Food Product Shelf-Life Guide

for Scaling Businesses

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As food businesses scale from local to regional or national distribution, decisions around packaging, formulation and production are inevitable as each affects a product's shelf life. Addressing a product's shelf life is a common stumbling block for food businesses. The following guide helps food businesses understand the basics of product shelf life, impacting factors, an introduction to testing and business implications of shelf life decisions.

What is Shelf Life — and What is it Not?

Simply put, the definition of product shelf life is the time period during which a food manufacturer expects the product will deliver the desired experience to the consumer. This experience is not something regulated or predefined by an outside entity, rather defined by the food business. Typically, the product experience is reflected in terms of taste and texture, but may also include factors like odor, color, nutritional content or product performance.

Food businesses, as well as many consumers, often confuse shelf life as a timepoint after which a product is no longer safe to eat. With the exception of a few highly perishable products, this is not the case. Food businesses should not use the time frame indicated by a product's shelf life as a substitute for building food safety into the production process. Rather, both the product design (ingredients or storage temperature for example) and the manufacturing process, should protect against the introduction or growth of food-borne pathogens.

Code Dating Basics

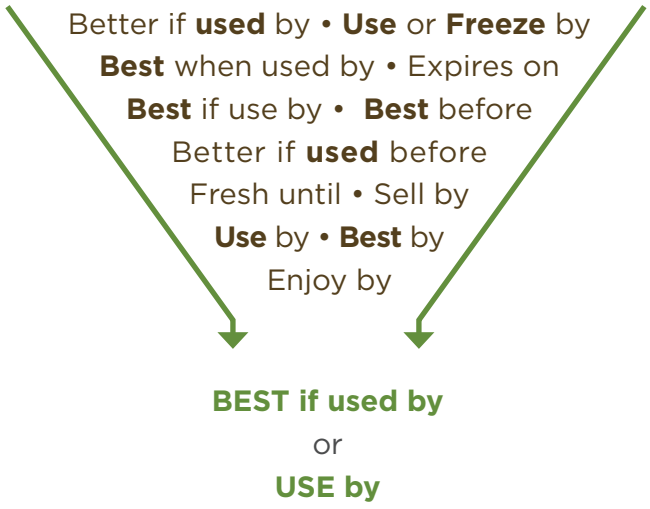
With the exception of baby formula, the code dates on food products are not federally regulated. This contributes to varying language appearing on packages, including, "Best If Used By", "Use By", "Best On Or Before", "Sell By", "Best By," and so on. This has understandably led to a healthy dose of consumer confusion.

In 2017, the Food Marketing Institute (FMI) and Grocery Manufacturer's Association (GMA) issued voluntary guidance to streamline product code dating to two phrases:

- **"BEST if Used By"** indicates to the consumer that, after a specified date, the product may not taste or perform as expected, but is still consumable.
- **"USE By"** or **"USE or FREEZE By"** applies to perishable products and indicates the date by which the food should be consumed or discarded.

While the above code dating guidance is voluntary, the Food and Drug Administration has offered directional support. FMI and GMA hope common adoption will reduce consumer confusion and alleviate some food waste by avoiding unnecessary disposal.

Simplifying Product Code Labeling



In addition to the commonly visible code date, most food packages also carry a manufacturing code date. This may include a Julian-style code date and/or a series of letters and numbers that help the brand owner track the date, time, and location (including the specific production line) of production and is a critical component of every manufacturer's food safety plan.

What is a Julian Date?

The Julian calendar began in 45 BC and sequentially counts each day rather than identifying days by days, months and years like the Gregorian calendar now commonly used. Often, dates are represented with the number of the day within the year, followed by a two-digit year number. For example, May 31, 2019, would display as 15119 as it is the 151st day of the year 2019.

Factors that Impact Product Shelf Life

Two groups of characteristics impact a food product's shelf life. The first group is comprised of chemical and physical changes, while the second includes microbiological changes and spoilage.

These quality changes, which are visible to the consumer, impact a product's shelf life. Food manufacturers need to make decisions on how to minimize the impact of these factors while also considering the impact on the cost of goods (product, packaging, manufacturing, or logistics cost) and brand image.

CHEMICAL AND PHYSICAL CHANGE DRIVERS

When exposed to external factors such as moisture, heat, oxygen and light, a product undergoes chemical or physical changes. While these changes do not generally create food safety issues, they may change the product's sensory experience, which impacts consumer satisfaction.

Moisture – Even in a sealed package, moisture can migrate in and out of a food product. When introduced to a product, moisture may create a soft texture. Conversely, as moisture migrates out of a product the item dehydrates. Additionally, ingredients may impact others within the product. For example, moisture will migrate from raisins to the drier grain ingredients in a granola or cereal.

