The Challenges of Developing a Food System for Space Exploration

Grace Douglas, Ph.D.

February 10, 2014

Food System Considerations

International Space Station:

- 6 month microgravity missions
- No refrigerators or freezers for food storage, all food processed and prepackaged
- Regularly scheduled resupply
- Eight day standard menu cycle augmented by crew preference foods

Mars Expedition Scenario:

- 2.5 year mission; microgravity and reduced gravity
- No refrigerators or freezers for food storage
- No resupply; food may be prepositioned to accommodate high mass and volume
- Current food system is mass constraining and will not maintain nutrition/acceptability

AFT Research Strategy

Mitigate the **Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System** during all mission phases

AFT1 - Knowledge Gap
We need to determine how processing and storage affect the nutritional content of the food system.

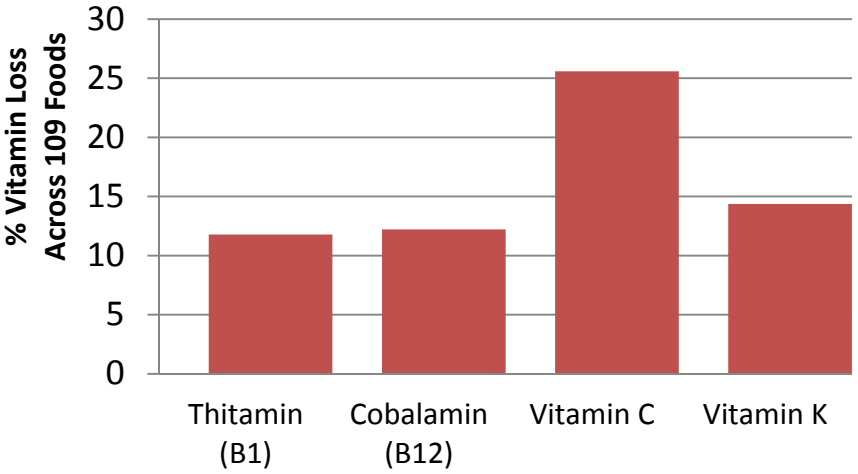
AFT3 - Knowledge Gap
We need to determine how the sensory and psychosocial acceptability of the food system changes due to microgravity, processing, storage, choice, and eating environment.

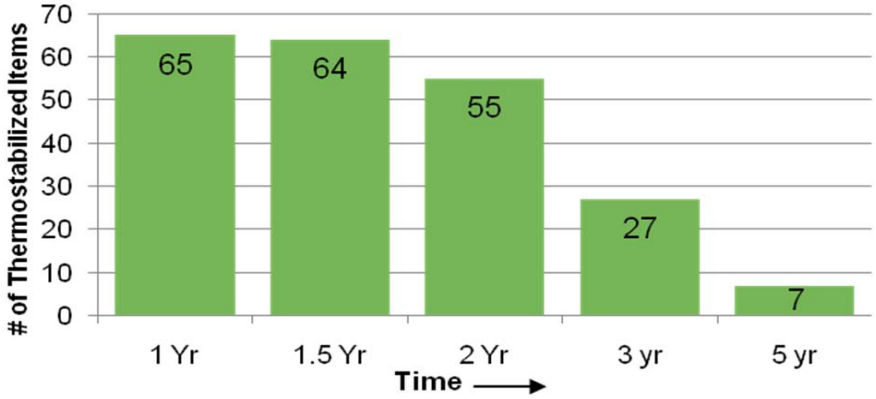
AFT4 - Mitigation Gap
We need to identify the methods, technologies, and requirements that will deliver a food system that provides adequate safety, nutrition, and acceptability for proposed long-duration Design Reference Mission operations.

AFT5 - Disposition Gap
We need to identify tools or methods that can be used or developed to help mission planners and vehicle developers determine the most effective combination of methods, technologies, and requirements to balance crew food system needs with vehicle resources.

Nutrition and Acceptability Impacts of Room Temperature Storage

- Critical micronutrients show concerning degradation in space food system after 1 year of storage.
- Only 7 out of 65 thermostabilized foods are expected to be palatable after 5 years of storage. (Catauro. JFS. 2011)
- Current mass requirement for 3000 kcal per crewmember per day is 1.83 kg. Total mass for a Mars scenario (6 crewmembers, 1095 days) is 12,023 kg.





