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Detection and Prevention and Control of Biotoxins in Grain and Oil Foods

Yumeng Zhou

Henan University of Technology, Zhengzhou, Henan, 450000, China

ABSTRACT
Grain and oil food is an indispensable part of the dietary structure of our people, which plays an important role in improving the nutritional health of the nation and preventing chronic diseases. The purpose of this paper is to discuss the detection technology of biotoxins in grain and oil foods and their prevention and control measures. The review firstly provides an overview of the common biotoxins in grain and oil foods, and then details the current mainstream biotoxin detection methods, including enzyme-linked immunosorbent assay, high performance liquid chromatography and microfluidic chip method. At the same time, this paper also discusses the prevention and control strategies of biotoxins in the production process of grain and oil food, and puts forward targeted suggestions and measures. The research results show that through scientific and effective detection and prevention and control means, the risk of biotoxin contamination in grain and oil food can be effectively reduced to ensure food safety.

KEYWORDS
Grain and oil food; Biotoxins; Detection methods; Prevention and control measures

1 Introduction

Mycotoxins are secondary metabolites produced by fungi during the growth process, which are highly toxic and carcinogenic, posing a serious threat to human health. According to the Food and Agriculture Organization of the United Nations (FAO), it is estimated that globally about 25% of agricultural products are contaminated by mycotoxins every year. As an important part of people's daily diet, the safety of food and oil food is directly related to public health and social stability. Biotoxin contamination not only leads to huge economic losses, but also may cause food safety incidents, affecting international trade and national image. Therefore, the establishment of efficient, rapid and sensitive detection methods and the adoption of scientific and effective preventive and control measures are crucial for guaranteeing the safety of grain, oil and food. In this paper, the types of biotoxins in food, oil and foodstuffs, detection techniques and prevention and control strategies are systematically sorted out, with a view to providing reference for related research and practice.

2 Types of biotoxins and their hazards

Biotoxins are a class of natural toxic substances produced by living organisms, which are widely present in grain and oil foods, mainly including fungal toxins, plant toxins, animal toxins and marine toxins. Among them, mycotoxins have become the main threat to the safety of foodstuffs due to their wide range of contamination, strong toxicity and high stability. Common fungal toxins include aflatoxin, zearalenone, deoxynivalenol, ochratoxin A and zearalenin. These toxins can be produced through direct contamination of crops or during storage and processing, causing serious health hazards such as carcinogenicity, teratogenicity, immunosuppression, and liver and kidney damage [1]. For example, aflatoxin B1 is classified by the International Agency for Research on Cancer (IARC) as a class I carcinogen, which is extremely toxic and can lead to liver cancer when ingested over a long period of time, while zearalenone has an endocrine disrupting effect and affects reproductive health [2-4]. Therefore, it is of great significance to strengthen the monitoring, prevention and control of biotoxins in order to safeguard the safety of grain, oil and food as well as public health.

3 Biotoxin detection techniques

3.1 Enzyme-linked immunosorbent assay (ELISA)

ELISA is a technique widely used for the detection of biotoxins in food, which utilizes the specific reaction between antigen and antibody to detect biotoxins. This method has the advantages of simplicity and sensitivity and has been used for the detection of microbial toxins, animal toxins and phytotoxins [5]. In addition, ELISA has also been used for the detection of carcinogenic biotoxins, as well as for the detection and control of common biotoxins in the food service industry [6-7].

The basic principle of ELISA is to immobilize an antigen or antibody on a solid-phase carrier, then bind the enzyme-labeled antibody or antigen to the target substance, and finally detect the presence of the target substance by the enzyme-catalyzed substrate that produces a color change. There are four different forms of ELISA: Direct ELISA, Indirect ELISA, Sandwich ELISA, and Competitive ELISA [8]. Of these, sandwich ELISA is the most powerful form because it binds antigens in the sample to be tested to capture and detection antibodies, thereby increasing the sensitivity and reliability of the assay [9].

ELISA has a wide range of applications in food testing, including the detection of mycotoxins, pesticide residues, heavy metal contamination, genetically modified foods, etc [10]. For example, ELISA can detect aflatoxin B1 with a detection limit of up to 2 ng/g, which is in accordance with the legal standards of the European Union [11]. In addition, ELISA can be used to detect pathogenic microorganisms in food, such as Staphylococcus aureus and Escherichia coli.

