NASA, We Have a Challenge and It's Food Packaging

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The Current Space Food System

Refrigerators and freezers not available to maintain food safety and quality

Natural Form Foods

Rehydratable Foods

Intermediate Moisture Foods

Beverages

Irradiated & Thermo-stabilized Foods

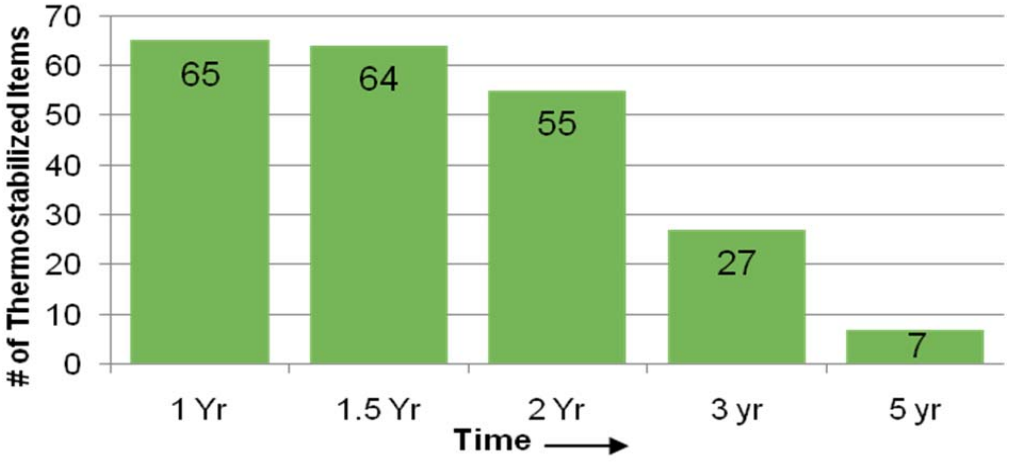
Not pictured: Extended shelf-life breads and fresh food (limited basis)

Overview of Hypothetical Mars Expedition

- Approximately 2.5 year mission
  - Earth-to-Mars transit: ~6 months
  - Mars surface stay: ~18 months
  - Mars-to-Earth transit: ~6 months
- A 5-yr shelf life requirement is expected
  - Food prepositioning may be required to accommodate high mass and volume of food
  - Production and stowage will take time due to volume
- The current food system would become unacceptable before the mission ended
  - No refrigerators or freezers available for food preservation

Nutrition and Acceptability Impacts of Room Temperature Storage

- Only 7 out of 65 thermostabilized foods are expected to be palatable after 5 years of storage. Limited data on nutritional content is available.
  - **Salmon in Pouch**
  - **Tuna in Pouch**
  - Meatloaf
  - Chicken Fajitas
  - Grilled Pork Chop
  - Chicken with Peanut Sauce
  - Fiesta Chicken



Catauro et al. JFS 2011

Omega-3 Fatty Acid Content in NASA Foods

- Currently, NASA food list does not contain many food items high in omega-3 fatty acids
  - Commercial items – Tuna and Salmon in a pouch
    - Initial content of omega-3 fatty acids in salmon contains the full recommended daily intake
  - Freeze-dried Shrimp Cocktail – minor amounts
  - ALA content in some non-seafood products
- ALA, EPA and DHA are being measured during a shelf life study (ambient and 35C)
- New fish-based food items are being developed to increase omega-3 fatty acid content in astronauts' diets

Prepackaged Food – 5 Year Shelf Life Challenge

Processing

Pressure Assisted Thermal Sterilization (PATS)
and
Microwave Assisted Thermal Sterilization (MATS)

Packaging

Materials to improve clarity and barrier with less mass

Formulation

Increase stability of nutrients

Environment

21°C storage | -80°C storage

Temperature
Radiation
Oxygen content (atmosphere)

It's a Balancing Act

OBJECTIVES ARE AT ODDS

For example, may require more packaging mass to protect food from moisture and oxygen and meet required food system shelf life