Temperature – Generally, food products are designed for distribution in a specific temperature state: frozen, refrigerated or ambient. Temperature abuse, or prolonged deviation from the desired temperature state, can cause quality issues. For example, a raw dough product such as refrigerated rolls or a rising crust frozen pizza will not gain proper volume when cooked if exposed to excess heat, prematurely activating the yeast in the dough.

Oxygen – Similar to moisture, oxygen will migrate through the packaging of a sealed food product. As oxygen migrates into a product, it may accelerate the development of off-flavors, often described as "soapy" or "paint-like" due to oxidative rancidity.

Light – Exposure to light will, over time, cause changes in the appearance of a product, such as color bleaching or product browning. For example, a fruit beverage in a clear bottle exposed to light will decrease in color intensity, or condiments that are green will turn brown. In addition, light exposure can also accelerate the oxidative rancidity reactions, such as with almonds which will go rancid faster in a clear container than in an opaque container.

Time – In addition to the factors above, which may change a product's flavor or texture, nutrients naturally degrade over time. If a product's nutrition facts show a certain percent of recommended daily value, the product must deliver the minimum claimed amount at the end of the stated shelf life.

MICROBIOLOGICAL CHANGES/SPOILAGE DRIVERS

Yeast, mold and bacteria growth can all contribute to a change in product sensory attributes, functionally reducing the product's shelf life. Growth of yeast, mold or lactic acid bacteria will often result in a visual growth on the product, a sour taste or aroma and/or a soft or mealy texture. They may also cause package bloating, providing a noticeable indicator to consumers that something is wrong with the product. While the appearance of mold or other growth on a product is highly unappealing, they are not generally a food safety concern. There are, however, some molds that produce toxins. If your product is susceptible to microbiological spoilage, consult a professional to ensure the spoilage organism is not a food safety concern.

Product formulation, processing method, and storage temperature can manage the risk of microbiological spoilage. For example, low product pH (less than 4.6) and low water activity (see sidebar below) prevent the growth of most spoilage organisms, while processing such as heat treatment or pasteurization reduces the overall microbiological load. Refrigeration slows down the rate of microorganism growth, but will not prevent it, and freezing essentially "pauses" any microbiological activity, but does not deactivate it. Keep in mind that products intended to remain frozen or refrigerated through distribution may experience temperature abuse, creating an opportunity for microbiological spoilage if not properly addressed in formulation and processing.

While consumers may worry about illness as they encounter microbiological spoilage, pathogenic microorganisms such as Listeria or Salmonella are truly the culprit of food-borne illness. Protection against pathogen growth must be built into product design and manufacturing processes. Licensed food manufacturers follow Current Good Manufacturing Practices (CGMP's) and use Hazardous Analysis and Risk-Based Preventative Controls (HARPC) protocols to ensure safe food production.

Moisture versus Water Activity

Water is present in food in two different ways. Bound water is attached to other molecules or cell structures. It does not support microbiological growth, chemical or enzymatic changes, or contribute to spoilage. Unbound water is free to contribute to all the above changes and thereby negatively impact shelf life. The water content or moisture level of a food is a measure of both bound and unbound water. Water Activity, measured on a scale from 0-1.0, is a measure of unbound water present in a product with food such as crisp crackers at about 0.2, jams and jellies at about 0.8, and pure water at 1.0. A level of less than or equal to 0.85 is important to prevent illness causing microorganism growth while a level of 0.60 will control spoilage microorganisms like yeasts and molds. Products with a water activity greater than 0.85 must use processing or storage methods in order to limit microbiological growth (for example canning or frozen storage).

To learn more about water activity, visit:
https://ext.vt.edu/food-health/food-innovations/basics.html

Product Design Considerations

Intrinsic and extrinsic factors impact a product's shelf life. Intrinsically, a product's ingredients, processing and packaging play a role in how long it will maintain intended quality. Extrinsically, factors such as product age, storage temperature and light exposure impact the product and are often exacerbated by a complex and imperfect supply chain.

Ingredient selection and quality both play a significant role in determining a product's shelf life. For instance, whole grain flour, with its higher fat content, could contribute to more rapid oxidation (and resulting off-flavors) than refined flour.

Additionally, using aged ingredients that have already begun to degrade will negatively impact the shelf life of the finished product relative to using fresher ingredients. These defects can manifest in either sensory characteristics or performance of the finished product. For example, using almonds that are rancid in a granola bar will make the entire bar taste rancid from the date of manufacture; while using old yeast in a rising crust pizza will cause the crust not to rise as intended while baking thus delivering a poor consumer experience.

Processing ingredients into a finished food product can positively or negatively impact shelf life. For example, drying or grinding may introduce oxygen or change moisture content, potentially leading to an increased rate of off-flavor development or texture changes thereby shortening shelf life.

