Shelf Life Studies

Basics – Concepts – Principles

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Shelf-life study definition

- A shelf-life study is an objective means to determine how long a product can reasonably be expected to keep, without an appreciable change in quality, safety & character

Shelf Life Factors…

- Three factors/considerations
  - Safety
  - Quality
  - Marketing (example)

Notables

- An acceptable shelf life is to allow desired sensory, chemical, functional, microbiological and physical characteristics of the product to be retained.
- These are called the “End Of Shelf life Parameters” or EOSL’s
- Tests employed to measure shelf life need to be product-specific, taking into account the ESOL’s
- Thus…The exact test procedure is unique for each product

Two Methods

- *Direct method*
- *Indirect method*

Determination of shelf life by the direct method

- Storing the product under selected conditions for a period of time longer than the expected shelf life and checking it at regular intervals to see when it begins to spoil.

- Selected conditions typical take into account the proposed processing, packaging, storage and distribution characteristics

Determination of shelf life by the indirect methods

Indirect methods predict the shelf life of a product without running a full length storage trial and are useful for products with long shelf lives.

Method Examples

	Cold Cuts	*Cookies*
Method:	Direct	Indirect
Desired Shelf Life:	21 days	12 months
Actual Test Time:	21 days	8 weeks
Temperatures:	5,10,20°C	20,30,40°C
Humidity:	20%	50% or 90%
Microbial:	aerobic yeast mold psychrophilic coliform salmonella	aerobic yeast mold
Color:	important	n/a
Texture:	important	important
Taste:	important	important
Inspection:	Daily	1-2 weeks

The two types of indirect methods

- *Accelerated shelf-life studies:* The trial period is shortened by deliberately increasing the rate of deterioration. This is usually done by increasing the storage temperature.

- *Predictive models:* Using information from a database to predict bacterial growth under defined conditions and then can be used to calculate the shelf life of a food.

Accelerated shelf-life studies:

"The Rule of Ten"

Temperature Coefficient (*Q*10)

*Q*10 is a unitless quantity.

*Q*10 is the *factor* by which the rate increases when the temperature is raised by ten degrees.

For typical chemical reactions, *Q*10 values are 2.0

Temperatures MUST be in ^{0}C or ^{0}K

The Rule of Ten

- The temperature coefficient (*Q*10) represents the factor by which the rate (*R*) of a reaction increases for every 10-degree rise in the temperature (*T*).

$$Q_{10} = \left(\frac{R_2}{R_1} \right)^{\left(\frac{10}{T_2 - T_1} \right)}$$

Example:

T_1	T_2	T_3
20°C	30°C	40°C

R_1	R_2	R_3
15	24	38

$$Q_{10} = \left(\frac{R_2}{R_1} \right)^{\left(\frac{10}{T_2 - T_1} \right)}$$

Example calculations

$$Q_{10} = \left(\frac{R_2}{R_1}\right)^{\left(\frac{10}{T_2 - T_1}\right)}$$

$Q_{10} = (24/15)^{(10/(30-20))} = 1.6^1 = 1.6$

$Q_{10} = (38/24)^{(10/(40-30))} = 1.58^1 = 1.58$

Here we find that the actual Q10 value is 1.6 not 2

How Q10 values can be applied

A (Accelerated Aging Rate) = $Q10^{((Te - Ta)/10)}$

Where... Ta = Ambient Temperature
Te = Elevated Temperature
Q10 = Reaction Rate

And...

B (Accelerated Aging Time Duration) = Desired Real Time/A

FOR EXAMPLE

If the desired expiration date of the product is one year, and the test temperature is chosen to be 55C, Q10 is 2; the AATD is determined as follows...

$A = 2^{((55-22)/10)} = 9.85$

B = 365 days/9.85 = 37.06 days

or

B = 37 days for every year of desired shelf life

How Q10 values can be applied

ACCELERATED AGING EQUIVALENCY TABLE

based on Q10 =2
ambient Temp. = 22C

DEGREES C	DEGREES F	1 YEAR SHELF LIFE EQUIVALENCY (WKS)
35	95	21.1
40	104	14.9
45	113	10.6
50	122	7.5
55	131	5.3
60	140	3.8
65	149	2.7
70	158	1.9
75	167	1.4

B = 37 days for every year of desired shelf life

Water Activity of Foods or a_w

Water activity or aw is a measurement of water content.

It is defined as the vapor pressure of water divided by that of pure water at the same temperature; therefore, pure water has a water activity of exactly one.

Free water versus bound water

- Water activity is sometimes defined as "***free***“ or "available water" in a system.
- A portion of the total water content present in a product is strongly ***bound*** to specific sites on the chemicals within the product
- Combined they are called the “moisture content”

Example

A Jar of Honey:

- Honey is very fluid and can pour from the jar, thus it has a high moisture content
- It’s very shelf stable, has a long shelf life because its water activity is very low

Why is water activity important?

- **Most microorganisms grow well at a_w between 0.91 to 0.99.**
- **Controlling non-enzymatic reactions.**
  Foods containing proteins and carbohydrates, for example, are prone to non-enzymatic browning reactions, called Maillard reactions which are rate dependant with a_w
- **Slowing down enzymatic reactions.**
  Most enzymatic reactions are slowed down at water activities below 0.8.
- **Water Activity values assist with measuring, predicting and controlling the above.**

Measuring water activity

- There is no device that can be put into a ***product*** to directly measure the water activity.
- The water activity of a product can be determined from the relative humidity of the air surrounding the sample when the air and the sample are at equilibrium.
- The sample must be in an enclosed space where this equilibrium can take place. Once this occurs, the water activity of the sample and the relative humidity of the air are equal.

Summary- we have just scratched the surface!

- Shelf life studies can be complex and need to be product specific
- Key considerations: Safety, Quality, Character (marketability)
- They ***ALL*** require detailed information about the product to establish the End Of Shelf Life parameters or EOSL's
- Direct methods are good for products with shorter shelf lives
- Indirect methods work well for products with longer shelf lives
- Q_{10} values are a great tool for accelerated studies
- Water Activity values can be a critical aspect of most shelf life studies

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- Shelf-life Modeling and Studies
- Microbial Studies
- Accelerated Aging Studies
- Chemical and Physical Analysis of food and packaging
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