Experimental Design Matrix

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>FOOD SAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed Oil</td>
<td>Cheerios</td>
</tr>
<tr>
<td>Cheerios</td>
<td>Peanuts</td>
</tr>
<tr>
<td>Peanuts</td>
<td>Cottonseed Oil</td>
</tr>
</tbody>
</table>

Storage:
- 3 variables-
  - High temperature during heat sealing
  - Stress cracking from folds in the films caused by vacuum packing
  - Relative humidity during storage

Analyses:
- *Free Fatty Acid
- *Peroxide Value
- *Moisture
- *Sensory
- *Hexanal

Rate of Analysis = Full testing once every 3 months for 18 months, then quantitative analyses only through 36 months.

PURPOSE
- Evaluate new high barrier food packaging films for use on long duration space missions.
- Determine the effects of:
  - High temperatures during heat sealing
  - Stress cracking from folds in the films caused by vacuum packing
  - Relative humidity during storage

Deliverables
- Quantitatively evaluate each packaging material after final processing for oxygen and water vapor transmission through analyses of ingredients susceptible to moisture uptake and lipid oxidation.
- Qualitatively determine changes in food product attributes through sensory evaluation methods after storage in 3 different packaging films.
- Evaluate the potential of each packaging material based on qualitative and quantitative results.

Food Sample Selection
- Dry cereal is prone to reduced quality from absorption of water vapor.
- Cottonseed oil is susceptible to lipid oxidation in the presence of oxygen.
- Peanuts produce a rancidity marker, hexanal, which can be quantified by analysis of the gas in the headspace of the package.

Permeation Rate Comparison
- The table below shows the oxygen transmission rate (OTR) and water vapor transmission rate (WVTR) for each packaging material.
- Glass and aluminum have the best available barrier properties for food packaging purposes.
- Temperature and relative humidity may have an effect on the permeation rate of a packaging film.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>OTR @ 73°F &amp; 100% RH (grams/100in²/day)</th>
<th>WVTR @ 100°F &amp; 100% RH (grams/100in²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>&lt;0.0003</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>Aluminum</td>
<td>&lt;0.0003</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>Tolas</td>
<td>&lt;0.0003</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>Technipaq</td>
<td>0.35</td>
<td>25</td>
</tr>
<tr>
<td>Combitherm</td>
<td>5.40</td>
<td>5</td>
</tr>
</tbody>
</table>

Packaging Material Information

**Combitherm Film**
- Structure: Nylon/EVOH/Nylon/High Ethylene Vinyl Acetate Polyethylene/LLDPE
- PROS: Lightweight and transparent. Microwaveable and can be incinerated.
- CONS: Requires an overwrap film due to poor barrier properties. Overwrap causes a major increase in mass for food system.

**Technipaq Film**
- Structure: A quadlaminate film. PET/Polyethylene/Aluminum/lonomer
- PROS: Best barrier properties available in a film.
- CONS: Film cannot be incinerated or microwaved due to aluminum layer. Film is not clear to allow for food identification.

**Tolas Film**
- Structure: A PET film coated with a thin layer of aluminum oxide.
- PROS: Very lightweight with excellent barrier properties. Transparent film. Microwaveable and can be incinerated.
- CONS: Stress cracking caused by wrinkles during vacuum packing may reduce the barrier properties.

**Cheerios**
- Tolas (AlOX Coated Film)
- Technipaq Film

**Peanuts in Combitherm**
- Oil in Combitherm