mycotoxins removal, adsorption, and bioaccumulation. Therefore, we believe that the awareness of these interactions can be helpful to contribute to the elaboration of new approaches in mycotoxin control like new methods for detoxifying the mycotoxins and improved standards.

2. Common Sources of Mycotoxins in food and the Implications of Nanoparticles

Mycotoxins are toxic compounds that are produced naturally by some fungi, which poses a threat to the quality of food products. It is widely distributed in food products like cereals, nuts and oil seeds, fruits and vegetables. Mycotoxins are toxic compounds produced by fungi that can be found in food and can cause acute and chronic toxic effects, immune suppression, and even cancer. In order to reduce the effects of mycotoxins, the following measures have been put in place; processing, storage and packaging of food as well as the application of natural or synthetic antimicrobial agents. Nevertheless, the development of nanotechnology has given a new perspective to the interaction of nanoparticles with mycotoxins and therefore human health (5).

Nanoparticles are particles which have one to hundred nanometers dimensions and have been investigated for numerous applications in fields such as agriculture, food processing, and even medicine. Endorsed. The issue stems from the uncertainty as to how nanoparticles used in food packaging or as preservatives can affect mycotoxins in food and whether the interactions enhance or diminish the toxins' characteristics or bioavailability. This could result in changes in mycotoxin levels, toxicity or degree of degradation that could be potential health risks to humans The relationship between mycotoxin and nanoparticles is however unknown and much more research has to be done to identify the extent and kind of interaction between these two. Thus, the interaction of mycotoxins and nanoparticles needs to be studied by the researchers, regulatory bodies, and industries, as both compounds are commonly found in the food chain. The purpose is to promote the proper utilization of nanotechnology and prevent risk factors threatening public health(7).

There has however been a rising concern especially in the recent past over the possible advantages and disadvantages that come with the incorporation of nanomaterials in foods. Whereas, these tiny particles can help prolong the shelf-life of food, enhance on the taste and quality improve food safety, they pose the risk of interacting with mycotoxins hence being a health concern. The prospects of these interactions are still vague, and more efforts in research in the fight against the ill effects of Mycotoxins have been considered of high priority to the food

3. Types of Mycotoxins and Their Effects on Health

Aflatoxin is one mic of mycotoxin that is very hazardous and has been associated with liver cancer and other diseases. Other known mycotoxins include: ochratoxin A which has the ability to affect the kidney Other risks associated with these toxins necessitate that producers of foods should ensure that the foods they produce do not contain mycotoxins. There is also a possibility that, reducing or eliminating these toxins cannot be achieved by implementing the conventional food inspection procedures. This is where the rein of nanotechnology comes to the foreground. As mycotoxins research advances in understanding of changes that occur with environmental factors there has been the emergence of nanoparticles as a unique way to identify and safely disarm these toxins. Nanoparticles can be defined as particles which are generally less than 100nm in size and can also be lesser than 1nm. These tiny particles have some special characteristics that make them profoundly multifunctional and emergency in numerous fields, particularly in medicine, Electronics and food Industries. (8)

Nanoparticles offer a reasonable chance of decontaminating food products of mycotoxins since the latter have affinity for the former. This binding process can be enhanced through modifying the nanoparticles to enhance their ability to selectively target and bind with the mycotoxins. It is then possible to ingest or apply the functionalized nanoparticles to contaminated food, and they will only be attracted to the mycotoxins and will not be absorbed by the body. This form of mycotoxin decontamination is very effective since it is selective, with the ability of eliminating selected forms of mycotoxins without any alterations to the nutritional content or palatability of the food in question. Furthermore, it is possible to control the biodegradability of the nanoparticles so that the consumers face no threats of ill health. It is a good rational for changing the trend in the food industry in a positive way by helping to prevent the adverse impacts of

mycotoxin to the health of people. But a special emphasis should be made on the prolongation of the research concerning the impact of nanoparticles for mycotoxin. (6)

