Shelf Life of Food Products

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What is Shelf Life?

Definition

Shelf life encompasses several facets of food quality including safety, nutritional value, and sensory properties. Shelf life affects food quality which in turn influences the consumer's buying decisions.

For many food companies, the ability of a food to retain its overall quality from the processing line, through distribution and marketing, and finally to the consumer, is the result of intensive studies to predict the "life" of a food.

Shelf life is the time frame over which a food product can be relied upon to retain its quality characteristics.

Intrinsic Parameters

Certain factors that are a part of the food's system cannot be controlled.

The intrinsic factors inherent within food include pH, moisture content, water activity, nutrient content, antimicrobial agents, biological structures, and oxidation/reduction potential.

pH

pH is the index of acidity or alkalinity of a food ranging from 0 to 14. A pH value of 7 is considered neutral, while values of 0 and 14 are extremely acidic and basic, respectively.

The lower the pH, the more acidic the food. The acidity or alkalinity of a food influences the type of microbial spoilage that will occur.

Most bacteria do not prosper in acidic conditions, but prefer food with a pH range between 6.6 and 7.5. Foods included within this range are red meat, chicken, fish, eggs, and vegetables.

Spoilage of citrus fruits, tomatoes, and other food products with a lower pH occurs as a result of mold and/or yeast growing.

Water activity (A_w)

Moisture content and water activity are also a part of food composition. However, the two should not be confused.

Water activity (A_w) is the amount of unbound or "free" water in a system available to support biological and chemical reactions. A_w ranges from 0 to 1, with pure water ranking 1.

Most fresh foods have A_w values close to 1.0, while dry foods have values ranging from 0.2 to 0.6. Therefore, the objective of food dehydration is to reduce the water available to support biological growth. A food may have a high moisture content, but low water activity due to other food constituents (sugars, salt, etc.) that may bind the water and therefore rendering it unavailable. In this instance, sugar and salt serve as humectants which are often added to bind the water.

In general, bacteria require higher A_w for growth than yeast or mold. Most spoilage bacteria do not grow below A_w 0.91; however, halophilic (salt-loving) bacteria such as *Staphylococcus aureus* have been known to grow at values as low as 0.75.

Spoilage molds grow at much lower levels. Xerophilic (dry-loving) molds and osmophilic (preferring high osmotic pressure) yeasts have been reported to grow at A_w values of 0.65 and 0.60, respectively.

For the most part, lowering the A_w of a food below 0.65 eliminates the majority of the spoilage microorganisms.

Nutrient content

Nutrient content is another factor that influences spoilage. The more nutritious foods tend to undergo more spoilage. This occurs because microorganisms require certain nutrients, such as vitamins and other growth factors.

Foods high in protein tend to undergo bacterial spoilage because these microorganisms require a source of nitrogen. Several examples include eggs, red meat, chicken, and seafood.

Lipids or fats in food may also cause problems. Foods high in lipid content, especially unsaturated fats, may undergo oxidation. The loss of certain vitamins and pigments often results in fading color and other undesirable events.

Antimicrobial agents

Various foods, such as eggs, cloves, and cranberries, have built-in defense mechanisms—antimicrobial agents that are present naturally. Lysozyme, an enzyme present in egg white, prevents the growth of gram-positive bacteria which include *Listeria monocytogenes*, *Staphylococcus aureus*, and *Streptococcus*. The compounds benzoic acid and eugenol, present in cranberries and cloves respectively, hinder the growth of mold and some bacteria.

Biological structures

Animals are considered to be good filters because the hides protect and prevent the animal from invasion. Other biological structures, such as shells on eggs and nuts, protect the inner contents. The natural coverings perform functions similar to animal skin.

Oxidation/reduction potential

Oxidation/reduction potential is the ease by which a substrate (food) loses or gains electrons; it involves the oxygen tension and certain other characteristics of food.

For example, steak has low oxygen penetration compared to ground beef. Ground meat, because of its increased surface area, has a higher oxygen penetration level. Therefore, ground beef contains a higher initial microbial load. Based on the assumption that the inner portion of a steak is intact and no oxygen has penetrated to the core, the inner portion of a steak may be “sterile.”

Extrinsic Parameters

Unlike the previously described intrinsic parameters, extrinsic factors, including temperature, time, relative humidity, presence of gases, physical stress, and other environmental parameters, can be controlled or changed to influence a product's shelf life.

