Development and Analysis of Food Provisioning Strategies for Long Duration Missions

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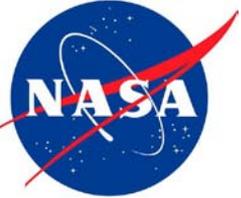
Overview

Food Provisioning Strategies

➢ Prepackaged food system

➢ A bioregenerative food system or combination bioregenerative/prepackaged food system

➢ High density meal replacement bars and beverages
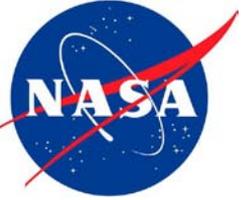
Nutritional Status of Prepackaged Food

Objective: Determine the nutritional adequacy of the current NASA prepackaged food system by measuring the change in 24 vitamins and minerals in each food following storage at 72°F for 1 month, 1 year, and 3 years post-processing.

Estimate vs. Actual Nutrition


Menu Landscape Based on Analyzed Nutrient Values
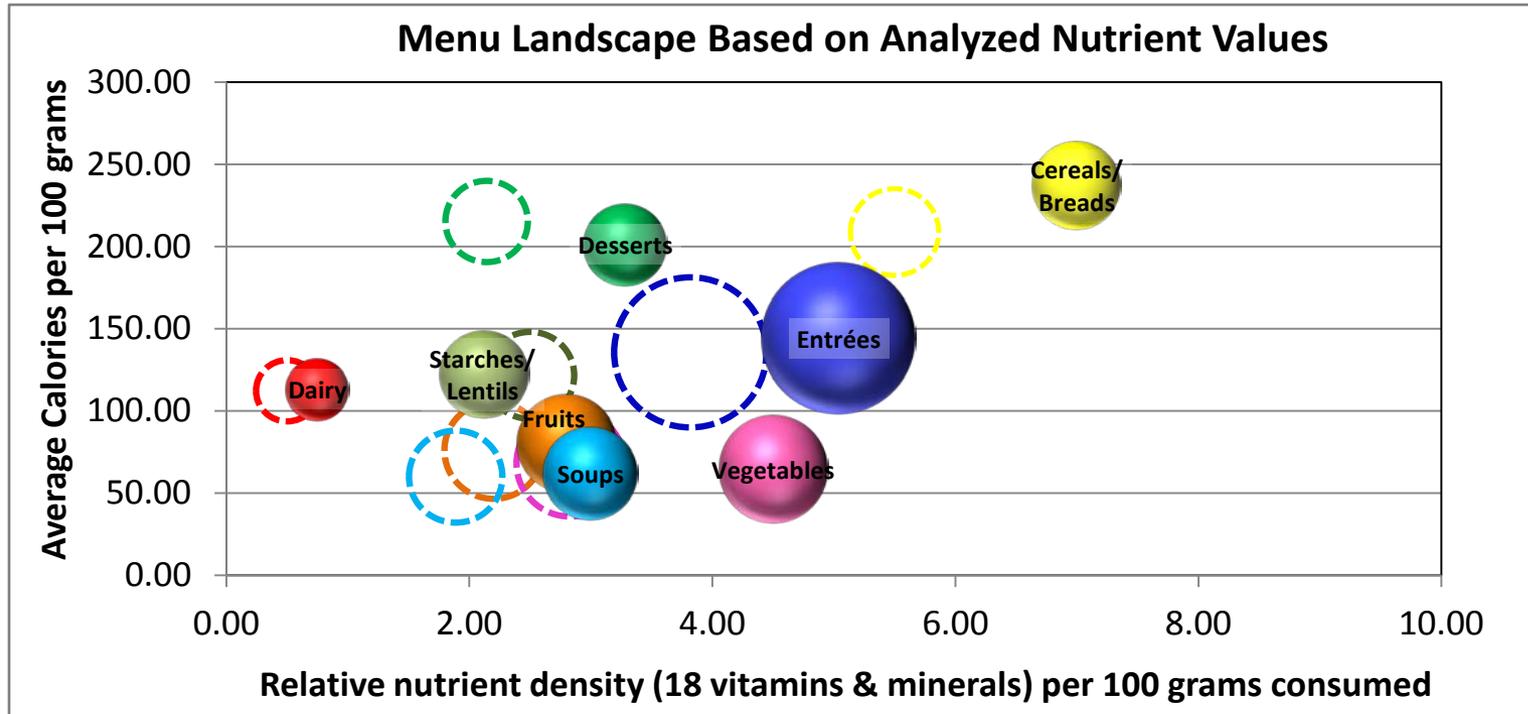
- ➤ Estimated nutritional content (dotted circles) compared to empirical one-month post-processing (solid circles, same color) for 87 NASA foods.
- ➤ Differences are attributed to ingredient source and changes in hydration level of freeze dried foods.

