Chapter V

Establishing Open Dates

In order to establish a fairly accurate open date (except a pack date) for a particular food, one needs to know how that food deteriorates. All foods begin to deteriorate at some speed (rate) as soon as they are packaged and continue to deteriorate until they may no longer be acceptable. Some foods deteriorate relatively quickly and others very slowly.

Food shelf life is not totally dependent on time but also on environmental conditions such as temperature, humidity, light, and oxygen. The prime factors—temperature and humidity-may increase deterioration as they rise, or slow the process as they become lower. However, their impact depends on how widely they vary and on the product itself. Also, as the food deteriorates, the process may accelerate because of its own momentum.

Examples of possible modes of deterioration, the most critical environmental factors; and the most feasible open date for some perishable, semiperishable, and long shelf-life foods are listed in table 5. The primary mode, if known for normal conditions, is in bold italic type. How foods deteriorate may change radically with sterilization procedures, packaging, condition of raw material, etc.

As can be seen in table 5, in no case is safety a concern in any of the normal deteriorations of food. In cases of certain meats or poultry, foodborne infections that might be disseminated by the product could make the question of safety more relevant than for other foods. However, for most food, other factors that result in an inedible product occur before a point of health hazard is reached if the product has been properly processed, packaged, and not abused or contaminated.

Most perishable and semiperishable foods degradate mainly on sensory quality criteria. For example, fresh meat degrades mainly by bacterial activity and oxidation that cause an off-flavor development and loss of color. This is readily recognizable by consumers.

In contrast, many long shelf-life foods degradate mainly on nutritional criteria. For example, frozen fruits and vegetables are consumed as a major dietary source of vitamins and minerals. In some cases, vitamin content may fall below some accepted standard before sensory quality becomes inadequate. In addition, most long shelf-life foods are packaged so that it is impossible to examine the contents. Consumers cannot recognize loss of sensory quality until the product is unpackaged after purchase. Open shelf-life dating is, therefore, as applicable to long shelf-life foods as it is to perishable and semiperishable foods, particularly if these foods are stored in the distribution system or home for a fairly long period of time. Some type of date is useful to ensure proper rotation and give

Table 5.—Major Modes of Deterioration, Critical Environmental Factors, Shelf Life, and Type of Open Dating by Food Product

Food product	Mode of deterioration (assuming an intact package)	Critical environmental factors	Shelf life (average)	Date most suitable for product	Additional information
Perishables					
Fluid milk and products	bacterial growth, oxidized flavor, hydrolytic rancidity	oxygen, temperature	7-14 days at refrigerated temperature	sell-by	length of time product can be stored at home
Fresh bakery products	staling, microbial growth, moisture loss causing hardening, oxidative rancidity	oxygen, temperature, moisture	2 days (bread) 7 days (cake)	sell-by	
Fresh red meat	bacterial activity, oxidation	oxygen, temperature, light	3-4 days at refrigerated temperature	pack or sell-by[a]	
Fresh poultry	pathogen growth, **microbial** *decay*	oxygen, temperature, light	2-7 days at refrigerated temperature	sell-by[a]	length of time product can be stored in home either frozen or refrigerated
Fresh fish	bacterial growth	temperature	14 days when stored on ice (marine fish)	pack (catch date)[a]	
Fresh fruits and vegetables	microbial decay, nutrient loss, wilting, bruising	temperature, light, oxygen, relative humidity, soil & water, physical handling	(b)	pack[a]	
Semiperishables and perishables					
Fried snack foods	rancidity, loss of crispness	oxygen, light, temperature, moisture	4-6 weeks	sell-by or best-if-used-by	home storage information such as "store in a cool, dry place"
Cheese	rancidity, browning, lactose crystallization	temperature	processed cheese 4-24 months; natural cheese 4-12 months	best-if-used-by	
Ice cream	**graininess caused by lactose crystallization,** loss of solubilization (caking), lysine loss	fluctuating temperature (below freezing)	1-4 months	sell-by or best-if-used-by	recommended home storage temperature
Long shelf-life foods					
Dehydrated foods	browning, rancidity, loss of pigment, loss of texture, loss of nutrients	moisture, temperature, light, oxygen	dehydrated vegetables 3-15 months; dehydrated meat 1-6 months; dried fruit 1-24 months	sell-by or best-if-used-by	estimate of shelf life beyond sell-by date; store in cool, dry place
Nonfat dry milk	*flavor deterioration,* loss of solubilization (caking), lysine loss	moisture, temperature	12 months	best-if-used-by	

Table 5.—Major Modes of Deterioration, Critical Environmental Factors, Shelf Life, and Type of Open Dating by Food Product—Continued

