The Process of Conducting a Shelf Life Study

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Definition of Shelf Life

Objective means to determine the time a product can be expected to keep without appreciable change in quality, safety or character.
Why Conduct a Shelf Life Study?
What Are the Benefits?

- Confidence in having an actual calculated shelf life and not just an estimate
- Prevent recalls
- Maintain quality
- Protect brand/reputation
- Improve profitability
- Avoid expensive litigation
- Consumer safety
Food For Thought - Did You Know?

A total of 132.9 BILLION Pounds of wasted food!!
When to Conduct a Shelf Life Study

- New product launch
- Package re-design/New packaging
- Challenge the lifespan
- Collect data for validation
- Change in ingredients
- Change in supplier materials
- As part of your QA/QC Program
  - Is your current package still performing?
Product Considerations

- Safety
- Functionality
- Quality/Marketability

Something changed but product is still safe and functions (e.g., color)
End of Shelf Life Parameters

• An acceptable shelf life allows the following desired characteristics of the product to be retained:
  • Sensory
  • Chemical
  • Functional
  • Microbiological
  • Physical

• These are called “End Of Shelf Life Parameters” (EOSLs)

• Tests deployed to measure shelf life must be product-specific, taking into account EOSLs

• The exact test procedure is unique for each product
Direct Method (Real Time)

- Store under **selected conditions** for longer than the expected shelf life
- Check at regular intervals to see when spoilage begins

**Benefits:**
- No calculations
- See the effects of precise condition

**Application:**
- Products with a shorter shelf life
Indirect Method (Accelerated)

By increasing the storage temperature, the trial period is shortened and rate of deterioration is increased.

**Benefits:**
- Avoid running a full length storage trial
- See the impact of any changes much sooner

**Application:**
- Products with a longer shelf life
## Example Comparison of Direct and Indirect Test Methods

<table>
<thead>
<tr>
<th></th>
<th>Cold Cuts</th>
<th>Cookies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method:</strong></td>
<td>Direct</td>
<td>Indirect</td>
</tr>
<tr>
<td>Desired Shelf Life:</td>
<td>21 days</td>
<td>12 months</td>
</tr>
<tr>
<td>Actual Test Time:</td>
<td>12 days</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Temperatures:</td>
<td>5,10,20°C</td>
<td>20,30,40°C</td>
</tr>
<tr>
<td>Humidity:</td>
<td>20%</td>
<td>50% or 90%</td>
</tr>
<tr>
<td>Microbial:</td>
<td>Aerobic</td>
<td>Aerobic</td>
</tr>
<tr>
<td></td>
<td>Yeast</td>
<td>Yeast</td>
</tr>
<tr>
<td></td>
<td>Mold</td>
<td>Mold</td>
</tr>
<tr>
<td></td>
<td>Coliform</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Salmonella</td>
<td></td>
</tr>
<tr>
<td>Color:</td>
<td>Important</td>
<td>N/A</td>
</tr>
<tr>
<td>Texture:</td>
<td>Important</td>
<td>Important</td>
</tr>
<tr>
<td>Taste:</td>
<td>Important</td>
<td>Important</td>
</tr>
<tr>
<td>Inspection:</td>
<td>Daily</td>
<td>1-2 weeks</td>
</tr>
</tbody>
</table>
Before You Begin Testing

The following aspects must be determined
1. Determine Test Method & Duration

- Direct (Real Time) = just past expected shelf life
- Indirect (Accelerated) = Approximately $\frac{1}{4}$ of expected
Initial steps must determine the following:

- Storage condition(s)
- Testing methods & protocol
- Testing interval
- Number of samples required
2. Determine Storage Conditions

- Direct (Real Time)
  - Expected conditions
  - Worst case scenario

- Indirect (Accelerated)
  - Standard storage conditions
  - Elevated storage conditions
    - $10^\circ$ C difference
3. Determine Testing Intervals

- Direct (Real Time)
  - 8-10 data points (3-5 days)

- Indirect (Accelerated)
  - Weekly/Bi-weekly

The key is to have the failure occur within a time frame of acceptable margin of error.
4. Determine Product Samples & Protocol

This requires knowledge of:

- Commonly known parameters
- Scientific expertise of product

When combined with the Testing Interval, one can determine the number of samples needed.
The Rule of Ten \((Q_{10})\)

- \(Q_{10}\) is a unitless quantity

- \(Q_{10}\) is the **factor** by which the rate increases when the temperature is raised by ten degrees

- Temperatures **MUST** be in C or K

- **Assumption:** For typical chemical reactions, \(Q_{10}\) values are 2.0
The Rule of Ten \((Q_{10})\)

\[ Q_{10} = \left( \frac{R_2}{R_1} \right) \left( \frac{10}{T_2 - T_1} \right) \]
## Example Calculations