4. Occurrence of Mycotoxins in Food and relationship with nanoparticals

Mycotoxins are also common in food products with the average global incidence of mycotoxins in food products ranging from 20 to 80%. Mycoflora toxins prove to be a challenge in crops to farmers, food processors, and consumers as well. If this issue is not addressed, there are serious health implications for both human beings as well as animals. Some of the existing mycotoxins include aflatoxins, and these are well known to be found in cereals, nuts and even spices. Aflatoxins specially aflatoxin B1 is acknowledged to be potent carcinogens and implicated in liver cancer. Other mycotoxins like trichothecenes, fumonisins and patulin were also reported to have toxic effects which include immunotoxicity neurotoxicity and renal toxicity (9). Due to the rising concern of food safety and human health, it is significant to assess the possible negative effects of mycotoxins and devise mechanisms to minimize their threats. Still, as the situation develops and the pool of knowledge expands, new opportunities are being introduced to address this issue on an international level. Some of these are the nanoparticles which has been used in food protection since it kills mycotoxins in the processing of foods. For instance, the nanoparticles can be used as containers with enzymes that are capable of breaking mycotoxins or sensors used in identification of mycotoxins in samples of food products(10). In addition, it will also be important to note that nanoparticles may act in synergy with current remediation technologies to improve the efficiency of the methods that are in use today. For instance, in the case of nanoparticles, antibody or receptors can be attached to the oxide surface enhancing its selectivity to mycotoxines, thereby improving the treatment's efficacy . It not only brings about lower total mycotoxins in food items but also eliminates or lessens the adverse impact on the other beneficial ingredients of a food.

Additionally, tracing articles based on nanoptechnology can be applied also to the identification and control of mycotoxin-contaminated products and to minimize the threats of the mycotoxin contamination crisis for consumer health and to the more effective management of affected products, in order to decrease the general losses, associated with mycotoxin contamination. (11)

Therefore, nanotechnology offers a unique opportunity not only in the detection of mycotoxin contamination but also in the creation of novel methods of its treatment. Therefore, utilizing nanoparticles in combating mycotoxin contamination poses a viable solution in enhancing food safety, reducing the effects of hazardous toxic metabolites from the fungi, and its potential deleterious impacts on the consumer. This is why it is crucial for us to keep on seeking more about nanotechnology application in mycotoxins control and study. In doing so, we are then able to further the improvement of our capability (6).

An even greater focus has been on the possible effects of nanoparticles on the environment and human health, and studies revealing their interactions with mycotoxins were recently conducted. Such interaction may contradict conventional knowledge regarding toxin toxicities, sources, and risks and opportunities of reducing the impact of mycotoxins. This article establishes the importance of the growing trends and the expansion of nanotechnology in our lives as well as the various relationships that are present in this context. This article further discusses the current literature review on the impacts of nanoparticles with respect to mycotoxin contamination and emphasized that more research is still needed to generate definitive data on the health risks of nanoparticles on human beings. Mycotoxins are secondary metabolites that have toxic effects on human and animals and are produced by certain moulds of fungi that contaminate different food and feed m commodities. They are known to cause a plethora of health impacts such as acute poisonous reactions, tumor formation, immune dysfunction, neurological disorders and endocrine disruption(12).

The level of mycotoxin accumulation in food and feed items depends on the type of moulds, plant variety, climatic conditions, and the availability of toxins in the substrate. The raised presence of nanoparticles, particularly engineered nanoparticles (ENPs), has been noticed as a source that may influence mycotoxin generation, transference, and incorporation to humans. ENPs possess specific chemical characteristics, which enable them to produce an effect on biological systems at a molecular level, and, therefore, have an impact on the mycotoxins' properties and toxicity. This may pose a threat to the well-being of the people because the application of ENPs is on the rise. In order to address this concern, various researchers have been investigating the effects of ENPs on mycotoxin synthesis and behavior in different matrices of food and feed. It has been ranked that ENPs can interfere with mycotoxin-producing fungi, on growth, metabolic processes, and toxin synthesis (6).

5. The Role of Nanoparticles in Mycotoxin Interactions

The application of nanoparticles can therefore be considered as a new approach of managing the mycotoxin contamination in foods. These tiny particles with size and surface that is smaller than a micro metre are capable of interacting with mycotoxins in many ways. Scientists have looked into the application of nanoparticles in increasing the ability to detect, remove and degrade mycotoxin. Based on the information available, the following are some of the notable uses of nanoparticles in relation to mycotoxins:

5.1. Nanosensors for Mycotoxin Detection

Due to the high toxicity of mycotoxins there is a need to come up with highly sensitive and specific nanosensors for detecting of these toxins in foods. These sensors work based on such properties as size, shape, and surface chemistry of the nanoparticles to selectively interact with mycotoxins and give an amber signal. This is because the initial sensing element can be reduced in size to less than 1 micron and this gives a great variety and ingenuity of mycotoxins that can be detected by the nanosensors and these include; aflatoxins, ochratoxins, fumonisins and trichothecenes among others known widely. These are the areas where is crucial to enhance quick, accurate, and noninvasive detection rates, and nanosensors contribute essentially to the safety of foods and general health. In addition to playing the role of mycotoxin probes, nanoparticles can also be applied to several other stage of the food supply chain (12) . For instance, they find application in food preservation by suppressing the growth of mold, conserving food items from early contamination and spoiling. Silver nanoparticles can be effectively implemented into the food packaging materials to provide antimicrobial films that have an ability to retarded bacterial and fungi growth on the food contact surfaces. Moreover, certain nanoparticles have been shown to have antioxid ant properties, which can help to prevent oxidative damage to food and extend its shelf life. This is particularly important for fruits and vegetables, which are highly susceptible to spoilage due to their high water content and perishable nature(13).