Food product	Mode of deteriorate ion (assuming an intact package)	Critical environmental factors	Shelf life (average)	Date-most suitable for product	Additional information
Breakfast cereals	rancidity, loss of crispness, vitamin loss, particle breakage	moisture, temperature, rough handling	6-18 months	best-if-used-by or sell-by	recommended storage conditions
Pasta	texture changes, staling, vitamin and protein loss	too high or low moisture, temperature	pasta with egg solids 9-36 months; macaroni and spaghetti 24-48 months	best-if-used-by	
Frozen concentrated juices	loss of turbidity or cloudiness, yeast growth, loss of vitamins, loss of color or flavor	temperature	18-30 months	sell-by or best-if-used-by	month of high quality left in home storage
Frozen fruits and vegetables	loss of nutrients; loss of texture, **f/aver, color:** and formation of package ice	temperature	6-24 months	best-if-used-by	recommended storage conditions
Frozen meats, poultry, and fish	**rancidity,** protein denaturation, color change, desiccation	temperature	beef 6-12 months veal 4-14 months pork 4-12 months fish 2-8 months lamb 6-16 months	best-if-used-by	recommended storage conditions
Frozen convenience foods	rancidity i n meat port ions, weeping and curdling of sauces, loss of flavor, loss of color	oxygen, temperature	6-12 months	best-if-used-by	recommended storage conditions
Canned fruits and vegetables	loss **of** *flavor,* texture, color, nutrients	temperature	12-36 months	best-if-used-by	
Coffee	**rancidity,** loss of flavor and odor	oxygen	ground, roasted, vacuum-packed, 9 months; instant coffee 18-36 months	best-if-used-by	
Tea	loss of **flavor** absorption of foreign odors	moisture	18 months	best-if-used-by	

[a]This date applies only if the product is packaged prior to sale If unpacked or sold in bulk prior to sale this product is exempt from an open date
[b]Depends on the specific commodity Sweet corn has a shelf life of 4 to 8 days and apples range from 3 to 8 months at ProPer temperature For this specific information see Theodore Labuza et al Open Shelf Dating of Foods. Dept of Food Science and Nutrition University of Minnesota report prepared for the Office of Technology Assessment 1978

NOTE When known the primary mode of deterioration is in bold italic type the consumer an index of when foods should be used.

Since the mode of deterioration and critical environmental factors determine the shelf life of a product, they should be considered in selecting the type of open date. In general, for perishable products, the most feasible date is the pack or sell-by date. For example, almost all fresh red meat is packaged by the retailer who deals directly with the public. The meat may have been slaughtered from 1 day to 2 weeks previously. Since carcasses of properly handled beef are essentially sterile internally, it is the packaging procedure that initiates color change and bacterial spoilage. Because the shelf life of fresh meat is relatively short beyond the date of packaging, a pack date or sell-by date may be sufficient for consumer use and understanding.

A best-if-used-by date would also be useful to the consumer for fresh meat and other perishable products. However, these products are very sensitive to temperature changes, which can result in very rapid deterioration. Thus, the potential for consumer abuse may be too great for a best-if-used-by date to be a practical alternative.

In general, the most suitable date for long shelf-life foods is the best-if-used-by date. For example, with canned fruits and vegetables, the date of pack would be the easiest to implement but would not tell the consumer anything about the shelf life of the product. Canners who pack seasonal crops would be in a difficult position because the date on the cans would seem old when the product is actually still well within the shelf life of the product. This would be especially true in years when an overabundant crop would force the canner to sell some products the following year.

A sell-by date is not applicable to cans that are often stored in the home for some long period of time after being sold. The best-if-used-by date could be useful to consumers because it would give an appreciation of the shelf life of the product if conditions of storage were known or uniform. (For a detailed discussion by product, see appendix A.)

ALTERNATIVE CRITERIA

The general criteria to establish a sell-by or best-if-used-by date will depend on what the date is meant to imply. A sell-by date should mean that there is still high-quality life left for some time period of home storage under reasonable conditions. A best-if-used-by date further states this by projecting a reasonable time period. It is not possible to set an exact end to shelf life (a definite use-by date) for any food product.

Such criteria would have to be based on what degree of change caused by each of the deteriorative reactions in table 5 would lead to a "significant" loss in high quality. This would apply to rancidity, flavor loss, browning, textural change, etc. Such tests for sensory quality (taste panels, preference tests, etc.), although well-developed and used in product testing, would be difficult to use in a regulatory sense to determine whether a specific food was in or out of compliance at a certain date unless the regulators were trained for each product. What is needed in this sense is a chemical or physical index that changes in a similar manner to the sensory changes.

Sensory Quality

Although more difficult to measure in certain cases, sensory quality is the most important characteristic for consumers and processors alike, and in some cases with foods of long shelf life, this quality may also be an indicator of nutrient quality. This is not true for shorter shelf-life foods such as milk.