<table>
<thead>
<tr>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>20° C</td>
<td>30° C</td>
<td>40° C</td>
</tr>
<tr>
<td>R1</td>
<td>R2</td>
<td>R3</td>
</tr>
<tr>
<td>15</td>
<td>24</td>
<td>38</td>
</tr>
</tbody>
</table>

\[
Q_{10} = \left( \frac{R_2}{R_1} \right) \left( \frac{10}{T_2 - T_1} \right)
\]
Example Calculations

\[ Q_{10} = \left(\frac{24}{15}\right) \left(\frac{10}{30-20}\right) = 1.61 \]

\[ = 1.6 \]

\[ Q_{10} = \left(\frac{38}{24}\right) \left(\frac{10}{40-30}\right) = 1.581 \]

\[ = 1.58 \]

Here the actual \( Q_{10} \) value is \textbf{1.6} and not 2

\[ \]
How $Q_{10}$ values can be applied

**If:**

We ran a study at 20° C & 40° C and found the product that tested at 40° C expired after 8 weeks. Based upon $Q_{10} = 2$ we would calculate the shelf life at room temperature to be:

$$8 \times (2 \times 2) = 32 \text{ weeks (8 months)}$$

**But:**

With actual $Q_{10} = 1.6$ the shelf life would be:

$$8 \times (1.6 \times 1.6) = 20.48 \text{ weeks (5.2 months)}$$
Summary

• Shelf life studies can be complex and need to be product specific

• Key considerations: Safety, Quality, Character (marketability)

• **ALL** studies require detailed information about the product to establish the End Of Shelf Life parameters (EOSLs)

• Direct methods are good for products with a shorter shelf life

• Indirect methods work well for products with a longer shelf life

• $Q_{10}$ values are a great tool for accelerated studies

• Most studies require expertise in food science
A leading manufacturer of snack chips is looking to increase its product’s current shelf life from 16 weeks to 36 weeks.

- Testing will include an accelerated shelf life study to analyze packaging material changes and the impact of M.A.P. Nitrogen gas flush.

- The manufacturer supplied product samples packaged in various film structures and samples that had been nitrogen gas flushed.
Shelf Life Case Study

- The EOSL parameter for this product is moisture content.
- At a certain moisture level, the chips become tough, chewy, and have a stale taste.
- The data collected determined the rates of change for each test parameter at the accelerated conditions.
- This data was used to accurately predict the rates of change at lower storage conditions and subsequent shelf life codes were established.
Testing Proposal

Samples were stored at 25° C and 45° C with 90% - 100% RH for 5 – 6 weeks.

Test samples were pulled from storage weekly and tested for:

- Leak test upon arrival
- Water activity
- Texture
- Oxidation of fats
- Oxygen head space content
- Moisture content
- Human Sensory for taste, odor, color and appearance
$a_w$ of less than 0.9 indicates little to no danger of microbial issues
A noticeable change in texture started to occur at 2-3 weeks.
TBARs is an analysis for measuring oxidation of oils & fats - commonly perceived as rancid taste & odor.

• No significant change measured
No detrimental change which correlates well with TBARs data
When the moisture content reached 2.5%, sensory detected a loss of texture – a main EOSL parameter.
Shelf Life Case Study

To predict the end of shelf life...

• $Q_{10}$ value was determined to be 2.19 based on rates of moisture change at 45° C and 25° C

• Texture measurements and sensory evaluation indicate that end of shelf life is reached at a moisture level of 2.5%. At this moisture level the chips were tough, chewy, and had a stale taste

• Based on this end of shelf life parameter, the predicted shelf life at 25° C (ambient) was calculated and is shown in Table 1
The calculation...

3.4 weeks x 2.19 x 2.19 = 16.31 weeks

3.4 weeks is the time at 45° C that it took to reach EOSL. We multiplied the weeks by the $Q_{10}$ twice, once for each 10° change in temperature.
## Shelf Life Case Study – Table 1

<table>
<thead>
<tr>
<th>Film Type</th>
<th>Shelf life (wks.) at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Clear Film</td>
<td>16.3</td>
</tr>
<tr>
<td>B) NON MAP</td>
<td>64.6</td>
</tr>
<tr>
<td>B) MAP</td>
<td>86.0</td>
</tr>
</tbody>
</table>
Case Study Conclusions

• A leading manufacturer of snack chips wants to increase its current shelf life from 16 weeks to 36 weeks.

  We calculated actual current shelf life to be 16.3 weeks.

  Through further in-depth testing, film changes and using M.A.P. gas flushing we were able to greatly increase the shelf life of 16.3 weeks to reach their goal of 36 weeks!

• The EOSL parameter for this product is moisture content. At a certain moisture level the chips become tough, chewy, and have a stale taste.

  We confirmed this to be true. Through various tests they found ways to keep out moisture and keep the moisture levels consistent over the length of the products lifetime.
Ensuring Consistent Quality

Now that you have spent the time to determine the correct shelf life of your product, how do you ensure its consistency?

- Through a strict Quality Control and Assurance Program of continued testing of key products, package and process parameters.
Thank you for attending!

Please visit www.mocon.com for more educational resources