Prepackaged Food – 5 Year Shelf Life Challenge

Focus on nutritional stability, acceptability, health promotion, and mass reduction

Processing

Pressure Assisted Thermal Sterilization (PATS)

Lyophilization Improvement

Microwave Sterilization

3D Printing Technology (SBIR)

Packaging

Improve clarity

Improve barrier

Mass reduction

Formulation

Fortification

Food Matrix

Functional Foods

Meal Replacement

Environment

Atmosphere

Temperature

Radiation

Integrate Bioregenerative Foods

- ISS: Supplement prepackaged with “Pick and Eat” in microgravity transit
- Mars Scenario: Optimize mission specific phased implementation and balance with prepackaged foods – based on nutrition, acceptability, resources
- Benefits: initial food upmass, nutrition, variety, acceptability, psychosocial
- Research gaps: infrastructure, resource use, radiation effects, safe handling/micro procedures, system integration, crew time usage

Completed AFT Projects FY12-13

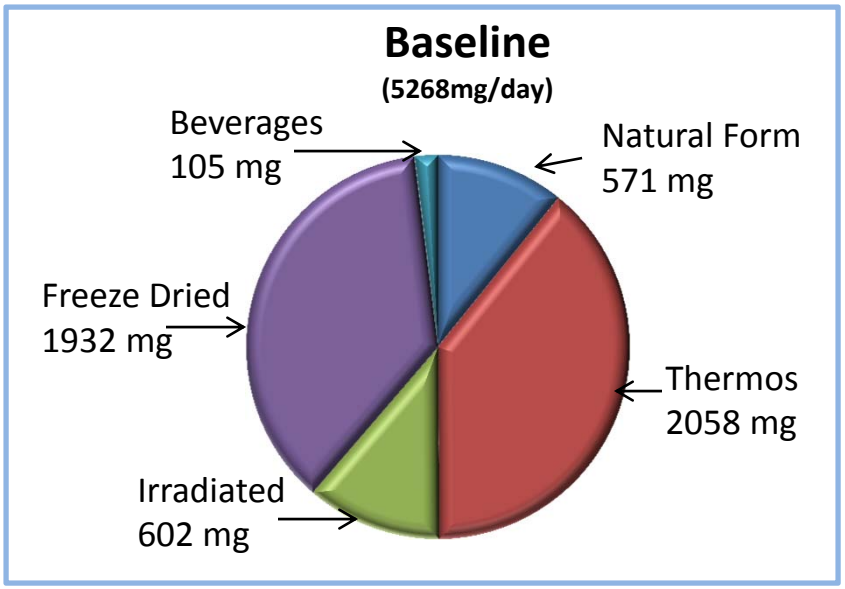
- <u>Food Processing vs. Packaged Food Study</u>
  Analyzed mass and crew time trades for bioregenerative food system compared to prepackaged; developed 90 formulations from 15 crops and 11 ingredients

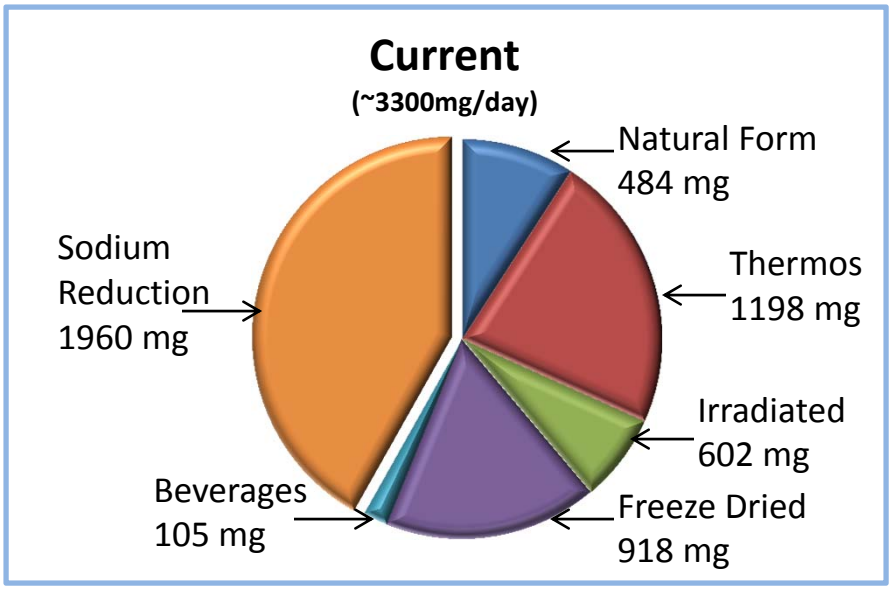
- <u>Mass Reduction Technology Development</u>
  Developed meal replacement bar and beverage prototypes with significant mass reduction capability

- <u>Suited Contingency Ops Food - 2</u>
  Developed delivery system prototype, both package and beverage requirements

Space Food System
Sodium Reduction Challenge

- Sodium exacerbates bone loss, possible factor in intracranial induced vision changes
- Reformulated 90 foods and reduced sodium content to ~3300 mg/d
- Maintained sensory acceptability similar to or better than original formulations (score of 6.0 or greater on a 9.0 point hedonic scale.





Acknowledgments

- Maya Cooper
- Monica Leong
- John Glass
- Vickie Kloeris
- Donna Nabors
- Kimberly Glaus-Late
- Michele Perchonok, Ph.D. (former AFT Project Scientist)

Questions