Manufacturers define their own quality standards through elaborate product development studies, many of which include sensory testing, when they put a brand name on a product with a best-if-used-by date. In this way, they assume quality loss up to that point is still acceptable enough that the consumer will buy the product. If consumers buy the product and find it below their own quality standards, they will probably not buy the product again.

Consumer reaction, then, is the key to quality standards, because Government regulatory agencies would not have available the needed methods to determine whether a given food that is still in date is out of compliance with some quality standard. For example, if an inspector picked up a can of soup and took it back to the laboratory, he might not have the scientific tests available which could determine with any degree of accuracy if that soup is of a designated quality and therefore acceptable to the consumer.

Assuring compliance with sensory quality might be feasible if the sell-by or best-if-used-by date were coupled with official Government or widely accepted industry quality grades. Thus, instead of merely stating "use-by" or "best-if-used-by" when there is no defined "best" quality, the open date could be preceded by a statement such as "to remain in grade, use by. "

The addition of an open date to a grade declaration would automatically solve the existing serious problem of unlimited guarantee of a specified quality grade level from the time the grade is marked on the container until its destruction. The more perishable the product, the more important would be the grade/open-date combination, While canned green beans could well remain in grade for a year or longer provided the container is undamaged and not exposed for long periods to high and/or fluctuating temperatures, fresh green beans could go out of grade in just a few weeks, or even days,

Open dating, when coupled with quality grade levels, can be based on accurate, rapid, and scientifically sound methods of analysis for some foods. However, open dating based on retention time within the grade can be applied only to those few hundred items for which generally recognized and approved grades already exist. These items are those for which grade levels can be measured accurately and precisely.

Nutrient Loss

Another measure of shelf life could be the loss of a certain percentage of a critical nutrient, such as vitamin C. This factor would be much easier to measure than overall quality, since it can be analyzed accurately and rapidly in the laboratory. The same would be true for moisture gain or loss of a critical value that would cause some textural change, such as loss of crispness of a potato chip.

However, many scientists favor a specific sensory quality criteria for each type of food rather than a given percentage loss of an unstable or critical nutrient for all commodities. Nutrient content of even the same foods can be quite variable, particularly the vitamin content of many raw agricultural commodities, For example, two tomatoes picked at the same time can vary significantly in vitamin C content. More importantly, some foods are naturally poor in some nutrients, are not eaten to provide those nutrients, and may be of good quality even if they have lost a certain percentage of the nutrients. In other words, if a food only contains 1 percent of the U.S. recommended daily allowance of vitamin C, a 10-percent decrease in this low amount would most likely have an insignificant effect on overall nutritional status of the consumer.

If nutrient loss is to be used as one index of quality loss, foods would have to be examined on a product-by-product basis. In essence, this has already been done for nutrition labeling. However, to prove that a loss in nutrients is of significance to overall quality of each and every commodity would be difficult.

Perishability Time Categories

Some States with open-dating requirements use perishability time categories to establish an open date. The three general categories are: perishable, semiperishable, and nonperishable. Time categories can be relevant for highly perishable foods that have a minimum of processing such as fresh meat or milk. However, processing conditions and types of packaging can increase the shelf life of semiperishable and long shelf-life foods to the point where such perishability time categories are not meaningful unless continuously modified to reflect new circumstances. For example, semiperishable foods can be defined as those foods with a shelf life of greater than 7 days but less than 90. Under this system, in general temperature and environmental conditions, most potato chips would be defined as semiperishable. However, if they were packed in a foil pouch under nitrogen with added antioxidants, the chips might last for up to 6 months and would not fit the category.

Some States have met this problem by developing a nonperishable or long shelf-life food category that can be defined as foods with a shelf life of greater than 6 months. As pointed out earlier in this report, this is, in fact, a scientific misnomer, for all foods decay at some rate by some means. Even in the above example with potato chips, if the new method of packaging gave an average shelf life of 120 days but the product was abused in distribution and held at high temperatures (38 °C) for a few days, it could deteriorate fast enough that it would no longer meet the criteria of nonperishability. Therefore, perishability terminology cannot be logically backed-up scientifically since one can control or change shelf life through varying processing, packaging, and environmental conditions.

Basing open dating on time categories could also be a hindrance to implementing new technology. For example, better packaging can increase shelf life of potato chips from 90 to 120 days, even in regions with high humidity. However, this better packaging would not be used if potato chips could not be sold at full price after 90 days no matter what their quality may be.

SCIENTIFIC TESTS AND DATA NEEDED

To develop sell-by or best-if-used-by dates scientifically, each manufacturer would need to conduct shelf-stability studies on each product and determine the point in time at which sensory quality falls below the point of consumer acceptance. This is very time-consuming and difficult to determine unless the food has a short life under constant normal environmental conditions.