The Food Packaging Material Used Contributes to the Shelf Life of the Food

- Shelf life of foods is determined by:
  - Bacterial growth – e.g., spoilage, pathogens
  - Nutritional degradation – e.g., loss of vitamins
  - Quality degradation – e.g., sensory qualities
- Packaging can:
  - Prevent contamination by microorganisms
  - Protect food from physical hazards
  - Control transmission of oxygen and water from outside environment into food
    - Nutrient, flavor, and aroma changes through oxidative reactions
    - Texture and color changes due to increase water content

Current Packaging

- Thermostabilized (Retort) and Irradiated foods
  - Fabricated from a quad-laminate of polyolefin/aluminum foil/polyamide/polyester
  - MRE Pouch
- Beverage pouch
  - Trilaminate of polyester/aluminum foil/polyethylene
  - Septum
    - Septum adapter is fabricated from low-density polyethylene
    - Septum is fabricated from silicone rubber is sealed in the adapter with a disk fabricated from a laminate of polyester/aluminum foil/polyethylene

Current Packaging

- Freeze Dried Foods Packaging
  - The thermoformed base is fabricated from Combitherm PAXX230 [a coextrusion of nylon/medium-density polyethylene (MDPE)/nylon/ethylene-vinyl alcohol (EVOH)/nylon/MDPE/linear low-density polyethylene (LLDPE)].
  - The lid is fabricated from Combitherm PAXX115 (a coextrusion of nylon/EVOH/nylon/LF adhesive/HV polyethylene/LLDPE)
- Natural form (Bite size) foods
  - The bite-size food package is fabricated from Combitherm PAXX115, a coextrusion of nylon/EVOH/nylon/LF adhesive/HV polyethylene/LLDPE.
- Overwrap
  - Packages are wrapped in a white pouch, .003-mm thick, fabricated from a laminate of polyester/polyethylene/aluminum foil/Surlyn®. This overwrap is removed before the food is prepared and heated.

NASA Packaging Technical Requirements

- Requirements
  - High barrier packaging – low oxygen and water vapor transmission rates
  - No aluminum layer
  - Mass - $\leq$145 grams per m^2
  - Flexible
  - Puncture resistant
  - Approved for food use
  - Amenable to sterilization
  - Able to be heat sealed
- Preferred (not required)
  - Transparent
  - Retortable, microwavable, high pressure use

10 Year Effort to Improve Food Packaging

- Small Business Innovative Research Program – 7 years
  - 8 Phase I contracts
  - 4 Phase II contracts
- Two workshops to bring together food packaging experts
- Three internal research tasks
- Public Outreach – average of 3 presentations/yr. for 8 years describing NASA's challenges
- Department of Defense Collaboration – Combat Feeding Program

