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Mold in Food and Prevention

I、Introduction

Molds are a type of tiny fungi that exist widely in various ecological environments such as air, animals, plants, etc. It is estimated that there are over tens of thousands to three hundred thousand species of molds. Molds grow in a filamentous or thread-like manner, forming a network structure called mycelium. The main method of mold reproduction is through the production of spores, which are spread by means such as wind, water, insects, etc. When mold spores enter a new environment, they can quickly germinate into new filamentous structures, much like dandelion seeds dispersed by the wind, rapidly spreading and reproducing everywhere. This biological characteristic gives mold extremely high adaptability and survival capabilities (USDA, 2013).

The mycelial structure of molds includes tiny branches and root-like absorption structures, which can penetrate deep into the interior of food to form intricate and complex structures that are difficult to observe. When food gets molds, invisible molds and bacteria may coexist, proliferating together and affecting the food. Food mold not only affects its texture, odor, or appearance but may also produce toxic substances, posing a potential threat to human health. Therefore, this article discusses the mechanism of food mold and the safety concerns it brings, as well as explores strategies for preventing and controlling food mold.

II、Literature Review

(i) Mechanism of Food Mold

In daily life, mold spores are omnipresent, and food is susceptible to mold if not properly packaged or stored. Mold growth requires three elements: temperature, humidity, and a source of nutrients, with food being an excellent substrate for mold growth. Especially in hot and humid tropical, subtropical, or monsoon climate countries, once mold spores settle on food, mold growth is likely to occur.

The growth mechanism of molds includes spore germination and hyphal

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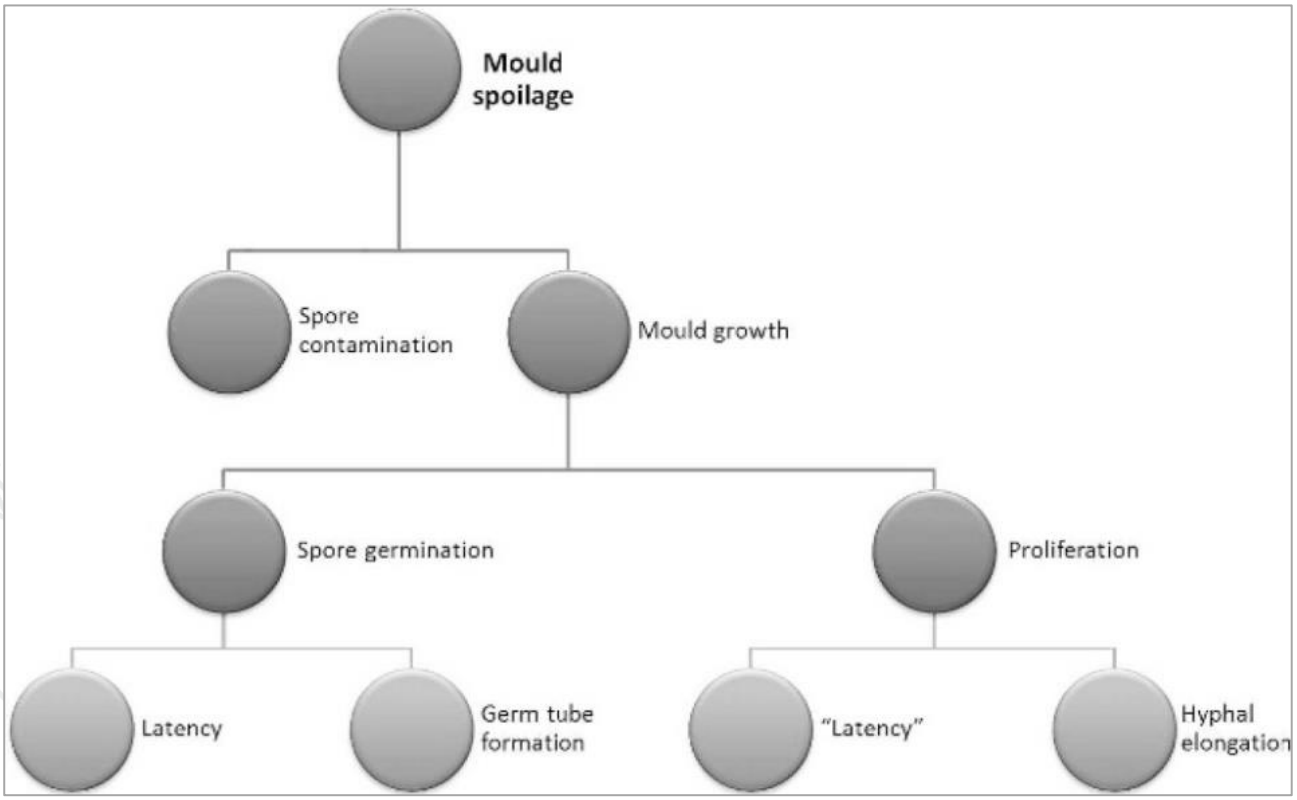
diffusion (Fig. 1), where spores grow on substrates, generating hyphae, leading to mold formation. During the mold formation process, certain enzymes may be produced, such as lipases, proteases, and carbohydrases, known as extracellular enzymes. These enzymes induce odor, discoloration, and even the production of mold toxins harmful to human health. Therefore, it is important to properly control environmental factors, understand the growth mechanism of these mold species, and implement corresponding management methods to prevent the spread of mold spores, thereby preventing mold and toxin formation.



