

Fungal Food Spoilage: Causes, Symptoms and Control Measures

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Fungal food spoilage is a significant concern affecting food quality, safety, shelf life across the globe, also a major concern in the food industry and for consumers worldwide. Fungi is a diverse kingdom of eukaryotic organisms that includes yeasts, molds, truffles and mushrooms they can grow on a wide variety of foods, leading to visible deterioration, off-odors, and sometimes the production of harmful mycotoxins. This spoilage not only leads to economic losses but also poses potential health risks.

What is Food Spoilage?

Food spoilage is the process of deterioration that renders a food item unfit for human consumption due to it food product becomes undesirable or unacceptable for consumption due to changes in its physical, chemical or microbial properties these changes can be detected by the senses (smell, taste, sight, touch). These changes rendered the spoiled food product unsuitable to ingest by the consumer. Food spoilage caused by fungi is a common problem that can lead to significant food losses. According to a united nations Food and Agriculture Organization (FAO) report, a developing country like India loses approximately 30-40% of its food production annually through post-harvest losses, inadequate storage, and transportation. Due to the food spoilage, one-third of the world's food produced for the human consumption is lost every year. Fungi as a group are some of the most resilient spoilage microorganisms effects the food quickly and degrade it.

How fungus spoil food?

Some species of fungus spoiled food through producing enzymes and mycotoxins. Fungi produce enzymes that break down food components, leading to changes in texture, flavor, and appearance of the food product. Some molds, like *Aspergillus flavus* produce mycotoxins which can contaminate food and pose health risks mycotoxins like fusarium toxins, aspergillus toxins, penicillium toxins and ergot toxins among these aflatoxins which are secreted by molds are very harmful, they are toxic in nature and potentially carcinogenic one can get sick by eating such food items.

Factors influencing fungal growth on food products

There are several factors which fungal growth on food. The various factors are listed below-

- **Temperature:** Fungi have optimal temperature ranges for growth, and some species can tolerate wider ranges than others. For example, some molds can grow at moderate and high temperatures, while others are more adapted to cooler environments.
- **Moisture:** Fungal spores require moisture to germinate, and excess moisture can lead to rapid fungal growth. Low water activity (aw) can inhibit fungal growth.
- **pH:** Most fungi prefer slightly acidic conditions, but certain species can tolerate a wider pH range.
- **Nutrient availability:** Fungi need a source of nutrients like carbon and nitrogen to grow. The type and amount of nutrients available in the food can affect fungal growth rates.
- **Gaseous environment:** Fungi are generally aerobic, meaning they require oxygen to grow. However, some species can tolerate anaerobic conditions, according to ScienceDirect.com.
- **Light:** Some fungi can tolerate light exposure, while others prefer darkness.
- **Environmental factors:** The presence of other microorganisms, such as bacteria, can also influence fungal growth by competing for resources or producing substances that inhibit or promote fungal growth.
- **Storage conditions:** The storage environment, including temperature, humidity, and packaging, can significantly impact fungal growth and spoilage in food products.

Types of fungi involved in spoilage

Yeasts: Single-celled fungi that ferment carbohydrates, causing spoilage through the production of acids and gases, when yeasts grow and metabolize food components, producing that alter the food's physical and sensory properties

Molds: Multicellular fungi that grow as filaments (hyphae) and can cause rot, discoloration, and off-flavors, when mold grows on food product it produces enzymes that break down the food's structure, leading to a soft or degraded texture and some molds produce mycotoxins which can be harmful if consumed.

Common fungi species responsible for spoilage

(A) Molds: *Aspergillus*, *Penicillium*, *Rhizopus*, *Fusarium*, and *Cladosporium*

(B) Yeasts: *Candida*, *Saccharomyces*, *Zygosaccharomyces*

Mold is a type of fungus, very well-known types of molds are *Aspergillus* and *Penicillium*, like regular fungi they create a fuzz, powder and slime of various colors. Several fungal genera attack on pickle including *Penicillium*, *Aspergillus*, *Alternaria*, *Rhizopus* and *Mucor*. The most harmful phytopathogenic fungi of oranges are *Penicillium digitatum* is responsible for 90% of citrus fruits. Several fungi attack on apple and causes many diseases like Apple scab (*Venturia inaequalis*), Soft rot (*Rhizopus stolonifer*, *Penicillium expansum*), Apple rot (*Aspergillus niger*), and Black rot (*Aspergillus* species). Several types of fungi can attack bread, leading to spoilage example like *Rhizopus*, *Aspergillus*, *Penicillium*, *Fusarium* and *mucor*, among all these the *Rhizopus stolonifera* mostly found on bread and commonly known as black bread mold. *Mucor mucedo* can be found on stored grains and plants like cucumbers and tomatoes. *Mucor rot*, caused caused by *mucor piriformis*, is also a common problem on pome fruits like apples and pears. *Fusarium* species are responsible for wilts, blights, root rots and cankers in legumes, coffee, pine trees, wheat, barley, corn, carnations and grasses. Fungi have varieties of microbes who all attacks on food items and make it unfit to eat them for consumer. Here below in the table are some examples of common fungi which causes fungal food spoilage:

