Review Article

An Overview on Food Spoilage Mechanism and Their Prevention

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Abstract

Food demand has increased as a result of the growing world population. Food of high quality and safety is necessary for a healthy lifestyle. Food insecurity has, however, been brought on by food spoiling several parts of the world. Food spoilage happens when the food loses the initial organoleptic qualities that were detected at the time of production. Food rotting causes both producers (farmers) and consumers to suffer significant financial losses. Storage temperature, pH, water availability, the presence of bacteria and fungi that cause rotting, processing all have an impact. Microorganisms that cause food to decay, including moulds, yeasts, and bacteria, as well as the intrinsic, extrinsic, implicit, and processing elements that influence their development and determine how dominant they become in foods. It is crucial to effectively monitor the chill chain throughout production, transit, distribution, and storage in retail cabinets and home refrigerators in order to guarantee the safety and quality of foods. Various procedures are now employed for evaluating food spoilage and implement different food preservation techniques like drying, chilling, freezing and pasteurization have been fostered. It has recently been recognised that the connection between microbial growth and the chemical alterations that take place during food storage is a possible signal that could be helpful for keeping an eye on food freshness and safety.

Keywords: Food processing, chill chain, spoilage, Microorganism, Pasteurisation, shelf life

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Introduction

A process or alteration that makes a product unpalatable or unfit for ingestion is referred to as food rotting. The result of the biochemical activity of microbial chemical processes, which will finally dominate in accordance with the dominant ecological drivers, is this complicated ecological phenomenon. Food becomes spoiled when microbiological, chemical, or physical changes take place that make the product unpalatable to consumers. The proliferation of microorganisms that create enzymes that result in unpalatable byproducts in the food is what causes microbiological food deterioration. Chemical food deterioration happens when different ingredients in the food react with one another or with an additional ingredient, changing the food's sensory properties. This can happen through enzymatic browning, or non enzymatic browning and oxidation. Physical food degradation occurs when moist foods are overly dried out or when dry foods retain too much moisture [1]. Since people began producing and storing food products, spoilage and food losses and waste became important issues for human with regards to food safety and security. Nowadays, up to one third of all food is spoiled or squandered before consumption, which represents about 1.3 billion tons per year. These losses are the results of one or more problems occurring in the supply chain, from initial agricultural production down to the consumer level [2].

Almost 25% of food spoiling is because of its packaging issues. Recently packaging has been found to be a great source of contamination in itself because of the migration of substances from the packaging into food. Appropriate packaging is necessary for maintaining the basic characteristics of food such as color, taste, temperature, texture, etc. The most important function of packaging is maintaining food safety. Thus, it becomes equally important that the material used for packaging is of good quality safety [3].

The processes of spoilage are largely influenced by microorganisms. Since fresh, chilled, and frozen foods are not subject to high temperatures or other types of sanitization or preservation, spoilage is a significant problem [4]. The residential psychographs attach to food surfaces and grow there, eventually causing complete food spoilage or cross-contamination when they multiply to a certain number. Cold-resistant bacteria have been the subject of numerous studies, and it is now known that Pseudomonas, Enterobacteriaceae, and Brochothrixthermosphacta are the most frequently found organisms linked to food spoilage. These organisms commonly cause slime, ruined food texture, malodor, and off-flavors [5], which can result in decreased food quality and lower consumer acceptability.

Basic Mechanism of Food Spoilage

The first and foremost step of food spoilage can be seen as change in colour, smell, flavour, texture or food. Different physical, microbial, or chemical action can cause spoilage of food. These mechanism are not necessarily mutually exclusive since spoilage caused by one mechanism can stimulate another. Likemicrobes contamination of foodstuffs and attack of microbes on food.These microbes may be present already in the food or they may enter from outside. After the contamination process, food spoiling microbes release enzymes which breakdown the food components and results in the starting ofdeterioration process. Enzymatic reactions take place between the enzymes and components of food like lipids, proteins, fats, vitamins, carbohydrates etc. which leads to other waste products develop. After a period of few hours or days the food product starts to decompose and many chemical changes are seen.These chemical changes involve: Degradation of carbohydrates, Degradation of N – compounds, Lipid degradation and Hydrolyses of pectin. The chemical changes lead to unpleasant taste and flavor as the process continues changes in texture, color and odor starts occurring and changes ultimately lead to food spoilage. The food becomes unsuitable for human consumption and hence needs to be discarded immediately and leads to wastage of food [6].

Factor affecting spoilage of food products

Different factors affecting food spoilage are shown in given figure [6].