Even with careful ingredient selection and appropriate processing, a product's packaging impacts shelf life as well. Selecting a package with inadequate barrier properties or poor package seals will shorten shelf life. To learn more about packaging's impact on food products, visit ***www.auri.org*** and review the *Packaging Guide for Scaling Food Businesses*.

Finally, the mode of a product's distribution and storage play a role in defining a finished food product's shelf life. Frozen and refrigerated temperature states may provide longer shelf life for food products but are typically more costly and may not be appropriate for some products.

Several external factors can negatively impact a product's shelf life. While a food manufacturer can carefully choose ingredients, processing, and packaging to mitigate the impacts of age, moisture, temperature, oxygen and light, the manufacturer cannot fully control these factors throughout the supply chain. For example, warehousing and trucking in Florida (hot and humid) versus Arizona (hot and dry) versus Minnesota (extreme seasonal changes) will expose the product to significantly different environmental conditions, possibly within the same truckload! Additionally, frozen or refrigerated products often suffer abuse sitting on a non-temperature-controlled dock while waiting for loading onto a truck or stocked at a grocery store. Once in a consumer's home, the product may be subject to improper handling such as refrigerated product sitting out for extended periods of time. Generally, while a manufacturer should not expect to control for these abuses within the product shelf life, it should consider the impact on the product shelf life.

Visit ***AURI.org*** to download a basic shelf life protocol worksheet to help establish shelf life for your products.

How to Determine Shelf Life

There is no table or piece of equipment to define a product's shelf life. Rather, shelf life is determined in real time using the actual product and packaging, while following a defined evaluation protocol.

Determining shelf life requires a study, which evaluates product attributes over time at typical storage conditions in finished packaging. Often, this can be as simple as holding multiple samples of a single product under steady temperature, humidity, and light conditions, then comparing that product to a reference sample (a sample stored in a sealed container in the freezer, or a freshly made sample). The time at which a critical product attribute no longer meets the business owner's quality expectations (known as the mode of failure, which differs by product) is defined as the shelf life end point under these test conditions reflected in its labeled code date. For example, the mode of failure for a snack chip may be loss of crispness whereas for a granola it may be rancidity.

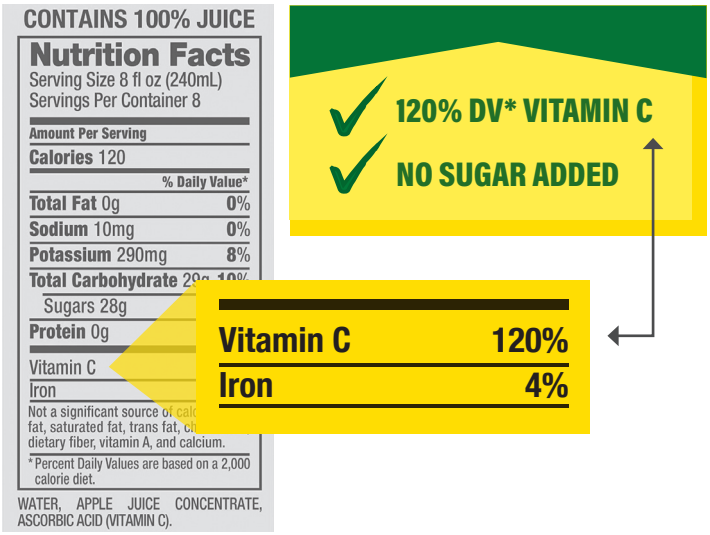


Image 1: Product must deliver Vitamin C content disclosed on nutrition facts panel through entire shelf life.

Shelf life product evaluations can take a number of forms, including small group assessment where a core team informally evaluates the test product versus a reference sample to a more formal sensory test engaging consumers to evaluate the product in a blind test. In some cases, analysis in a lab setting may also assess changes in specific product attributes. If a product has any nutritional claims, an analysis would be key in determining shelf life since nutrients such as vitamins, need to at a minimum, meet stated label value at the end of shelf life. Further, microbiological analysis over time may be important for some products, where spoilage may be the mode of failure.

Knowing that shelf life testing as described above can take a year or longer does not mean a food manufacturer needs to wait until completion of a test in order to launch a product. Several resources can help make an initial shelf life estimation. First, evaluating similar retail products – those in the same product category and using similar processing and ingredients – can provide a quick assessment. This approach can be challenging as it's difficult to know a competitor's exact shelf life unless the manufacturing date is decipherable from the on-pack manufacturer's date code. Second, speaking to retail store-level department manager or buyers, can provide guidance on shelf life norms within a category. Third, entrepreneurs can begin collecting information on shelf life as the product is developed. For example, when testing, set some product aside to evaluate over time. However, none of these approaches are a substitute for a traditional, product-specific shelf life test.