Reference: Dagnas & Membré (2013)

Figure 1. Schematic Diagram of Food Mold and Spoilage

("Mold" and "Mould" have the same meaning, with the former being the American spelling and the latter the British spelling.)

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(ii) Hazards of Moldy Food

The substrates for food mold are extensive, including vegetables, fruits, meat products, beverages, dairy products, jams, canned goods, pickled products, etc. From high-water activity beverages or food ingredients to low-water activity processed or pickled products, all are susceptible to mold contamination. Especially in baked goods such as cakes and bread, mold growth may not be easily detected. As hyphae can easily penetrate deep into the product and produce toxins, the presence of hyphae may not be readily identifiable, leading to the problem of people inadvertently consuming contaminated food and developing illnesses (Coton & Dantigny, 2019).

In April 2023, a well-known beverage brand in Taiwan faced public concern after consumers complained of unidentified precipitates and turbidity in their beverages. Upon inspection, mold and yeast were detected in the beverages, triggering societal concern. However, such food safety incidents involving molds are not isolated cases and may exist in various parts of the world. For instance, in August 2023, several schools in California, United States, reported illnesses among students due to consuming moldy lunches, resulting in symptoms such as food poisoning and stomach pain. Subsequent investigations revealed that the malfunctioning of refrigerator fans, covered by baking trays, disrupted the cooling cycle, leading to food spoilage and mold growth.

In 2019, a food safety incident occurred in Sichuan, China, where students at a school experienced health issues for two years, including abdominal pain, vomiting, severe nosebleeds, and rectal bleeding. Investigations revealed that the school cafeteria had used spoiled meat, moldy fruits, and beef patties with mold and foul odor as ingredients, resulting in food safety repercussions.

During the processes of manufacturing, storage, transportation, and sales, food is often susceptible to mold contamination due to environmental factors. Common filamentous fungi that can contaminate food include species from genera such as *Rhizopus* spp., *Mucor* spp., *Aspergillus* spp., and *Fusarium* spp. Improper handling can lead to food spoilage caused by these mold species,

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which are capable of producing toxic substances harmful to humans (Chou & Hsiao, 2023; USDA, 2013). Mold growth occurs within a wide temperature range, with most molds thriving between 10°C to 30°C. However, some molds, such as *Penicillium* sp., *Fusarium* sp., and *Cladosporium* sp., are cold-tolerant and can grow at temperatures beneath 5°C. Additionally, certain molds can produce mold toxins even at low temperatures during refrigeration. For example, *Penicillium* spp. can produce patulin, penicillic acid, and ochratoxin at temperatures ranging from 0 to 31°C, while *Fusarium* spp. can produce zearalenone and trichothecene compounds at temperatures below 10°C, even at or below freezing point (Bullerman et al., 1984; Bullerman et al., 1979). Based on the real cases of food mold mentioned above, it is imperative to maintain proper quality management during food manufacturing and storage processes.

(iii) Prevention and Control of Food Mold

To effectively prevent and control food mold, hygiene and management of the environment are crucial from food production to sale. The issue of food mold not only directly affects food quality, shortening its shelf life, but also leads to increased waste. Conversely, once these damaged foods are ingested, they pose a significant health risk to humans.

To prevent food mold and food safety issues, techniques such as hurdle technology can be employed to adjust water activity, pH value, add probiotics or other natural extracts, preservatives, and undergo heat treatment, post-sterilization, etc., to ensure food sterility. However, even after sterilization, there is still a risk of post-sterilization contamination if food is not properly packaged and stored. Therefore, environmental and storage conditions should be properly managed during the food manufacturing process. Starting from source management, strict quality control should be implemented for the raw materials used. If any signs of deterioration, mold, or poor quality are found in the raw materials, they should be immediately discarded and properly cleaned to reduce the probability of cross-contamination by mold spores. Additionally, to ensure quality and

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hygiene, attention should be paid to cross-contamination issues between different production areas, equipment, and personnel. Food industry personnel should maintain excellent hygiene standards, wear clean clothing, gloves, strictly clean and disinfect relevant equipment and food contact containers. Raw materials, semi-finished products, and finished products should be properly packaged or covered during the production process. Furthermore, environmental monitoring plans should be implemented in the production area and during product transportation, while also ensuring the building environment is pollution-free. Air conditioning, refrigerators, or other equipment are clean and operating normally, properly managing air quality, temperature, humidity, etc., in the environment, reducing the probability of mold growth and contamination, and ensuring that food meets excellent quality and safety requirements (Chou et al., 2023; Dagnas & Membré., 2013).

III、Conclusion

The growth characteristics of molds make food one of their abundant sources of nutrients. Depending on the type of mold, they can grow, reproduce, and even produce harmful mold toxins at various temperatures, leading to food spoilage and affecting the health and safety of consumers. Proper measures need to be taken during food preparation and storage to prevent decay and decomposition, ensuring that food has a sufficient shelf life. To reduce the risk of poisoning from consuming moldy food, hurdle technology can be utilized to manage food quality and reduce the risk of mold growth. Besides the responsibility of retailers and consumers to store food properly, the most important aspect of preventing food safety issues caused by molds is source control, encompassing quality control and hygiene from raw materials to production conditions.

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