Module II Scientific Principles of Shelf Life

Chapter 4. Designing Shelf Life Testing of Foods

Objectives: By the end of this module, you will have learnt

1) How to design a shelf life study?
2) What are some of the important considerations in any shelf life study?
3) What is an accelerated shelf life study?

In an industrial context, shelf life studies can be expensive and time consuming when actual storage life of a food is long. Often there is a need to determine the effect of changing product formulation and processing on shelf life of a given food. Therefore, any method that helps in reducing the testing period is advantageous. Accelerated shelf life testing (ASLT) is useful in conducting shelf life studies in a shorter time period thus minimizing the costs of such trials. The scientific basis of ASLT requires that the deterioration mechanism that causes reduction in shelf life is following some type of kinetic model. The deterioration mechanism may be caused by chemical, biochemical, physical or microbiological process. The goal of a shelf life study is to obtain reliable data regarding product stability in a short period.

4.1 Steps in Conducting a Shelf life Study

There are eight steps involved in conducting a shelf life study.

Step 1
Evaluate the microbiological safety factors for the proposed food product and process.
The first step is to ensure that proper HACCP principles have been used in manufacturing the product and the product's microbiologically safe.

Step 2
Determine attributes that may be used to describe the shelf life. This is often the most challenging aspect of shelf life testing. It requires the identification of key quality attributes that are expected to change during storage. Potential sources for such information include consumer complaints about an existing product.

Step 3
Select the package for the shelf life test. Dry products are normally stored in sealed glass containers. If the texture of the dry product is to be studied under the influence of different

humidities, then the humidity level in the sealed container may be controlled by using saturated salt solutions. Frozen, chilled, and canned products are stored in actual packages. This allows food-package system to be evaluated during the shelf life study.

Step 4

Define storage temperatures to be used in the test. The following are some recommendations,

Product Type	Test Temperature	Control
Canned	25, 30, 35, 40	4
Dehydrated	25, 30, 35, 40, 45	-18
Chilled	5, 10, 15, 20	0
Frozen	-5, -10, -15	< -40

Typically no perceptible quality changes occur at the control temperature for each category. For example, at -40 C the rate of most reactions is sufficiently slow to cause any change in the quality attributes during commercial storage time of most food products.

Step 5

Estimate testing time. Based on literature or other available information on Q_{10}, and from desired shelf life at the temperatures expected in storage and distribution, calculate testing time at each selected temperature. Where Q_{10} is defined as $Q_{10} = \frac{Rate\ of\ reaction\ at\ T^{\circ}C}{Rate\ of\ reaction\ at\ (T+10)^{\circ}C}$

When there is no information available on Q_{10}, then select a minimum of three test temperatures as a minimum.

Step 6

Next decide on the type and frequency of testing. A formula that may be used to determine the minimum frequency for testing is as follows:

$$f_2 = f_1 Q_{10}^{\Delta T/10} \quad (1)$$

As shown in Eq (1), where f_1 is the time between tests at highest test temp T_1, f_2 is the time between tests at any lower temperature T_2, ΔT is the difference between T_1 and T_2. Thus if a product is held at 40 C and tested once a month, then at 35 C (i.e. ΔT =5) and a Q_{10} =3, the food should be tested at least every 1.73 months. You should plan on obtaining at least 6 data points for each selected storage temperature. (Six points are necessary for statistical confidence in the calculated shelf life values). If Q_{10} is not accurately known, then it would require more frequent testing.

Step 7

Plot the data as it is collected. And, make necessary changes in protocol if warranted. Do not wait until all the data are collected to analyze it. From the plot, determine the reaction order to decide on the frequency of data collection. Alter the test frequency if so indicated (this is why one should not wait to the end to plot the experimental data).

Step 8

For each storage trial, determine the reaction order and rate constant, make appropriate shelf life plot and predict the shelf life at actual storage condition. Actual shelf life trial may be also done either at the storage condition (it may take too long) or at a temperature between actual condition and the accelerated condition.

4.2 Limitations of ASLT

1. Errors in analytical and sensory measurements.
2. At elevated temperatures the deteriorative reaction rate may be accelerated due to the influence of increased temperature and elevated temperature itself. For example, elevated temperature may increase the water activity of the product.
3. At too high storage temperatures, proteins may be denatured, altering the reaction mechanisms causing quality deterioration.
4. A phase change may occur at the elevated temperature changing the reaction mechanism that is not encountered in normal storage conditions.

4.3 Review Questions:

1. What are some of the advantages of using accelerated shelf life testing?

2. List three limitations of accelerated shelf life testing.

3. How can one determine frequency of testing?

4.4 References and Additional Reading:

Toukis, P.S., Labuza, T.P. and I.S.Saguy. (1997). Kinetics of food deterioration and shelf-life prediction. (Chapter 9) In *Handbook of Food Engineering Practice*, Eds Valentas, K.J. Rotstein, E., and R. P. Singh. CRC Press. Boca Raton, FL.