Prediction of shelf life of food

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Shelf life

- Time during which the food product will remain safe, retain desired sensory, chemical, physical and microbiological characteristics, comply with any label declaration of nutritional data, when stored under the recommended conditions.

- It begins from the time the food is finished processing and packaged.

Factors Affecting Shelf life

Intrinsic Factors	**Extrinsic Factors**
Water Activity	Time-temperature profile during processing, pressure in the headspace
pH	Temperature control during storage
Redox potential (Eh)	Relative humidity (RH)
Available oxygen	Exposure to light (UV and IR)
Nutrients	Environmental microbial counts during
Natural microflora and surviving microbiological counts	Composition of atmosphere within packaging.
Use of preservatives in product formulation	Subsequent heat treatment

Shelf life indication on food

- **Use by date** - foods that have a use by date are generally regarded as unsafe to eat after the designated date because a build-up of bad bacteria may have occurred even if the food in question still looks and smells good enough to consume.
- It is about safety

- **Best Before-** It signifies that although the date on the package may have passed, the product is still safe to consume on the proviso the item has been stored according to instructions, while still generally maintaining its colour, texture and flavour.
- It is about quality of food.

SHELF LIFE DETERMINATION

There are at least three situations when a shelf life determination might be required:

1. To determine the shelf life of existing products.
2. To study the effect of specific factors or combinations of factors such as storage temperature, packaging materials, processing parameters or food additives on product's shelf life.
3. To determine the shelf life of prototype or newly developed products.

Several established approaches are available for estimating the shelf life of foods:

1. Literature study: The shelf life of an analogous product is obtained from the published literature or in-house company files.

2. Turnover time: The average length of time which a product spends on the retail shelf is found by monitoring sales from retail outlets. This does not give the “true” shelf life of the product but rather the “required” shelf life.

3. Endpoint study: Random samples of the product are purchased from retail outlets and then tested in the laboratory to determine their quality. From this, a reasonable estimation of shelf life can be obtained because the product has been exposed to actual environmental stresses encountered during warehousing and retailing.

4. ASLT (Accelerated shelf life testing): Laboratory studies are undertaken during which environmental conditions are accelerated by a known factor so that the product deteriorates at a faster than normal rate. This method requires that the effect of environmental conditions on product shelf life can be quantified.

There are some parameters to calculate the shelf life.

CRITICAL DESCRIPTORS AND INDICES OF FAILURE

In designing suitable packaging for foods, it is important first to define the critical descriptors or indices of failure (IoFs) of the food, that is, the quality attributes that will indicate that the food is no longer acceptable to the consumer.

- An IoF could be development of rancid flavors in cereals due to oxidation,
- loss of red color in chilled beef due to depletion of O_2,
- reduction of carbonation in bottled soda due to permeation by CO_2 through the bottle wall,
- caking of instant coffee due to moisture ingress,
- loss of crispness in a snack food due to moisture uptake or moisture

CUTOFF POINT

The next step is to specify the cutoff point (COP) or the endpoint of the particular degradation, for example-

- how much moisture or O_2 can react with the food
- how much the flavor can deteriorate, before the food becomes unacceptable.