Temperature

Temperature is perhaps the most important extrinsic factor that must be controlled to minimize spoilage. By keeping certain foods hot and others cold, spoilage can be prevented or minimized.

Certain microorganisms (mesophiles) prefer room temperature, while others (psychrophiles) are capable of existing in or on refrigerated items. Placing meat in the refrigerator may reduce the growth of mesophiles, but promotes the existence of psychrophiles, such as *Pseudomonas*.

Temperature is also an important part of various chemical reactions. An increase in temperature often accelerates the rate of a chemical reaction.

Time

The duration of storage has an inverse relationship to food quality; in other words, spoilage occurs as time progresses. Thermal destruction of microorganisms is based on time as well as temperature; the time/temperature relationship is the basis for microbial destruction in products such as canned goods. For this reason, time and temperature are often grouped as one classification of extrinsic factors.

Relative humidity

Relative humidity affects the A_w within food. This factor is especially important if altering the A_w is the primary means of controlling spoilage within a food system.

All foods are different with respect to supporting microbial growth and becoming dried out. High humidity may encourage the growth of molds on refrigerated foods.

On the other hand, wet heat is more effective in destroying microorganisms and inactivating enzymes than dry heat. Relative humidity is a useful environmental factor.

Presence of gases

Gas flushing with certain inert gases can also be an effective means of extending the shelf life of foods such as meat and fruits.

For example, controlled atmospheric storage of apples is accomplished by increasing the relative humidity and the level of inert gases (carbon dioxide and/or nitrogen) to about 85 percent and 5 percent, respectively. The temperature and oxygen levels are reduced in order to slow down respiration and the physiological changes that accompany aging.

Other examples of controlled or modified atmospheric storage may involve using ethylene gas to speed ripening and color development of citrus fruits and bananas.

Physical stress

Proper handling of the food product is essential to avoid unnecessary spoilage from bruising and other physical abuse that may occur during transportation and storage.

Loss of quality is the ultimate outcome when the product's intrinsic and extrinsic factors are out of balance. Losses of quality fall into several categories depending on the mode of deterioration.

Types of Deterioration

Physical deterioration

Physical deterioration associated with aging is evident by signs such as color fading, moisture changes, and alterations in sensory properties including aroma and textural changes.

While our senses are capable of deciphering between desirable and undesirable characteristics in reference to color, texture, and aroma of foods, our senses can not always determine a product's safety, nutritional value, or shelf life. A product that looks appealing may not be conducive to good health.

Microbial deterioration

Microbial deterioration occurs when spoilage microorganisms survive processing treatments and cause deterioration via multiplication and propagation. Microorganisms also can produce off-flavors and slime.

Preservation of certain foods by using low temperatures (refrigeration) is based upon the fact that the activities of microorganisms can be slowed down. In reducing the temperature to freezing or subfreezing levels, these microbial activities may in fact cease.

The reason for the occurrence of this phenomenon lies in the fact that all metabolic reactions of microorganisms are enzymatic. Furthermore, the rate of enzyme-catalyzed reactions is dependent on temperature.

Pathogenic microorganisms may also be responsible for a decrease in shelf stability. These particular organisms are capable of causing illness as well as food spoilage. However, processing methods and techniques are aimed at the destruction of these harmful microorganisms; thus, only thermoduric (surviving heat processing) or thermophilic (heat loving) spoilage organisms remain to cause food decomposition.

Chemical deterioration

Chemically based deterioration of food products often involves oxidative and hydrolytic rancidity as well as other chemical reactions.

It is important to distinguish between oxidative and hydrolytic rancidity. Oxidative rancidity occurs when a fat (especially a highly unsaturated one) is attacked by oxygen, while hydrolytic rancidity involves enzymatic reactions.

An example of hydrolytic rancidity is evident when milk becomes sour over a period of time. Pasteurization of the milk eliminates pathogenic microorganisms, but may not destroy all the microflora.

It is important to remember that this type of mild heat treatment has the purpose of eliminating disease-causing microorganisms while the thermoduric microflora survives and with time multiplies. These microorganisms may possess lipases or enzymes which act upon the fat in the milk. As a result of this action, free fatty acids are liberated creating the acid flavor in the milk.

Oxidative rancidity usually occurs when the fat in the product contains many (poly) double bonds. Oxygen attacks at the site of the double bonds which in turn generates unstable free radicals that catalyze the production of more free radicals. Thus, it is a chain reaction that can quickly spread to all susceptible fatty acids.