Research and development of NP for food safety is currently underway and there are possibilities of tremendous applications of these materials in the food processing industries. Looking at the further development of ideas on the relationship between nanoparticles and mycotoxins, one can expect the appearance of new and non-trivial approaches that will help guarantee that food is safe and healthy for consumption for future generations. Thus, the incorporation of nanoparticles in the food security sector will help mitigate mycotoxin contamination hence leading to healthy, safe and sustainable food systems (14).

5.2. Nanoparticles for Mycotoxin Removal

In addition to their uses in detection, nanoparticles desalination, shows that the efficient removal of mycotoxins from water and food products cannot be overemphasized. High surface area-to-volume ration of the nanoparticles allows them to possess features of highly active sorbents that can bind mycototoxins on the top of them and stop human or animals from ingesting or absorbing them. Lastly, this ability of nystatin to eliminate the mycotoxins from the contaminated food and water can useful in preventing the outbreak of deadly diseases as well as the loss of huge sums of money in food that has been contaminated (15).

Nanotechnology is also used in the synthesis of new materials and techniques for decontamination of mycotoxins from water and food. These nanoparticle based technologies have a number of advantages over conventional methods in terms of efficiency and costs, make a bold yet accurate statement of fact. As a result, it can be concluded that nanoparticles and nanotechnology hold great potential in the context of mycotox in control. Due to their special characteristics, the nanoparticles can be used as effective means in Casting out Mycotoxins (16)

6. The Innovative Use of Nanoparticles

Nanoparticles have been cited to be of innovative nature when it comes to fight against mycotoxins. These micro particles that have characteristics that differentiate them from all other particles are at the apex of innovations and they are being deployed to counter the impacts of mycotoxins. Mycotoxins are a public health and food safety issue, and the interaction of nanoparticles with mycotoxins has a great potential for the development of safer food for the human consumption and a healthier environment. (17)

There are however number of significant application of nanoparticles in the mycotoxins field of study one, few of which include use of adsorbents. Molecular selectivity which is accorded by nanotechnology makes sure that it compels the friendly particles to have affinity in the mycotoxins so that they can easily decontaminate food and feeds. This innovative

strategy is effective to have a higher possibility of decreasing the terms of exposure to mycotoxins and its negative impacts on the health of individuals, making consumers to have assured and proper food quality. (18)

Furthermore, the domain of nanotechnology is making swift strides in the realm of mycotoxin detection as well as monitoring. This has enabled us to promptly recognize and respond to mycotoxin presences and scrutinize the probable danger they entail. These groundbreaking instruments exploit the distinctive characteristics of nanoparticles to magnify the sensitivity and precision of mycotoxin detection techniques, permitting swift and accurate food product screening for such contamination.(5)

7. Consumer Education and Awareness

The general public has a critical role in preventing the contamination of the food chain. In this way, they become knowledgeable about the mycotoxin contamination and the danger that comes along with it thus helping shape the food we eat and environment. It is therefore important to educate the consumers on mycotoxins and effects they may have on the health of people through complex consumer education programs with easily understandable information. (19)

The other way of communicating with consumers involves the different forms of media some of which include the print media, the television media and the social media. Some of the modality for dissemination of information includes; Educational aids such as food brochures, mycotoxininfographics, and mycotoxin websites can be prepared and distributed in a simple and understandable manner. Such resources should be placed in easily accessible areas; these include libraries, community centers, supermarkets, and online. (20)

Lastly, to further spread awareness, outreach campaigns or campaigns that involve teaching the public could be conducted to educate different groups of people for example children, pregnant women, and people living with diseases that could predispose them to the effects of mycotoxins. (21)