No significant improvement in food packaging capabilities after these efforts

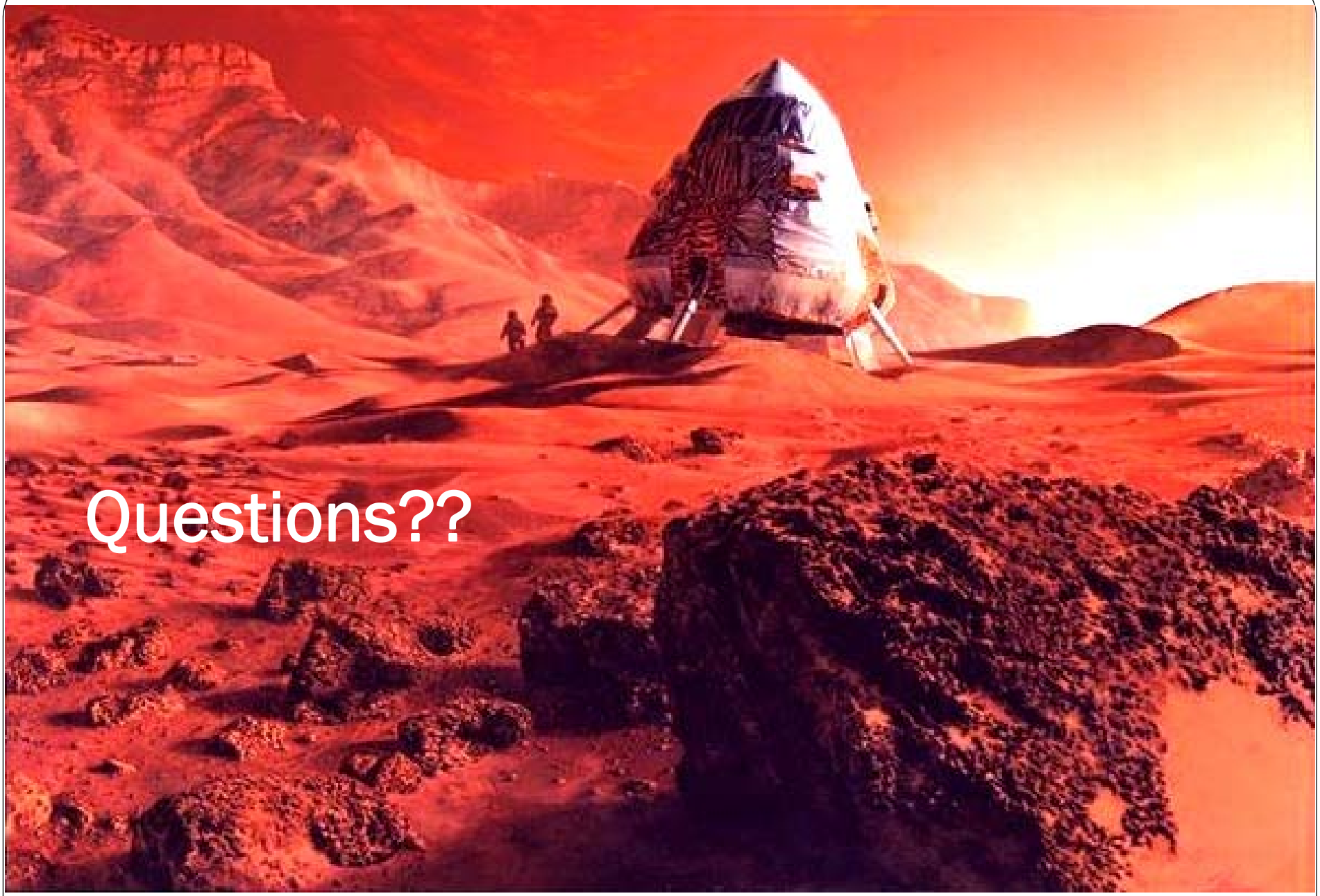
Innovation Techniques

- It was unlikely that a food packaging solution could be found within the food science community
  - There was a need to go outside to other industries such as pharmaceutical or electrical
  - Although a positive result was preferred, a negative result would also be useful
- Two Innovation Techniques were used as a comparison
  - InnoCentive – Theoretical Challenge to identify new technologies
  - Yet2.com – A matchmaker between NASA and commercial packaging manufacturers

NASA JSC Challenges Summary

Challenge Partner	Challenge Type / Award	Posted / Deadline	Final Numbers	Challenge Status
InnoCentive	Theoretical-IP / $15,000	December 18, 2009 / February 28, 2010	-174 Project Rooms from 33 Countries -22 Submissions from 10 Countries *16 for Evaluation*	A partial solution was awarded and material is being evaluated.
Yet2.com	Matching of commercial company and Technical Need Owner	July 2010/ October 2010	23 investigated; 5 researched; *2 for Evaluation*	Materials are being evaluated.

Conclusion: Both InnoCentive and Yet2.com provided good results. It really depends on what your required final outcome is and the state of the art of the technologies required.


Questions??