However, ELISA has some drawbacks such as cumbersome operation, requires skilled operators and may not be as readily available in environments lacking specialized personnel. In addition, ELISA can only determine a single toxin and cross-reacts to structurally similar compounds. Therefore, further research and development is needed to improve the detection range, sensitivity and specificity of ELISA.

3.2 High performance liquid chromatography (HPLC)

HPLC is a commonly used chromatographic technique that can be used for the detection of various types of biotoxins, such as aflatoxin, by means of different detectors (e.g., fluorescence detector). This method usually requires derivatization of the sample to improve the detection sensitivity.

The basic principle of HPLC is to take advantage of the different partition coefficients of the components in the sample between the stationary phase and the mobile phase to achieve separation and detection. The HPLC method is highly sensitive, selective, and reproducible, and is suitable for the analysis of complex samples. For example, the HPLC method can be used for the detection of aflatoxin in food with a detection limit of 0.01 μg/kg [12]. In addition, the HPLC method can be used in combination with other techniques (e.g., immunoaffinity column method) to improve the accuracy and speed of detection.

However, the HPLC method has some drawbacks, such as expensive equipment, complicated operation, and long sample pretreatment time. Therefore, the HPLC method is more suitable for accurate detection in a laboratory environment than for rapid detection in the field.

3.3 Microfluidic chip

Microfluidic chip, also known as "lab-on-a-chip", can integrate sample preparation, dilution and separation, detection and analysis on a chip of a few square centimeters to achieve automation, integration, portability, low cost and rapid detection [13]. The microfluidic technology can shorten the detection time of biotoxins in food, reduce the consumption of samples and reagents, while improving the portability, greatly reducing the detection cost, and realizing the multiplexed detection with high sensitivity and high throughput. Currently, microfluidic technology has been widely used in many fields such as environmental monitoring, food testing, drug screening and disease treatment [14].

The basic principle of microfluidic chips is to utilize micrometer-sized channels for precise control of fluids to achieve mixing, reaction, separation and detection of samples. Microfluidic chips have the advantages of high throughput, parallelization, and automation, which can significantly reduce the consumption of samples and reagents and improve the detection efficiency [15]. For example, microfluidic chips can be used to detect environmental algal toxins with sensitivities up to the pg/mL level [16]. In addition, microfluidic chips can be combined with ELISA technology to form digital ELISA, which further improves the sensitivity and specificity of detection.

However, microfluidic microarrays also have some challenges, such as the development of sample enrichment techniques, the precise control of microstructures such as microvalves and micropumps, and cost issues. Therefore, microfluidic chip technology still needs to be further optimized for wider application.

4 Prevention and control measures

4.1 Biological control

Biological control is an environmentally friendly, safe and effective means of prevention and control, mainly including the use of antagonistic microorganisms such as xylomycetes, yeasts and other antagonistic microorganisms to inhibit the growth of toxin-producing fungi by competing for nutrients, secretion of antimicrobial substances or degradation of toxins (e.g., Ren Xianfeng and others screened out the deep-green xylomycetes T32 and T50 can completely inhibit the growth of Aspergillus flavus), the use of certain microorganisms or materials (e.g., Xylomyces lisianthus) to adsorb or degrade toxins (e.g. effective degradation of aflatoxin B1), as well as through the inoculation of non-toxin-producing fungal strains (such as the United States and other countries in a variety of crops in the application of this method and the effectiveness of this method), the use of microorganisms, such as lactobacilli and bacillus, and their active substances to inhibit the production of aflatoxins and other ways [17-18].

4.2 Chemical control

Chemical control mainly includes the use of chemical preservatives, fumigants, etc., but they carry residual risks and may have negative impacts on the environment and human health. For example, the use of organic acids (e.g., propionic acid) as mold inhibitors facilitates the safe storage of food ingredients [19]. However, the use of chemical agents needs to be strictly controlled in terms of dosage and usage requirements to avoid adverse effects on the end use of food ingredients.

4.3 Control of storage conditions

Controlling the storage environment (e.g., temperature and humidity) of foodstuffs is a key measure to prevent the production of mycotoxins, e.g., lowering the storage temperature and humidity can effectively inhibit the growth of fungi, and the specific measures include lowering the moisture content of foodstuffs through techniques such as sunbathing, air drying, drying, etc. (the safe moisture of grains in general is 12% to 14%, and that of peanut kernels is below 8%), and the grain stores are equipped with ventilation equipment and according to the Grain temperature, storage temperature and humidity to take measures to reduce temperature and humidity, while the use of airtight storage of grain so that the grain pile oxygen down to 0.2% or less to inhibit most of the activities of molds, as well as in the pile of carbon dioxide or nitrogen to inhibit the growth and reproduction of molds, to prolong the period of storage of food.