8. Regulation and Mitigation Strategies

The most effective measures to reduce mycotoxin levels in foods and protect consumers' health are the implementation of strict legislative requirements. It became very important for governments and regulatory authorities to set and implement productive, storage, processing, and trading policies and legislations on foods. These government policies should establish maximum measurable levels of mycotoxins in foods and ensure food industries are responsible for the safety of their food products. In this manner, consumers are able to understand what they take and this will help reduce the instances of mycotoxin health implications(22). However, it is important to understand that regulation is not the only solution that individual can use to deal with mycotoxins. There should also be preventative measures in place, including GAPs, post harvest handling and management, and research and development of new technologies that can assist in eradicating mycotoxin production risks. These may include improvement of the current mould control measures whereby proper antifungal agents or even biological control measures can be used. Therefore, research and education should also be invested in for enhanced understanding of mycotoxins and possibilities of their dangerous effects on human health (23). The use of nanoparticles in mycotoxin decontamination is a field of relevance since it has substantial potential in terms of formulation and effectiveness of detoxification processes. Through the help of these state-of-the-art technologies, the agricultural industry has the capacity to lessen the possibility of occurrences like mycotoxin contamination within foods. Moreover, it is essential to increase awareness of the susceptibilities connected to mycotoxin consumption for consumers to act wisely while purchasing food products. This can be done via awareness and education, through booklets, flyers, and clear labeling systems that relay the information on the level of mycotoxin in certain products (24). However, there is a need for both governmental and regulatory organizations to engage scientific researchers, other governments, and interested industries in developing multilateral strategies for combating mycotoxin contamination in food. Through applying technology and integrating a diverse approach, it is possible to strive for the goal of safety and quality of the food, minimizing and preventing the emergence of diseases and thus provide protection of the population's health (25).

In conclusion, these results contribute to the increasing concern of mycotoxin contamination due to the high demand of food products in the market, it is important to implore various measures that can combat the risks that mycotoxin contamination brings to people's health and the availability of food products. This can be achieved by increasing the public awareness, making better regulations, and bringing together different sectors that will work together in reducing the effects of mycotoxins.

9. Future Perspectives and Research

Nanotechnology and other analytical techniques, along with labelling and packaging techniques can go a long in the process of avoiding the presence of mycotoxin in foods. These advanced tools possess the potential to facilitate identification of mycotoxins with increased efficiency, thereby enhancing control measures naturally. However, the use of nanoparticles in food packaging and preservation has been found to decrease the growth of mycotoxin-producing fungi. While proceeding to the future, it is essential to fund scientific studies aimed at identifying the sum effect realized by employing these innovative technologies and apply them optimally to counteract mycotoxins (26). Government and other relevant stakeholders have to support efforts being made by scientists in order to ensure that these innovations are put to good use in order to improve food safety and health of the people. The synergy of these technologies can help go a long way towards eradicating mycotoxins in the food chain system. This question points that it is our duty to guarantee that consumers' protection and safety are always the focus of our work. As the information on mycotoxins and their impact on human health begins to unfold, it beacons to note that there is need to advance the agenda of innovativeness and come up with new tactics with which the risks associated with mycotoxins may be neutralized (27). The creation of new ideas and the use of such inventions are actually manifestations of human creativity and our responsibility to protect the lives of people Universal knowledge is pivotal to the human population's growth as new discoveries are made and continuous awareness is spread regarding the threat of mycotoxins and the possible effects that people can experience as a result of mycotoxin presence in their daily life. Thus, it becomes basic human responsibility to spread awareness in this regard so that strategies and methods through which these toxins can be introduced to our diet can be known and preventive measures against their ill effects can be taken accordingly. Emphasis has to be laid on integrated and central efforts since mycotoxins are still in our foods and environment and have been proved to be a threat to the whole society and environment(28). Multilateral approach is required with governments, research and development facilities and firms in the private realm coming up with desirable solutions for the challenges posed by mycotoxin. This entails funding and funding related advocacy for new technologies and techniques of detection, campaigns to minimize contamination at its source, and programs of public awareness targeting both consumers and professionals. This is why the larger and diverse effort is so important towards addressing this significant and comprehensive challenge in order to realize a safer and healthier worldwide environment. (29)

10. Conclusion

In conclusion, mycotoxins present a great risk to the health of the general population and the food processing industry; therefore, it is vital to continue investigating the impact of mycotoxins on the food chain. The possibility of examining the effects of mycotoxins on ENPs and vice versa can be potent in creating new approaches to address the issues related to mycotoxins and their consequences on the food safety and quality. As the research goes on into the uses of ENPs, the methods by which they can control fungal growth and mycotoxin formation offers a new frontier of combating mycotoxin in foods. ENPs may be employed in food packing systems such as anti-mould films which may inhibit mould formation and mycotoxin generation hence reducing on cases of food poisoning and enhancing food safety and quality. Also, the fabrication of rapid, accurate mycotoxin detection system using ENPs may help to monitor and control food-borne mycotoxins, providing safer food products. Emerging innovations indicate that ENPs have the possibility of eliminating mycotoxin contaminants in food production in the future. By fully utilizing these peculiarities of such small particles, mankind could get closer to the world where the food is healthy, fresh, and free from pathogenic interferences.

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