Thermostabilized Shelf Life Study

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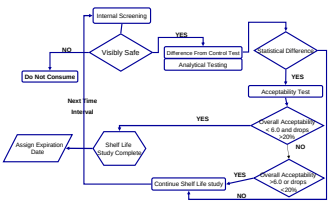
ABSTRACT

- The objective of this project is to determine the shelf life end-point of various food items by means of actual measurement or mathematical projection
- The primary goal of the Advanced Food Technology Project in these long duration exploratory missions is to provide the crew with a palatable, nutritious and safe food system while minimizing volume, mass, and waste
- The Mars missions could be as long as 2.5 years with the potential of the food being positioned prior to the crew arrival. Therefore, it is anticipated that foods that are used during the Mars missions will require a 5 year shelf life
- Shelf life criteria are safety, nutrition, and acceptability. Any of these criteria can be the limiting factor in determining the food's shelf life
- Due to the heat sterilization process used for the thermostabilized food items, safety will be preserved as long as the integrity of the package is maintained
  - Nutrition and acceptability will change over time. Since the food can be the sole source of nutrition to the crew, a significant loss in nutrition may determine when the shelf life endpoint has occurred
  - Shelf life can be defined when the food item is no longer acceptable. Acceptability can be defined in terms of appearance, flavor, texture, or aroma
- **Results from shelf life studies of the thermostabilized food items suggest that the shelf life of the foods range from 0 months to 8 years, depending on formulation**

MATERIALS AND METHODS

- Products stored at three temperatures – 40ºF, 72ºF and 95ºF for an accelerated shelf life test
- Products are evaluated for baseline within 3 weeks of production
- Evaluations are every four months for the first 2 years and every 6 months for the 3rd year
- Sensory testing includes difference from control testing and overall acceptance testing
- Analytical tests can include texture, color, moisture, and water activity determination



SHELF LIFE CALCULATIONS

- Shelf life will be determined by
  - Identify the quality attribute, such as color, flavor, or texture, that will determine the shelf life
  - Determine the Q_{10} for the product based on quality changes for the three temperatures
- The Q_{10} is a measure of how the rate of a reaction changes for every 10ºC change in temperature.
- The Q10 provides a prediction of shelf life at different temperatures.

$$\frac{\text{Shelf life at temperature T°C}}{\text{Shelf life at temperature (T°C + 10)}}$$

Preservation Method	Typical Q_{10} Values
Thermally Processed	1 – 4
Dehydrated	2 – 10
Frozen	3 – 40

Testing is still in progress for three vegetable products, one fruit, and one starch item. Testing will be completed in November 2008.

RESULTS AND DISCUSSION

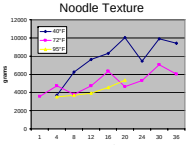
Entrées (Pork Chops, Tuna Noodle Casserole)

Meats in general
- Texture is the most altered quality attribute due to denaturation of the muscle proteins and the migration of free water, cross-linking of proteins and reduced protein solubility contribute to the toughness of meat
- Fatty fishes and pork, with higher unsaturated lipid content are more susceptible to oxidation

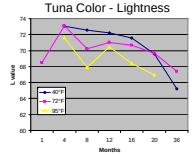
Grilled Pork Chops
- Vitamin B1 levels showed losses at higher storage temperatures
- Dryness of the product was cited as a reason for product failure
- **Shelf life projected to be 87 months at 72ºF**

Tuna Noodle Casserole
- Product failure was attributed to declining scores for hardening of noodles and darkening of color during the 36 month study
- Vitamin B6, folic acid and pantothenic acid showed linear decline as the holding temperature increased
- **Shelf life projected to be 49 months at 72ºF**

Noodle Texture



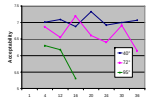
Tuna Color - Lightness



RESULTS AND DISCUSSION

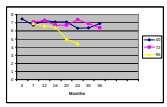
Fruits (Apricot Cobbler)

- Aroma is constituted by the presence of volatiles and by sweetness, acidity and the astringency contributed by the phenolics
- Vitamin C demonstrated a clear linear decline with time and temperature. At baseline, the content was 179 mg/100g After 36 months storage at 72F, the content was 4.87 mg/100g
- **Shelf life projected to be 65 months at 72F**



Sweets (Bread Pudding)

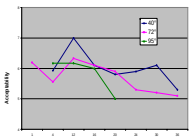
- High sugar items tend to have longer shelf lives
- Vitamins A, B1 and B12 demonstrated a linear decline with temperature
- The overall flavor, level of sweetness, level of vanilla, and overall aftertaste showed a decline likely due to the Maillard Browning reactions. The three most prevalent ingredients; skim milk, sugar and egg, would provide sufficient amounts of free amino groups and reducing sugar to allow for condensation reactions to occur
- **Shelf life projected to be 4 years at 72ºF**



	40F	72F	95F
Vitamin A	157	123	100
Vitamin B1	0.16	0.10	0.06
Vitamin B12	0.32	0.12	0.12

Vegetables (Carrot Coins)

- Gradual decreases in all related color values for all temperatures over the storage period, yellow in particular.
- Overall acceptance score for carrot coins declined gradually over the storage period with the comments as "too mushy"
- **Shelf life projected to be 48 months at 72ºF**



Eggs (Broccoli Soufflé, Vegetable Omelet)

It is difficult to product a thermostabilized egg product due to sugar-amino reaction produces dark pigments, decreasing the nutritive value of the proteins and resulting in a hardening of the texture

- **Both products were unacceptable shortly after production indicating a shelf life of 0 months**
- Testing was conducted to analytical data to try to better understand where the deterioration happens

Vegetable omelet
- Sensory panel did not find the 0 month (baseline) product to be acceptable, due to rubbery texture and brown color. Color continued to darken over time but the texture did not change
- Vitamins E, B1, B6, pantothenic acid and folic acid demonstrate a clear linear decline with time and temperature

Broccoli Soufflé
- Sensory testing shortly after production yielded an overall acceptance score below the established acceptance level
- Overall darkening of product color over time and a decreased in green color for samples held at 95°F and 72°F

Bulk Ingredients - Cocoa Powder, Dried Egg Whites, Corn Starch

All three products maintained their functionality over the three year test suggesting that the shelf life is at least 8 years

Corn Starch
- Starch can contribute to texture, viscosity, gel formation, adhesion, binding, moisture retention and film formation
- There was a big increase in yellow hues for all three temperatures (40°F, 72°F, 95°F)
- Thickening did not change throughout the test

Cocoa powder
- A noticeable change, darker and less yellow, was detected at 36 months in color for all cocoa powders regardless of storage temperatures
- The cocoa powder held at 95° F had a stronger cocoa flavor than that of cocoa powder held at 40°F and 72°F

Dried Egg Whites
- There was little color changes of color regardless of storage temperature and time
- Overall the foam stability increased over time regardless of storage temperatures

CONCLUSIONS

- Shelf life is determined by safety, acceptability, and nutritional content
  - Safety is not an issue due to the processing
  - Acceptability is dependant on formulation and processing conditions
  - Nutrition is lost over time
- Sugar can protect the food from degradation
- Formulations that contain whole eggs at a significant level do not provide acceptable products using the current thermostabilization process
- Fruit products tend to brown over time. The Maillard Browning reaction affects color and flavor
- The current thermostabilization process will not provide a 5 year shelf life for all formulations
- The emerging technologies of high pressure processing and microwave sterilization appear to result in higher quality products and should be investigated further

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