Preliminary Results: Nutrients of Concern

> Degradation of Vitamin A, C, and folic acid is significant in several foods.

> Thiamin content is low in most foods with the exception of bread products.

> Specific food matrices and some forms of vitamins used for fortification seem more stable.

> Degradation of each nutrient generally continued similarly to what was observed after one year.

Vitamin C content of subset of foods measured 1 month, 1 year, and 3 years post-processing.
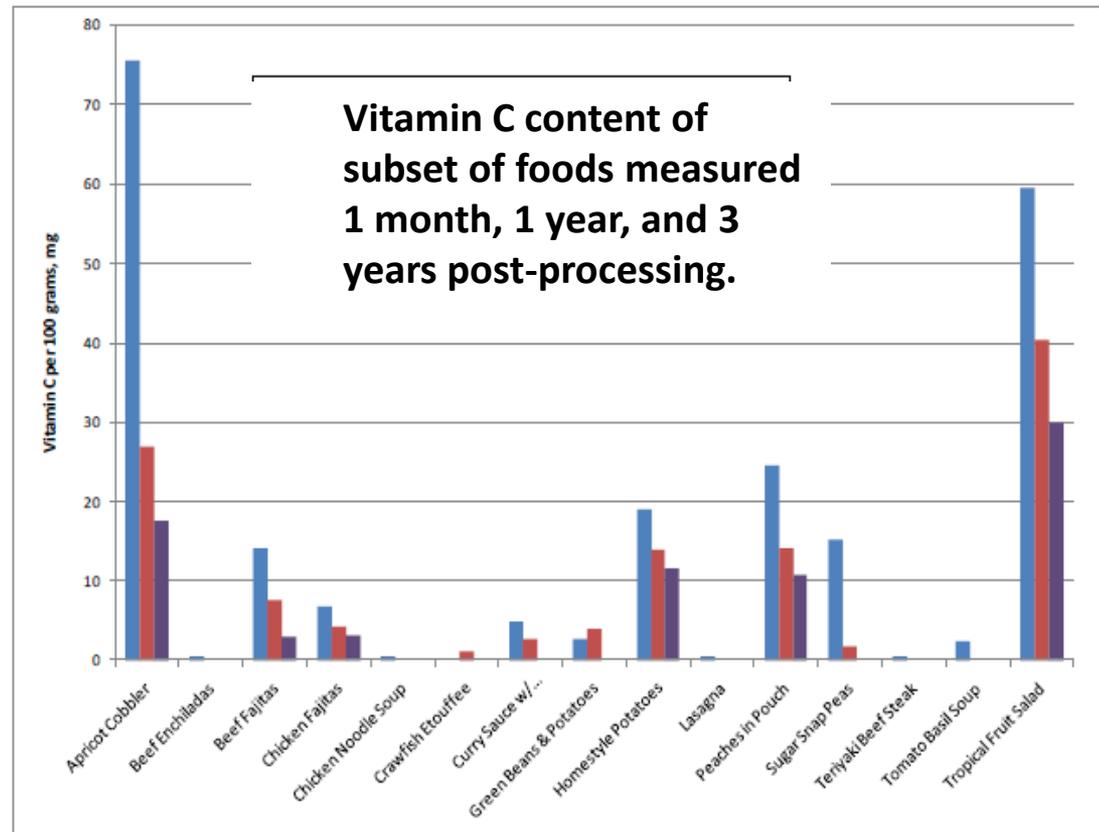
Processing vs. Prepackaged Food System

Objective: Compare the efficiencies and adequacies of growing produce and processing baseline crops into edible ingredients as compared to the efficiencies and adequacies of utilizing the existing prepackaged food system.

