Food Mass Reduction Trade Study

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ABSTRACT

Future long duration manned space flights beyond low earth orbit will require the food system to remain safe, acceptable, and nutritious while efficiently balancing appropriate vehicle resources such as mass, volume, power, water, and crewtime. Often, this presents a challenge since maintaining the quality of the food system can result in a higher mass and volume.

The Orion vehicle is significantly smaller than the Shuttle vehicle and the International Space Station and the mass and volume available for food is limited. Therefore, the food team has been challenged to reduce the mass of the packaged food from 1.82 kg per person per day to 1.14 kg per person per day. Past work has concentrated on how to reduce the mass of the packaging which contributes to about 15% of the total mass of the packaged food system. Designers have also focused on integrating and optimizing the Orion galley equipment as a system to reduce mass. To date, there has not been a significant effort to determine how to reduce the food itself.

The objective of this project is to determine how the mass and volume of the packaged food can be reduced while maintaining caloric and hydration requirements.

The following tasks are the key elements to this project:

•Conduct further analysis of the ISS Standard Menu to determine moisture, protein, carbohydrate, and fat levels.
•Conduct trade studies to determine how to bring the mass of the food system down. Trade studies may include removing the water of the total food system and/or increasing the fat content.
•Determine the preferred method for delivery of the new food (e.g. bars, or beverages) and the degree of replacement.
•Determine whether there are commercially available products that meet the requirements.

By the end of this study, an estimate of the mass and volume savings will be provided to the Constellation Program. In addition, if new technologies need to be developed to achieve the mass savings, the technologies, timeline, and budget will be identified at the end of the project.

JUSTIFICATION

The National Aeronautics and Space Administration (NASA) is working towards future long duration manned space flights to the Lunar surface by 2020 and to the Mars surface within the next 20 years. The primary goal of the Advanced Food Technology Project (AFT) is to develop requirements and technologies that will enable NASA to provide the crew with a safe, nutritious and acceptable food system while efficiently balancing appropriate vehicle resources such as mass, volume, power and crewtime in exploratory missions. The Inadequate Food System risk states that performance is critical for mission success. If the food system does not adequately provide for food safety, nutrition and acceptability, then crew health, performance and the overall mission may be adversely affected. Furthermore, if the food system uses more than its allocated mission resources, then total required mission resources may exceed capabilities, the mission deemed unfeasible, or allocation of resources to other systems may be unduly constrained (1). The objective of this project will be to explore and prioritize the opportunities of reducing mass of the actual food while maintaining caloric and hydration requirements. The AFT group has been challenged to reduce the mass of the packaged food from 1.82 kg per person per day to 1.14 kg per person per day. The current food system is comprised mainly of rehydrateable and thermostabilized items. Rehydrateable items are light weight, but require reconstitution with water while thermostabilized items are ready to eat, have higher crew acceptability, but have significantly more mass. Past work focused on the reduction of packaging which contributes to about 15% of the total mass of the packaged food system. To date, there has not been a significant effort to determine how to reduce the mass of the food itself. In this study, a total food system approach to minimizing the mass is being investigated including weight, water usage, heating time, and meal replacement options.

BACKGROUND

AFT System

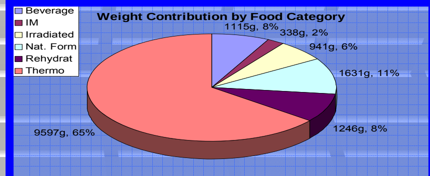
- Food system optimization will require total system resources be minimized.
- Weight of food item is one factor in a total system approach.
- Weight optimization opportunities exist by increasing fat and decreasing water content in food items.
- Meal replacement options would be an efficient manner of delivering nutrition.
- Crew acceptability of meal replacement options will determine degree of use.

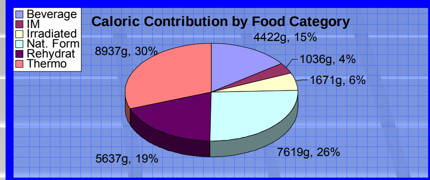
Current Food System

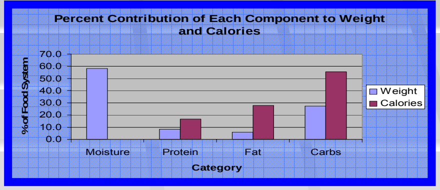
1. Thermostabilized – Food items in cans or pouches are heat processed with steam or water-overpressure to remove excess air/oxygen and temperatures to render the food commercially sterile.
2. Irradiated - Radiation levels, with special FDA permission (2), control naturally occurring processes such as ripening of raw fruits and vegetables, and is effective for inactivation of spoilage and pathogenic microorganisms.
3. Rehydrateable – Drying with heat, osmotic drying, or freeze drying reduces the water activity of foods, which results in the inability of microorganisms to thrive.
4. Natural form - Commercially available, shelf-stable foods with low moisture content, such as almonds and brownies, rely on reduced water activity to prevent microbial activity.
5. Intermediate moisture - Dried meat and fruit products use increased salt or sugar concentration and reduced moisture to prevent microbial activity.
6. Fresh Food - Fresh fruit and vegetables have a short shelf life and are provided for psychological support than as part of meeting dietary requirements.
7. Beverages - Freeze dried beverage mixes (such as coffee or tea) or flavored drink mixes (such as lemonade or orange drink) are currently being used on International Space Station (ISS) and Shuttle. Drink mixes are prepared and vacuum sealed inside a beverage pouch. Empty beverage pouches are provided for drinking water.

RESULTS AND DISCUSSION

Current Menu Analysis





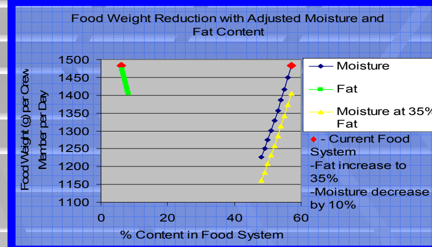


- Thermostabilized pouches accounted for the majority of the food weight (65%) while providing 30% of the caloric value.
- Fat content of menu was 27.8%; below maximum allowable fat levels of 35% (4).
- Natural form provided highest ratio of calories to gram of food and does not require addition vehicle resources.

Meal Replacement Options

- Meal replacement options are being investigated.
- Currently available meal replacement bars have either the organoleptic or nutritional properties sought, but not both.
- Energy gel packets are rich in carbohydrates, but lack protein and fat.
- Determining the degree of use for these items is necessary to reduce food system mass while maintaining crew member acceptability.
- Maintaining a variety for preventing dietary fatigue with these products will be a major concern (3).

Current Menu Analysis



- Increasing fat to permitted dietary maximum of 35% of the caloric value decreased weight by 75g per crew member per day.
- Food weight decreased by ~30g per crew member for each % moisture decreased.
- Decreasing moisture by 10% at max. fat levels decreased weight by 320 g per crew member per day, or 22%.

CONCLUSIONS

- Opportunities for weight reduction in the food system exist.
- The food item form influences nutrient concentration and extent of necessary preparation prior to consumption.
- Fat content is below their maximum allowable values leaving room for improvement.
- Currently available meal replacement options are lacking nutritional and organoleptic properties .
- Maintaining crew member acceptability will be the primary challenge in implementing the meal replacement options.
- Increasing fat and decreasing moisture content in the current food system could decrease mass by as much as 22%.

REFERENCES

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