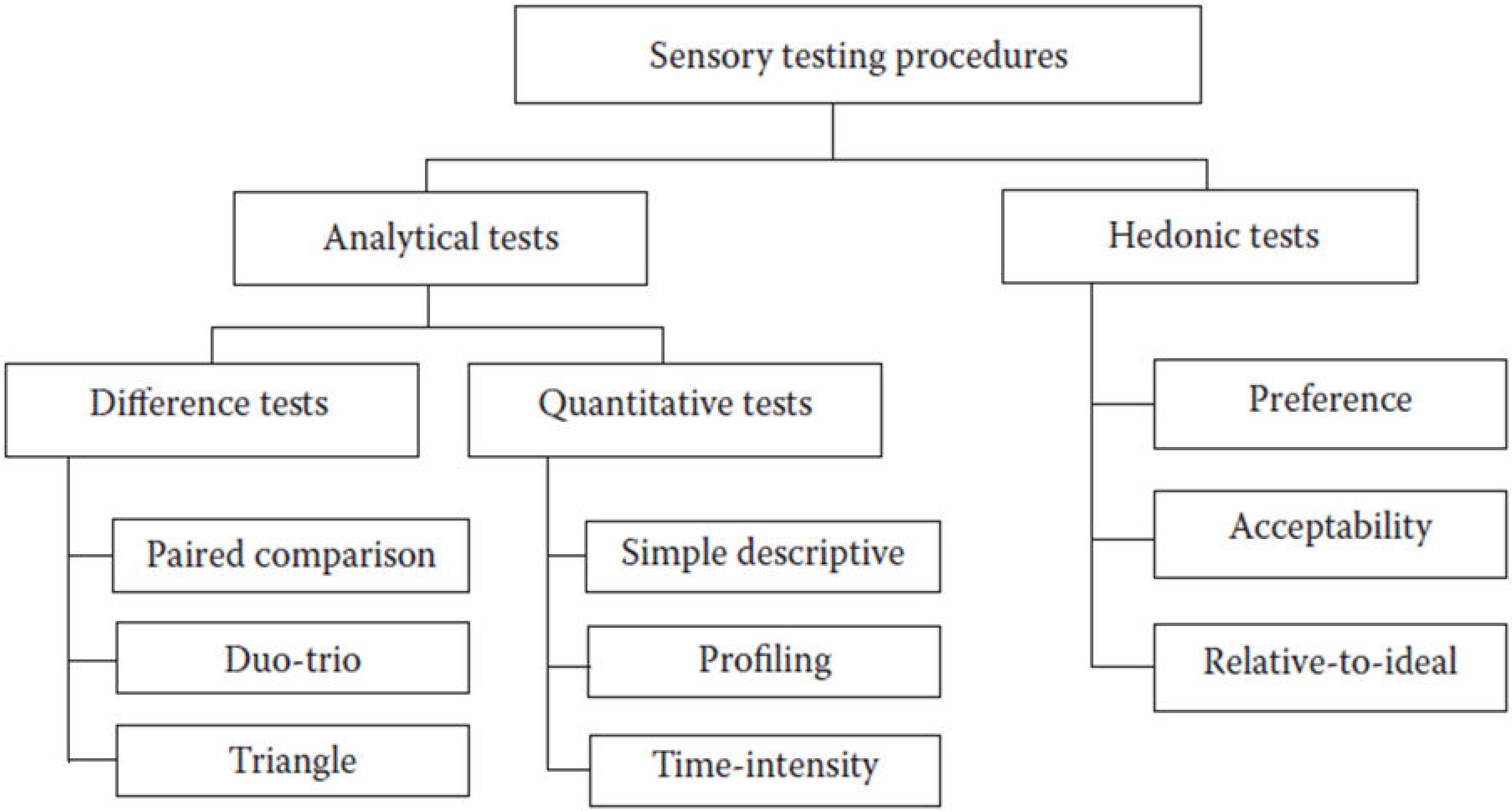
- The COP indicates the limit on an analytical sensory scale.
- Instrumental measurement beyond which acceptance by the consumer is significantly decreased.

The determination of a sensory COP is a function of the criteria selected, the test method used and sampling.
Three test methods are most commonly used:

(1) discrimination
(2) descriptive
(3) affective

- Descriptive methods are used to measure quantitative and/or qualitative characteristics of products and require specially trained panelists.

- Affective methods are used to evaluate preference, acceptance and/or opinions of products and do not require trained panelists.


Sensory testing procedures
Analytical tests
Hedonic tests
Difference tests
Quantitative tests
Paired comparison
Duo-trio
Triangle
Simple descriptive
Profiling
Time-intensity
Preference
Acceptability
Relative-to-ideal

INFLUENCE OF PACKAGING MATERIAL

The final step is to ascertain which of the critical descriptors or IoFs might be influenced by the packaging material, as packaging cannot prevent all deteriorative reactions or undesirable changes in foods.

- The IoF of a snack food was loss of crispness, then the packaging material could influence this by the extent to which it permitted the ingress of moisture.

- Different plastic films have different WVTRs thus, the shelf life obtained varies depending on the particular plastic polymer selected for a given pack size.