Processing vs. Prepackaged Food System

**Bioregenerative &
Bulk Ingredients Only**

**Bioregenerative &
Packaged Combo**
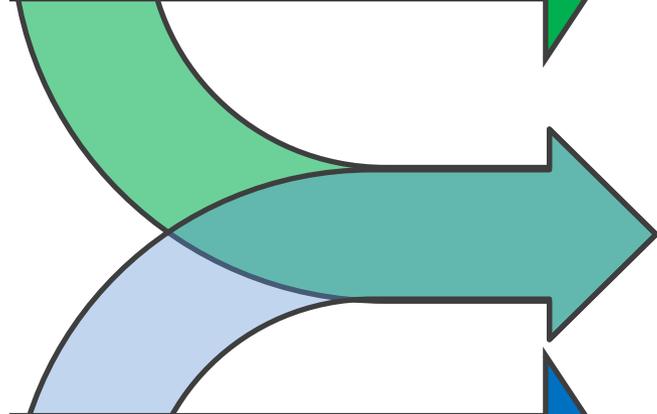
**Packaged Foods
Only**

Key Assumptions

15 different crops (including soybeans and tomatoes) and 11 bulk ingredients plus minors are used in menu development and analysis.

Only existing products with a shelf life > 3 years are used to supplement the above bioregenerative menu.

Frozen and refrigerated storage are presumed to deliver feasible food shelf life.

Food System Resource Use

Food System	Edible Crop (kg)	Ship (kg)	Active Crew Time (min/day)
Farm edible, grow wheat/rice/beans/peanuts	12058.2	2041.3	450
Farm edible, ship wheat flour/rice/beans/peanut oil	7651.3	4854.4	
Farm with prepackaged food and resupply	9650.5	3103.0	379
Farm, bulk, prepackaged, and resupply	6266.0	5271.5	
Prepackaged food only	0	10765	30

Bioregenerative

Lower Stowage Mass
Agri-Therapy
Higher Nutrient Density
Fresher Food
Food Variety / Customization

Shipped from Earth

Less Habitat Infrastructure
Lower Power Requirements
Sterile Food Supply
Less Crew Time
No Risk of Food Scarcity
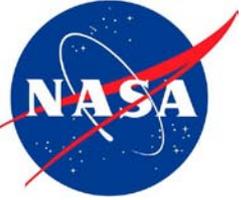
Mass Reduction

Objective: Develop meal replacement bar and beverage prototypes that meet nutrition and acceptability requirements and reduce the mass and volume of the food system.

- ➤ Commercially available products do not contain the appropriate caloric density and nutritional content necessary for a direct meal replacement.
- ➤ Meal replacement prototypes will be specific for breakfast and lunch.
- ➤ A categorical bar and beverage prototype will be developed to supplement storage labile nutrients.

Conclusions and ongoing work

➢ Several key nutrients show significant degradation in the NASA food items that have currently been evaluated. The nutrition of each food must be measured through the 3 year time point before the adequacy of the current prepackaged food system can be determined or countermeasures can be developed to enable use for long duration missions.

➢ The processing vs. prepackaged trade study shows a significant savings in shipped mass with the use of a bioregenerative system and a significant savings in crew time with a prepackaged system. Both systems require further analysis including packaging, nutrition, and acceptability before a final recommendation can be made.

➢ No commercial bars or beverages have been identified that meet NASA's nutritional requirements. Specific guidelines are currently being determined for a breakfast, lunch, and categorical meal replacement bar or beverage prior to development of prototypes.

Acknowledgments

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