S. No.	Name of fungi	Effects which food product
1	Red Mold (<i>Neurospora crassa</i>)	Leftover meat, poultry, fish & tomatoes
2	White Mold (<i>Sclerotinia sclerotiorum</i>)	Dairy products, such yogurt & cheese
3	Yeasts (<i>Saccharomyces cerevisiae</i>)	Yogurt, fruit juice, jams & cheese
4	<i>Aspergillus niger</i> (black mold)	Peanuts, grapes, apple, pickle and onions.
5	<i>Rhizopus stolonifera</i>	Mostly on bread, fruits & vegetables
6	<i>Mucor mucedo</i> (pinmould)	Pickle, fruits, vegetables and dairy products
7	<i>Penicillium</i>	Grains, bread, frozen chicken & refrigerated food

Symptoms of fungal food spoilage

Signs of food spoilage may include an appearance different from the food's natural look or unlike from its fresh form, such as a change in color, a change in texture, an unpleasant odor, or an undesirable taste. The item may become softer than normal. Let us discuss some of its common symptoms like:

- **Visible signs:** Mold growth especially visible on items like bread, and are a clear indication of fungal spoilage, sometime dark black in color and sometime dark green to olive green in color.
- **Changes in appearance:** Food color changes it may become discolored, pale, dark black some time & may develop unnatural color compare to natural one.
- **Changes in texture:** Fruits and vegetables may soften or become mushy, and other foods may develop a slimy consistency.
- **Sensory changes:** Spoiled food may develop unpleasant, rotten, a foul smell or sour odor. The food may taste rancid, bitter and sour than normal. Other indicators are rising air bubbles a sign of fermentation by yeasts, a type of fungus.

How we can control fungal spoilage of food

To control fungal spoilage in food, several methods can be used such as refrigeration, freezing, heat treatment, and the use of chemical preservatives. Additionally, proper storage conditions, like maintaining low water activity, using airtight containers can help in controlling the fungal activity in food, by limiting air and moisture, which are essential for fungal growth. Airtight storage reduces the availability of oxygen and moisture, creating an environment less hospitable for fungi, this helping to prevent and slow down fungal spoilage. Basically, one can follow these easy steps to control fungal growth like limit exposure like packing in airtight container, rapid cooling after cooking the food and early detection of fungal can help in preventing fungal growth on food item and save our food from rotting and deterioration. Let us discuss some common control measures like-

Physical Methods

- **Refrigeration and freezing:** This method slow-down or stop fungal growth by lowering the temperature.
- **Heat treatment:** Canning and other thermal processing techniques can inactivate or destroy fungi, extending the shelf life of food item.

- **Water activity control:** Reducing water activity in food, either through drying, adding salts, or using hygroscopic substances which inhibits the fungal growth.
- **Modified atmosphere packaging (MAP):** This technique involves controlling the oxygen and carbon dioxide levels in the packaging, which can help prevent fungal spoilage.

Chemical Methods

- **Use of preservatives:** Chemicals like sorbic acid, potassium sorbate, propionic acid, and sodium benzoate can inhibit fungal growth. In addition, some fungicides can be used on food surfaces to prevent or reduce fungal spoilage.

Biological Methods

- **Bio-preservation:** Utilizing beneficial microorganisms or their products to inhibit the growth of fungi on food product. For instance, using live microorganisms or their metabolites to reduce the population of pathogenic fungi, like using lactic acid bacteria against mold on fruits.

Conclusion

Food spoilage is a major concern nowadays, as with increasing population we need more food to feed people however to cope up with such situation we should follow sustainable development method but indeed food is getting waste, spoiled, thrown, stale and no one is paying much attention on it. The major reason of food spoilage is Fungal food spoilage. Fungal food spoilage is a multifaceted issue influenced by environmental conditions, food type, and handling practices. Fungi can render food, unpalatable, distasteful and the real danger lies in the potential production of mycotoxins which are more harmful for whoever who consume it. Through a combination of preventive practices, modern technologies, common methods, and consumer awareness, fungal contamination can be effectively minimized, ensuring food safety and reducing waste. We should follow these practices to save food for being deteriorating.