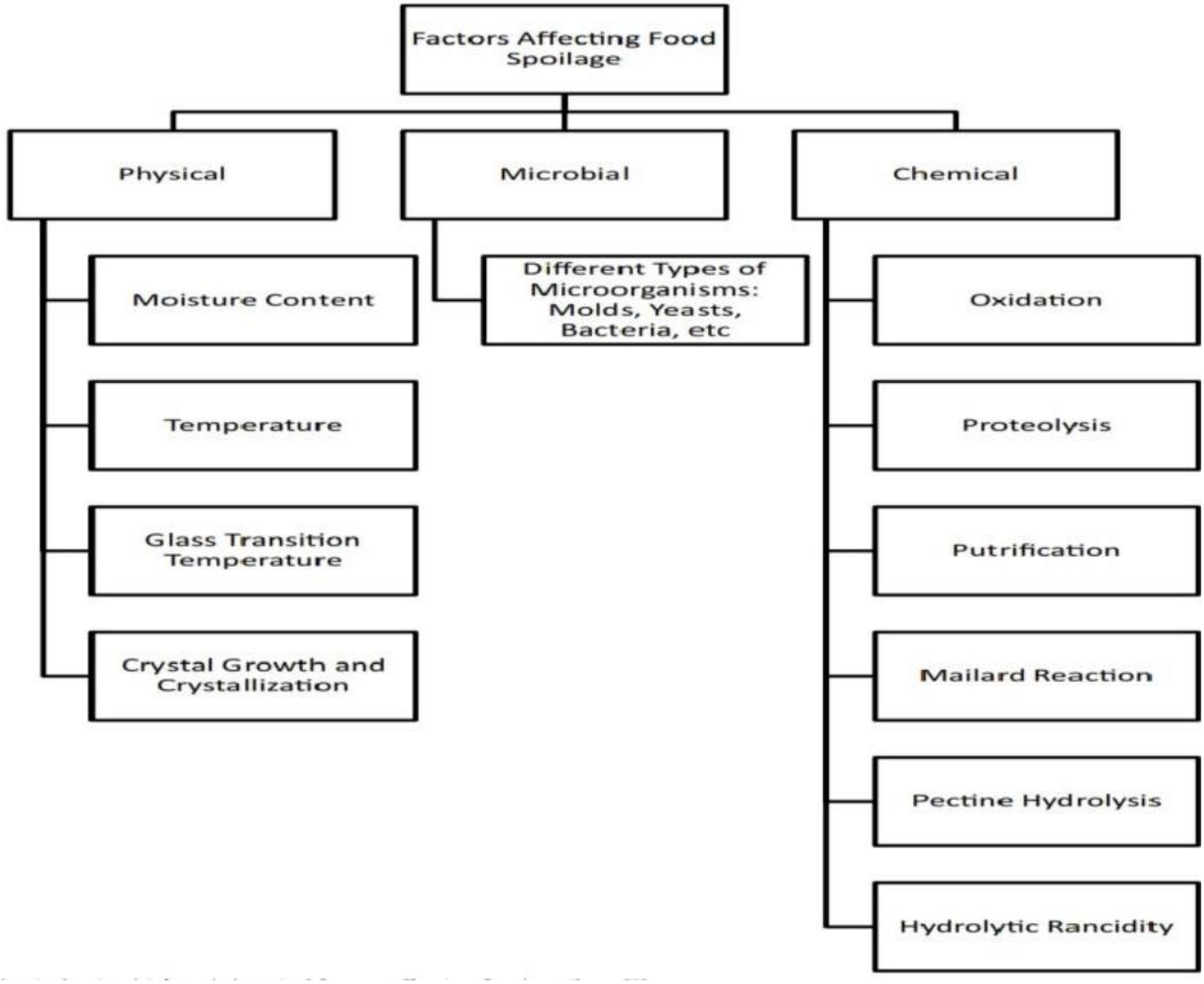

Figure 1. Factor affecting spoilage of food products

Physical spoilage

Physical food degradation is the term used to describe physically changed or unstable food. Moisture gain or loss, moisture migration between different components, and the physical separation of substances or components are all examples of physical degradation. The primary factors affecting physical deterioration are moisture content, temperature, glass transient temperature, crystal development, and crystallization.

Moisture content

The cause of degradation of food products is the change in their water content. It occur in the form of water loss, water gain, or migration of water. Moisture migrate in food is directly related to the water activity (*a*w) of food item [7].

Temperature

The most important element is the impact of temperature. A low temperature may also adverse impact on food products that are vulnerable to freeze damage. Food goods become damaged when their cells break when partially frozen at lower temperatures. Food deterioration can also be facilitated by freezing. Foods that are slowly frozen or frozen several times suffer greatly as a result of crystal development. Emulsifiers and other water binding agents can be applied during freezing cycles to reduce the formation of big ice crystals. Foods with a high sugar content may crystallise sugar. Such as, the Staling of sugar biscuits and the graininess of candies and ice creams [6].