A NOTE ON ACCELERATED SHELF LIFE TESTING

Food manufacturers will often consider accelerated shelf life testing as a shortcut to the process described above. In accelerated shelf life testing, the test product is stored at a higher temperature (or other abusive conditions such as higher humidity or light) to accelerate degradation reactions. However, this approach is not a short cut or substitution to doing a "real time" shelf life study under typical conditions. Rather, it's a useful tool to evaluate product or processing changes against a known baseline of the original product.

Business Considerations of Shelf Life

Determining a product's shelf life has real economic and consumer implications for food businesses.

Retailers typically have rules governing shelf life, most often, seeking to maximize the amount of time a retailer has in order to sell through its inventory. This can create unintended costs for the food manufacturer. For example, retailers often require the product to have a certain percentage of the shelf life remaining (see Table 1), thereby limiting the amount of time the manufacturer has between production and delivery to the retailer. This may impact the amount of inventory that can be produced at a given time or how long that inventory may be held at a distribution warehouse and may cause product to become unsaleable while within the manufacturer's system.

Shelf Life Remaining	Actions
180 days (100%)	Production date; shelf life begins to deplete
90 days (50%)	Product must be shipped to retailer
30-10 days (16%-5%)	Retailer may pull from shelf at manufacturer expense
0 days (0%)	Shelf life ends; product discarded at manufacturer expense if not sold

Table 1: Remaining Shelf Life Days

Additionally, a retailer may remove a product from its shelf as it nears its code date and dispose of it, having made a determination that it is not offering the shopper enough remaining shelf life. The manufacturer bears associated costs. Further, if a product shelf life is too short, it may create a barrier to retail market entry for the product. Ultimately, the brand owner must weigh these factors in setting a product shelf life and make the best decision for its business, sometimes to the detriment of either retailer distribution or product quality over time.

Shelf life can also impact consumer perception regarding what it implies about the brand. For example, a long shelf life may be a disconnect with a "natural" or "clean label". Despite consumers often comparing product code dates and purchasing the item with the most shelf life remaining, the concept of product expiration can be an indicator of quality and freshness. Products with long shelf lives may be viewed as less fresh or natural. Aligning shelf life with intended brand promise can positively impact long-term brand health.

Finally, determining the appropriate shelf life can ultimately help to reduce food waste both in the supply chain and in the home. According to Refed.com, 83% of food waste occurs downstream from the manufacturer. A maximized shelf life, that does not negatively impact the product experience the food manufacturer wants to deliver, will help reduce unsaleable product within the supply chain and reduce the amount of food prematurely discarded at home.

Despite potential cost of increased unsaleables, it may be advantageous to err on the side of setting a shorter shelf life as, once launched, it is much easier to communicate (in particular, to a retailer or distributor) an increase in shelf life than a decrease.

Examples of Typical Shelf Life & Modes of Failure

Product & Approximate Shelf Life	Mode of Failure
ICE CREAM & FROZEN DESSERTS 6-12 Months	Ice Crystal Growth Freezer Burn / Surface Ice Formation Gritty & Grainy Texture Loss of Flavor Color Change / Darkening
FROZEN BAKED GOODS 3-6 Months	Loss of Baked Volume Surface Drying or Freezer Burn Dough Color Change
REFRIGERATED PRODUCTS 1 week - 4 months	Off Flavor Development Liquid Separation or Viscosity Change Color Change Microbial Spoilage
BEVERAGES 3 days - 12 months (depending on type and processing method)	Color Loss Browning Loss of Flavor Off Flavors Thickening / Sedimentation Vitamin Degradation
FRESH-BAKED PRODUCTS 1-7 days	Drying Loss of Flavor and/or Stale Flavor Staling, Firming of Structure
CEREALS 6-12 months	Loss of Flavor Off Flavor Including Rancidity Loss of Crispiness
COOKIES & CRACKERS 6-12 months	Off Flavors Texture Changes (loss of crispiness for crackers or firming for moist cookies) Color Changes
SNACK CHIPS 2-3 months	Off Flavor Including Rancidity Loss of Crispiness
GRANOLA BARS 6-9 months	Texture Changes (loss of crispiness or loss of chewiness) Binder Separation (causing pooling at the surface or stickiness) Flavor Loss Off Flavors
JAMS / JELLIES 6-24 months	Color Changes / Browning Loss in Flavor Separation
SAUCES 9-18 months	Color Changes / Browning Loss in Flavor Separation

Getting Started

If you have further questions about product shelf life, contact AURI to consult with our expert staff. While AURI does not conduct formal shelf life studies on behalf of food businesses, it does provide consultation and guidance in development and evaluation of appropriate shelf life testing protocols.

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