DETERMINING SHELF LIFE FROM THE PRODUCT SIDE

The shelf life of a food is controlled by three factors:

1. The product characteristics including formulation and processing parameters **(intrinsic factors)**

2. The properties of the package

3. The environment to which the product is exposed during distribution and storage **(extrinsic factors)**

PRODUCT CHARACTERISTICS

Perishability

Perishable foods are those that must be held at chill or freezer temperatures if they are to be kept for more than short periods. Examples include milk, meat, poultry and fish, minimally processed foods

Semi perishable foods are those that contain natural inhibitors (e.g., some cheeses, root vegetables and eggs) or those that have received some type of mild preservation treatment (e.g., pasteurization of milk, smoking of hams and pickling of vegetables) that produces greater tolerance to environmental conditions

Nonperishable

Bulk Density

The free space volume of a package (V) *is directly related to the bulk density* (ρ_b) *and the true density* (ρ_p) of the food as follows:

$$V = V_t - V_p = \frac{W}{\rho_b} - \frac{W}{\rho_p}$$

where
V_t is the total volume of the package
V_p is the volume of the product
W is the weight of the product

- While the true density of a food depends largely on its composition and cannot be changed significantly.

- The bulk density of food powders can be affected by processing and packaging.

- Some food powders (e.g., milk and coffee) are instantized by treating individual particles so that they form free-flowing agglomerates or aggregates in which there are relatively few points of contact.

- The surface of each particle is, thus, more easily wetted when the powder is rehydrated.

PACKAGE PROPERTIES

$$\frac{\delta w}{\delta t} = \frac{P}{X} A(p_1 - p_2)$$

Water Vapor Transfer

Gas and Odor Transfer

Light Transmission

Package Dimensions

Package/Product Interactions

Methods

1. **Accelerated shelf-life testing -** The food product is conditioned and stored at elevated temperature and/or humidity and the quality changes of the product are evaluated at a specific sampling rate.

- It can be two to four times faster than the real shelf life study.

Kinetic Model

Zero order kinetics –

$$t_s = \frac{A_0 - A_e}{k}$$

A_0 = initial conc

A_e = Conc of A at the end of shelf life

k = Zero order rate const

First order kinetics –

$$t_s = \frac{\ln (A_0/A_e)}{k}$$

A_0 = initial conc

A_e = Conc of A at the end of shelf life

k = First order rate const

2. Real Time shelf life testing – Food products are Stored under stated or selected conditions for longer than the expected shelf life and check at regular intervals to see when spoilage begins.

Effect of Q_{10} on shelf life

	Shelf Life (Weeks)			
Temperature (°C)	$Q_{10} = 2$	$Q_{10} = 2.5$	$Q_{10} = 3$	$Q_{10} = 5$
50	2[a]	2[a]	2[a]	2[a]
40	4	5	6	10
30	8	12.5	18	50
20	16	31.3	54	4.8 years

Source: Labuza, T.P. and Kamman, J.F., Reaction kinetics and accelerated tests simulation as a function of temperature, in: *Computer-Aided Techniques in Food Technology*, Saguy, I. (Ed.), Marcel Dekker, New York, pp. 71–115, 1983.