Microbial spoilage

Microbial spoilage are source of food spoilage, which occurs due to the action of microorganisms and can be averted or lingered by adjusting storage temperature, reducing water activity, lowering pH, using preservatives, and using proper packaging [8].

Micro organisms	**P^H**	**Temperature**	**Water activity**	**Heat sensitivity**	**Affected foods**
Mold	3.0-8.0	Grow across a wide range of temperature	0.62-1.0	Heat sensitive	Eottled minerals water, fermented foods
Yeast	Grow around the broad range of acidic p^H	Grow around the wide range of temperature, but prefer natural ambient temperature	Above 0.9	Heat resistant and can survive under scorching sunlight	fermented foods
Bacteria	Broad P^H range	Prefer growth at high temperaturegreater than equal to 55^0C	Above 0.9 for gram positive and above 0.98 for gram negative	Mostly thermophiles	Eggs and heat treated foods

Microorganisms involved in food spoilage

Microorganisms involved in food spoilage can be divided into three major categories, which are molds, yeasts, and bacteria.

Factors affecting microbial spoilage

There are internal and external factors that can affect microbial spoilage in foods. The internal properties of foods determine the expected shelf life, perishability of foods,affect the type and rate of microbial spoilage. Endogenous enzymes, substrates, sensitivity of light, and oxygen are the primary intrinsic properties associated with food spoilage. Intrinsic factors of food spoilage include, water activity, pH, nutrient content, and oxidation–reduction potential. External factor of processed food spoilage include relative humidity, temperature and activities of other microbes [7].

Chemical spoilage

Chemical and biochemical reactions occur in foods and lead to spoilage and changes are:

- microbial growth and metabolism which results in pH changes,
- toxic compounds, and
- the oxidation of lipids and pigments in fat

which results in undesirable favors and discoloration. Chemical spoilage is interrelated with microbial actions. While, oxidation phenomena are chemical in nature and also dependent on temperature variations.

Oxidation

Amino acids convert into organic acid and ammonia in presence of oxygen. This Is occur in refrigerated fresh meat and fish. The term 'rancidifcation' is used to indicate lipids oxidation through which unsaturated fats (lipids) undergo reaction with oxygen. This result in food change in color, off-flavor, and toxic substances formation [6].

Proteolysis

A ubiquitous and irreversible posttranslational modification, involves limited and highly specific hydrolysis of peptide and iso-peptide bonds of a protein is proteolysis. The entire phenomena require the presence of protease enzymes.

The following reaction presents proteolysis mechanism:

$$\text{Proteins} \xrightarrow{\text{proteinase}} \text{Peptides} \xrightarrow{\text{peptidase}} \text{Amino Acids}$$

Many of these peptides have stiff taste which can be bitter or sweet [9].

Putrefaction

As a result of a sequence of anaerobic processes, amino acids divert to a mixture of amines, organic acids, and sulphur compounds with strong odours like mercaptans and hydrogen sulphide. Due to the necessity of bacteria throughout the entire process, this is a biological phenomenon. Together with amino acids, indole, phenols, and ammonia are also present in protein putrefaction, and these chemicals are unpleasant to smell. With foods high in protein that are heated over 15°C, putrefaction is extremely common [10].

Maillard reaction

It is non-enzymatic browning, which is also known also as Maillard reaction, is another cause of food spoilage. This reaction occurs in the amino group of proteins, or the amino acids present in foods. Color darkening, reducing proteins solubility, developing bitter favors, and reducing nutritional availability of certain amino acids are the common outcomes of Maillard reaction. E.g during the storing of dry milk, dry whole eggs, and breakfast cereals [11].

Pectin hydrolysis

About one-third of dicotyledonous and certain monocotyledonous plants, the cell wall is composed of pectins, a complex mixture of polysaccharides. Pectin methyl esterase de-esterifies pectin-containing compounds. Through a mechanism involving calcium, the esterification process improves the intercellular cohesiveness. Fruit colours that are heat-labile and made of pectin components are broken down by metals. The fruit jams or jellies' colour changes as a result of this process. As a result, glass jars are used to store jams and jellies rather than metal ones [12].

Hydrolytic rancidity

As a result of hydrolytic rancidity, lipids are broken down by lipolytic enzymes. Water aids in the separation of free fatty acids from triglyceride molecules during this process. These free fatty acids have a bad odour or flavour. In fats like butter, hydrolytic rancidity is particularly noticeable due to the strong malodor and taste of the freed volatile fatty acids [6].

