**ABSTRACT**

Food system optimization will require total system resources to 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.

**BACKGROUND**

The Orion vehicle is significantly smaller than the Shuttle vehicle and the current food system design is not available for Apollo-related missions. Therefore, the food team has been challenged to reduce the mass of the packaged food from 1.4 kg per person per day to 1.1 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 environment as a system to reduce mass. To date, there has not been a significant effort to determine how to reduce the food mass 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 practicality for delivery of the new food (i.e., form, in beverages) and the degree of replacement.
- Determine whether new, currently available, or new to market products meet the requirements.

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

**RESULTS AND DISCUSSION**

### 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, to control naturally occurring processes such as ripening of raw fruits and vegetables, and to be effective for inactivation of spoilage and pathogenic microorganisms.

#### 3. Rehydratable

- Pouches or bags with heat, osmotically, or freeze drying reduces the water activity of foods, which results in the instability of microorganisms to thrive.

#### Natural Form

- Commercially available, shelf-stable foods with low moisture content, such as almonds and browns, rely on reduced water activity to prevent microbial activity.

#### Meal Replacement Options

- Thrust motorized - 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.
- Irradiated - Radiation levels, with special FDA permission, to control naturally occurring processes such as ripening of raw fruits and vegetables, and to be effective for inactivation of spoilage and pathogenic microorganisms.
- Rehydratable - Pouches or bags with heat, osmotically, or freeze drying reduces the water activity of foods, which results in the instability of microorganisms to thrive.
- Natural Form - Commercially available, shelf-stable foods with low moisture content, such as almonds and browns, rely on reduced water activity to prevent microbial activity.
- Meal Replacement Options - Thrust motorized - 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. Irradiated - Radiation levels, with special FDA permission, to control naturally occurring processes such as ripening of raw fruits and vegetables, and to be effective for inactivation of spoilage and pathogenic microorganisms. Rehydratable - Pouches or bags with heat, osmotically, or freeze drying reduces the water activity of foods, which results in the instability of microorganisms to thrive.
- Natural Form - Commercially available, shelf-stable foods with low moisture content, such as almonds and browns, rely on reduced water activity to prevent microbial activity.

**CONCLUSIONS**

Opportunities for weight reduction in the food system exist.

- The food item formulation influences nutrient concentration and extent of necessary preparation prior to consumption.
- Current available meal replacement options lack 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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**FOOD MASS REDUCTION TRADE STUDY**

**M.H. Perchonok, A.M. Stoklosa**

**NASA JSC, 2101 NASA Parkway, Houston, TX 77058**

**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 Aviation and Space Transportation (AST) Program is to develop a unique, flexible, and affordable Generic Space Systems (GSS) 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, water, and pressurization. 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 current food system design is not available for Apollo-related missions. Therefore, the food team has been challenged to reduce the mass of the packaged food from 1.4 kg per person per day to 1.1 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 environment as a system to reduce mass. To date, there has not been a significant effort to determine how to reduce the food mass 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.
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- Trade studies may include removing the water of the total food system and/or increasing the fat content.
- Determine the practicality for delivery of the new food (i.e., form, in beverages) and the degree of replacement.
- Determine whether new, currently available, or new to market products meet the requirements.

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

**BACKGROUND**

The Orion vehicle is significantly smaller than the Shuttle vehicle and the current food system design is not available for Apollo-related missions. Therefore, the food team has been challenged to reduce the mass of the packaged food from 1.4 kg per person per day to 1.1 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 environment as a system to reduce mass. To date, there has not been a significant effort to determine how to reduce the food mass itself.

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**RESULTS AND DISCUSSION**

### Current Menu Analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight Contribution by Food Category</th>
<th>Caloric Contribution by Food Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>32%</td>
<td>42%</td>
</tr>
<tr>
<td>Vegetable</td>
<td>21%</td>
<td>26%</td>
</tr>
<tr>
<td>Fruit</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Dairy</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Snack</td>
<td>4%</td>
<td>6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Contribution of Each Component to Weight</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meal Replacement Options</td>
<td>Meat</td>
</tr>
</tbody>
</table>

Thermoregulating pouches accounted for the majority of the food weight (65%) while providing 30% of the caloric value.

**CONCLUSIONS**

Opportunities for weight reduction in the food system exist.

- The food item formulation influences nutrient concentration and extent of necessary preparation prior to consumption.
- Current available meal replacement options lack 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**