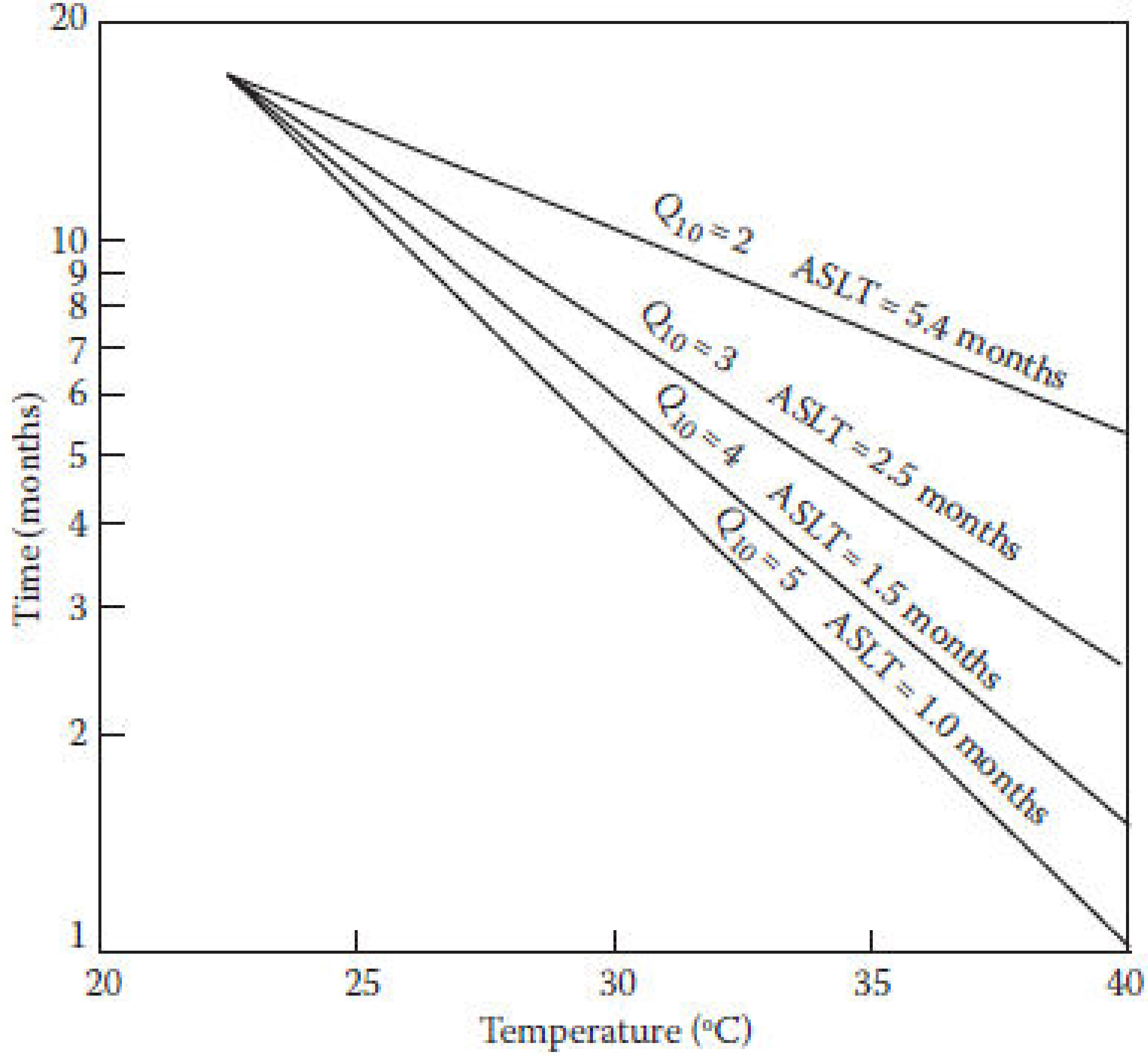
[a] Arbitrarily set at 2 weeks at 50°C. Shelf lives at lower temperatures are calculated on this arbitrary assumption.

$$Q_{10} = \frac{k_{T+10}}{k_T} = \frac{\theta_{sT}}{\theta_{sT+10}}$$

where

θ_s is the shelf life at temperature *T*°C

θ_{s+10} is the shelf life at temperature (*T*+10)° C



20
10
9
8
7
6
5
4
3
2
1
Time (months)
20
25
30
35
40
Temperature (°C)
$Q_{10} = 2$
ASLT = 5.4 months
$Q_{10} = 3$
ASLT = 2.5 months
$Q_{10} = 4$
ASLT = 1.5 months
$Q_{10} = 5$
ASLT = 1.0 months

ASLT PROCEDURES

1. Determine the microbiological safety and quality parameters for the product.

2. Select the key critical descriptor(s) or IoFs that will cause quality loss and, thus, consumer unacceptability in the food, and decide what tests (sensory and/or instrumental) should be performed on the product during the trial.

3. Select the package to be used. Often, a range of packaging materials will be tested so that the most cost-effective material can be selected.

4. Select the extrinsic factors that are to be accelerated. Typical storage temperatures used for ASLT procedures are shown in the following, and it is usually necessary to select at least two.

5. Using a plot determine how long the product must be held at each test temperature. If no Q10 values are known, then an open-ended ASLT will have to be conducted using a minimum of three test temperatures.

6. Calculate the number of samples that must be stored at each test condition, including those samples that will be held as controls.

8. Begin the ASLTs, plotting the data as they come to hand so that, if necessary, the frequency of sampling can be increased or decreased as appropriate.

9. From each test storage condition, estimate k or θ_s and construct appropriate shelf life plots from which to estimate the potential shelf life of the product under normal storage conditions. Provided that the shelf life plots indicate that the product shelf life is at least as long as that desired by the company, then the product has a chance of performing satisfactorily in the marketplace.