An increase in temperature and the presence of transition metals such as iron and copper may further increase the rate of any chemical reaction.

Biological deterioration

Biological deterioration involves contamination of food products via birds, rodents, or insects. These biological vectors not only devour the food supply, but have the capacity of transmitting disease; hence, this type of deterioration may lead to microbial problems.

The cockroach, a common pest, can carry millions of microorganisms on the hairs of its legs. Because of the health problems associated with roaches and other biological vectors, preventative measures, such as proper packaging, must be taken to protect the food supply.

Each mode of deterioration influences a food product's shelf life. Loss of food quality can be attributed to any or all of the modes of deterioration previously described. Occasionally, the various modes of deterioration may occur simultaneously.

Although the previously described modes of food deterioration are the basis of food decomposition, numerous deteriorative factors exist. Temperature, light, oxygen, moisture, dryness, natural enzymes, microorganisms, macroorganisms, industrial contaminants, time, and food-to-food interactions can adversely affect certain products.

These factors are not isolated in nature. For example, microorganisms, rodents, and oxygen may all be operating in a simultaneous manner to compromise a food. These deteriorative factors may work together in a food system to spoil the food supply in the warehouse, the supermarket, or the household.

Shelf-life Dating

Because consumers feel that they have the right to know about the product and its shelf life, various dating systems have been implemented in order to provide the consumer with information necessary to purchase food items. The purpose of dating is to inform the consumer about the shelf life of the product.

Many different types of dating may appear on the label of various food products. Thus, shelf-life dating can be evident in several ways.

- pack date—the date on which the food was manufactured.
- display dating—the date that the food was placed on the store shelf.
- sell by/pull date—the date that the food must be sold or removed from the shelf.
- best if used by dating— the date of the maximum quality of the product.
- expiration date/use by date—the date the food must be consumed or discarded.

There is no universally accepted dating system used for food in the United States. Most perishable and semi-perishable commodities, such as dairy products and meat, carry one type of dating system on the label.

If someone approached you with a question concerning shelf life of your product, could you give an appropriate answer in response to the question?

Is a package of cupcakes dated two months ago fit for human consumption?

The type of date (pack, sell, use by) is crucial in decision making and responsive action. Because the pack date simply refers to the date of manufacture, the product would only be two months old and could probably be consumed as long as the package was intact. However, if the use by date was two months ago, the contents of the package may be unfit for human consumption.

Other considerations, such as off-flavors, decreasing nutritional value, and microbial spoilage, will make the type of dating important when evaluating a product's shelf stability and safety.

Shelf-life Effects on Food Distribution and Marketing

One question often asked is whether longer shelf life always has a positive impact. Benefits of extending shelf life include ease of distribution and stocking, less product rotation, and less waste.

Although the advantages of beneficial results from shelf-life extension far outweigh the disadvantages, drawbacks such as quality deterioration and difficulty in tracking the product still exist.

Consumer expectations and demands

With increasing demand for more healthy food products, processors have the responsibility for modifying conventional products. A conventional cookie formulation may contain 35 percent fat; however, the consumer may request an adapted recipe where the recipe is tailored to a fat content of only 5 percent. In addition, the new formulation must be palatable, cost efficient, and stable.

Increasing or maintaining the shelf life of a product encourages the processor to look for new and improved shelf-life extenders.

Consumers fear the unfamiliar; one example is additives. The absence of additives may result in inferior food quality, limited shelf life and availability of certain foods, and more danger of microbiological contamination.The growing demand for natural and untreated foods with a long shelf life has led to increased use of packaging.

Thermo-formed packaging, gas flushing (CO2), vacuum packaging, and other materials for prolongation of the shelf life have been used with successful results on a variety of bakery products, including cakes, breads, and croissants. Packaging technology can extend shelf life and freshness without incorporating artificial preservatives into the product's formulation.

Shelf-life Testing

Normally, a food product might take from weeks to as long as months to deteriorate. An accelerated method of testing must be utilized in order to minimize time, expense, and possible risk of foodborne illness. Models, equations, and formulas are used in conjunction with special chambers to obtain accurate and quick shelf-life results.

To have your product analyzed for shelf life or for more information on accelerated shelf-life testing, contact:

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Suggested Reading Material

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