4.4 Control during processing

In the process of food processing, heat treatment, drying, screening and other means to remove or reduce the toxin content, such as high temperature treatment can destroy part of the mycotoxins, but the effect of certain stable toxins (such as zearalenone) is limited, the specific methods include picking off the mold particles (due to the distribution of aflatoxin in food is not uniform, mainly concentrated in the moldy, damaged, wrinkled, discoloration and insect infestation of grain particles, the removal of its removal can be (because of the uniform distribution of aflatoxin in food, mainly concentrated in the grain of moldy, broken, wrinkled and worm-eaten, the removal of which can greatly reduce the content of toxin), the magnetic pressure processing method (applicable to contaminated rice and corn, the toxin mainly exists in the grain skin and embryo, so the toxin is removed along with the rice bran during the magnetic pressure processing process), the use of activated charcoal, silica gel and other adsorbent adsorption of toxin to effectively remove aflatoxin adsorption method, the oxidative degradation method which uses bleach, chlorine, hydrogen peroxide, ozone and other oxidizing agents to rapidly oxidize aflatoxin toxins method, and the alkaline treatment that destroys aflatoxin under alkaline conditions and then dissolves it in water, and removes 85.7% of the toxin by repeated water washing or by applying high pressure.

5 Challenges and perspectives of detection and control technologies

In the current research on biotoxin detection, prevention and control technologies in food, although a variety of methods have been applied to the actual detection and prevention and control, they still face many challenges. First, the sensitivity and specificity of detection techniques still need to be improved, especially for the detection of small molecule toxins, and most of the current methods are susceptible to interference in complex matrices, leading to false-positive or false-negative results [20]. For example, although traditional immunoassay methods are easy to operate, they are susceptible to interference in complex food matrices, and the preparation of antibodies is complicated, which affects their practical application value [21]. In addition, the low penetration rate of testing equipment and insufficient testing equipment at the grassroots level limit the wide application of rapid testing technology[22].

The industrialization level of biological prevention and control technologies is not high, and most biological prevention and control technologies are still in the laboratory research stage, lacking large-scale promotion and application. For example, the screening, purification and formulation of biocontrol agents still face many technical bottlenecks, making it difficult to achieve efficient and stable control effects. In addition, although emerging detection technologies such as biosensors show good application prospects, there are still problems such as poor stability and insufficient standardization in practical application. For example, biosensors need to maintain high sensitivity and specificity in diverse food matrices, which vary greatly in composition and complexity, leading to many challenges in their practical application.

In the future, the following aspects should be strengthened. First, the research and development of novel detection technologies should be promoted, such as the application of nanomaterial labeling, quantum dot labeling, microfluidic chip, and other new technologies, in order to improve the sensitivity and specificity of detection. For example, microfluidic chip technology has been widely used in the detection of pesticide residues and mycotoxins due to its advantages of small size, low reagent cost and short detection time. Secondly, we will strengthen the industrialization of biological prevention and control technology, promote the screening, purification and formulation of biocontrol agents, and improve their effectiveness in practical application. Third, improve the testing standards and regulatory system, establish unified testing standards and regulatory mechanisms to ensure the comparability and authority of testing results. In addition, it is also necessary to build a prediction model of detection data with the help of artificial intelligence and big data analysis, so as to improve the accuracy of detection and the scientificity of decision-making.

6 Conclusion

The problem of biotoxin contamination in foodstuffs runs through planting, harvesting, storage and processing, posing a continuous threat to food safety and public health. Currently, detection technologies such as enzyme-linked immunosorbent assay (ELISA), high performance liquid chromatography (HPLC), and microfluidic chip (MFC) provide an important support for the identification of biotoxins, while measures such as biological control, chemical control, optimization of storage conditions, and processing control play a key role in the prevention and control of toxins. However, the improvement of sensitivity and specificity of detection technology, the popularization of grass-roots equipment, and the industrialization and promotion of biocontrol technology are still challenges that need to be broken through.

In the future, by strengthening the research and development of new detection technologies, promoting the implementation of biological prevention and control technologies, improving the standard and regulatory system, and combining artificial intelligence and other technologies to build data prediction models, multidisciplinary synergistic efforts are expected to realize the whole chain of biotoxins in food and oil food, so as to effectively protect the safety of food and oil food and guard public health.

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