Spoilage microbes found in Food products [13-17]

Spoilage organism	Food products
Gas forming bacteria (*Bacilus-licheni-formis, Lactobacillus alimentarius,and Lactobacillus acidipiscis)*	Chilli sauce
Yeast *like Candida tropicalis, Canditermedia, Sacchacomyces cerevisiae*	Kiwi juice
Fluorescens, E. Fluorescens	Cucumber juice
Bacillus Mycoides/Weihenstephanensis	Ricotta cheese
Bacillus spp. *And Staphylococcus Saprophytices, Candida* spp, *Goetrichum Candidurm*	Paoicai (fermented vegetables)
Rhizopus, Mucor, Aspergillus and Fusarium	Baked products

Spoilage of Canned Food

Spore-forming microorganisms frequently contaminate heat-treated food because they can withstand high processing temperatures. Temperatures above 55°C are ideal for thermophilic spore-forming organisms. Some anaerobic thermophiles, like Desulfotomaculum, produce H2S while growing on foods that are canned or sealed and kept at high temperatures, whereas others, like Thermoanaerobacterium, produce hydrogen and CO2 [18].

Prevention from Food Spoilage

The amount of food wasted each year as a result of infection and deterioration makes food preservation more crucial than ever. Due to their widespread distribution around the globe, meals must now have a longer shelf life. To increase the food's shelf life and prevent rotting, preservatives are also added. The following list of preservatives and processing methods is diverse:

Physical processing

Drying: It is process of removing water from solids or liquid food by means of evaporation. The aim of drying is to obtain a solid products with low water content [19].

Pasteurization: It kill germs and enzymes, food is heated to a precise temperature using a physical approach. [20] Food's shelf life is extended by the majority of pathogenic bacteria, mould, and yeasts being eliminated. [21] According to temperature and heat exposure, it is once more divided into high temperature short time (HTST), ultra-high temperature (UHT), and vat categories (batch) [22] To avoid overheating, overholding, or burning, pasteurisation in a vat requires regular attention. (HTST) is a continuous process pasteurizer with an advanced control system, flow diverting pumps or valves, and heat exchanger equipment. Products that have been UHT pasteurised last longer than other goods.

Thermal sterilization: It is a procedure that results in a prolonged shelf life by totally destroying all the live microorganisms (yeast, moulds, vegetative bacteria, and sore-forming bacteria). Thermal sterilisation is divided into two categories: retorting and aseptic processing [23].

Freezing: By forming ice from water below freezing temperature and its slow down the reaction thus inhibit the the growth of microorganisms in food. So it result in reduce amount of water in food items.

Chilling: it is temperature between -1 and 8°C and reduce the initial temperature and maintains the final temperature of the products for a prolong period of time.

Biological process:

Enzymes are used during fermentation to break down carbohydrates. Mold, yeast, and bacteria are the most frequently used natural alternatives to many chemical preservatives in the fermentation of foods such as dairy products, meat products, and cereal-based foods [24].

Chemical preservatives

They are acetic acid, ascorbic acid, lactic acid, benzoic acid, and others. Bacterial cells cannot grow due to them. Moreover, a variety of chemical preservatives are used to slow down microbial activities including fermentation and decomposition. They consist of sugar, vinegar, salt from the table, etc. The addition of sodium benzoates often occurs in fruit juices. [25] Packaging has an impact on food preservation. The majority of the work has been done on active and intelligent packaging. A key factor in food preservation is active packaging, which inhibits microbial growth and moisture movement. Its uses include moisture management, ethylene absorbers, antimicrobials, CO_2 emitters, oxygen scavenging, and antimicrobials. Food product attributes are checked through intelligent packaging. Leak indicators and pathogen indicators are also included, along with temporal temperature indicators (TTI), biosensors, and radio frequency identification [25].

Conclusion

Microorganisms that grow in food and produce chemicals that alter its flavour, colour, and texture. These microorganisms include bacteria and fungi. The food will eventually be unfit for human eating. When food is maintained with a hairy growth and turns pulpy to produce unpleasant odours, which leads to the growth of moulds and yeasts, which spoils the food. Mold and yeast-related spoilage includes the sour taste of milk and the development of mould on bread. Humans are rarely harmed by these organisms, but bacterial contamination is frequently more severe since even when food is seriously contaminated, it may not necessarily seem awful. When microbes are present in food, they quickly multiply and consume the nutrients that are there.To the demand of consumers, processing sector has been expanding in a rapid manner. To ensure food safety and long shelf life of food, it is vital to understand food spoilage, mechanism and preservation techniques. This review has compiled and discussed different food spoilage mechanisms and application of food preservative techniques.

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