Knowledge of temperature and humidity conditions encountered during distribution are necessary to set the sell-by or best-if-used-by dates. A manufacturer can determine this in one of two ways. He can put a product out in the marketplace, pick up samples at various times and places in the marketing channel, and test the quality of the samples at regular time intervals to establish the appropriate date for the product. But for products with several years shelf life, such as canned vegetables, these studies could take as long as 3 to 4 years.

The other alternative for the manufacturer is accelerated shelf-life tests (ASLT). These tests would be necessary for new-product development and could be advantageously used for existing products where shelf life under normal marketplace conditions is very long. ASLT involves subjecting the product to two or three given constant environmental conditions and measuring the rate of quality loss at each condition. A mathematical formula can then be established for the rate of deterioration as a function of temperature and/or humidity and used to predict the time needed to reach an unacceptable amount of change during distribution and storage.[1]

In a select sample of 50 food manufacturers, OTA found that the scientific approach described in this section and in the background report is frequently not utilized except by major corporations with highly qualified scientific personnel. The low use of shelf-life testing results from lack of knowledge and, more importantly, lack of experience in determining the shelf life of established foods as well as the costs involved.[2]

The major impact of developing scientific data would fall on the food manufacturer. A significant amount of time and money must be used to establish a data base for each product because broad generalizations cannot suffice, Because of the cost, most manufacturers would probably consider these data to be of a proprietary nature and would not release it to the Federal Government or the scientific literature. Another impact would be that the wholesalers, distributors, food brokers, and retailers would need to supply information on each product's history, as regards time, temperature, and humidity conditions encountered along the way to final sale.

‘Theodore Labuza et al., “Open Shelf-Life Dating of Foods,” Department of Food Science and Nutrition, University of Minnesota, report prepared for the Office of Technology Assessment, 1978.

‘Ibid.

Since shelf-life testing is product-specific, it would be very expensive for the Federal Government to undertake these types of tests for all food products. The Government could, however:

1. Support research into modeling shelf-life studies for various reactions leading to loss of quality under variable time/temperature/humidity conditions.
2. Support or conduct research into development of reasonable cost devices that could be attached to food packages which could detect the impact of time, temperature, and humidity on shelf life of an individual food.

IMPACT ON TECHNOLOGY DEVELOPMENT

An open-dating system based on perishability time categories with a sell-by date, such as many States have now adopted, can inhibit efforts to improve processing technology, packaging methodology, and a distribution system that would extend the shelf life of many foods. This is because there is no benefit gained in improving a food if it cannot be sold at full price beyond a certain date after manufacture. However, if manufacturers are allowed to use the best-if-used-by date on a voluntary basis that they feel is reasonable, the incentive to do research to extend the date may be greater than it is now.

From the consumer's viewpoint, however, extending the date may be a processor's attempt to make old foods taste and look good, at the risk of some additives. Many consumers today are extremely distrustful of food additives used simply to extend shelf life. Also, consumer distrust may be a reason why UHT (ultra-high temperature) milk has not been widely accepted in the United States. Because of improved sterilization techniques, this milk can remain shelf-stable for at least 6 months at room temperature.

Another pitfall to consider is that too much emphasis in product development may be put simply on extending shelf life and thus decrease efforts to develop a wide variety of other interesting and convenient foods that are enjoyable but which may not have an extremely long shelf life. It is impossible, however, to project such an impact at this time.

At present, theoretically accurate and reliable shelf-life indicators for some types of food products exist that could measure the reaction rate of food to both temperature and moisture. However, these indicators are not technologically or economically feasible for individual consumer-size packages.

If such indicators were in widespread use, food companies buying commodities or ingredients from other food companies could include a value on the indicator as part of their specification for the ordered food. Some Government contracts currently mandate use of shelf-life indicators in shipping frozen food cases. The use of indicators could well be extended to other cases or pallets of food. However, the indicators may never become inexpensive enough to warrant their use on individual consumer packages, They would probably cost at least as much as the package itself.

Open dating could have a real impact on labeling technology. There would be increased incentive to develop quick-drying inks and ways of printing on difficult surfaces, especially at high speed. At present, it is not possible to do this, and the materials are not available, according to the industry. New unidirectional shrink-film that can be preprinted without distortion as the label is applied could be the answer. It is currently used for bottle labels.

The other major issue is in the area of quality standards. With the exception of the commodities for which there are now quality grades and standards, no specific guidelines exist for thousands of new, fabricated, and processed foods. However, the vast sources of existing knowledge on which Government and industry quality grades are based could be tapped.

If a best-if-used-by or sell-by dating system were imposed, research by Government, universities, and industry laboratories would be stimulated. They would most likely center on:

1. shelf-life indicators,
2. modes of deteriorations and quality indicators,
3. prediction of packaging requirements, and
4. more precise and objective methodology for measuring changes in sensory quality attributes.