LONG-TERM STABILITY OF SPACEFLIGHT FOOD FOR MULTI-YEAR EXPLORATION MISSIONS

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Introduction: Food is one of the most basic needs for sustaining life and is a major factor in human health and well being. To enable optimal performance of crewmembers on multi-year exploration missions the food needs to supply an adequate amount of calories, provide all required macro- and micro-nutrients, be palatable for an extended period of time, and remain safe for consumption and free from microbial or chemical spoilage. While food intended for terrestrial consumption has a limited shelf life of between 6-24 months, foods packaged for deep-space exploration missions will need to maintain shelf life for at least 5 years, based on plans to send food supplies ahead of the crew in an unmanned vehicle, pre-positioning it on the surface of the intended planet or in orbit around it [1]. Foods that are stored for prolonged periods of time undergo chemical transformations including degradation and loss of vitamin content, oxidation of fats resulting in rancidity, and undesirable changes to texture and taste [2][3]. Such reactions may be accelerated when foods are exposed to the higher levels of radiation found in deep space. A study conducetd on the International Space Station (ISS) evaluated stability of low-moisture food items that were maintained in orbit for a period of 880 days [4]. Although no significant decrease was found in the 30 nutrients measured, the levels of radiation found in deep space are very different from those found in low-Earth orbit and high-moisture foods, which are more radiation sensitive, were not adequately evaluated.

Methods: Food items will be sent to the Deep Space Gateway for storage, and samples will be brought back to Earth for periodic analysis. Food items will include meat products (preferably both fish [high in omega-3 fatty acids] and pork [high in B vitamins]), a vegetable, a fruit, a starch (preferably a vitamin fortified bread product that can be evaluated for stability of B vitamins in a second matrix), and a nut item. Items sent would be mostly high moisture products, which are expected to be more susceptible to raditation effects. Preferably, food items would be kept at 3 conditions onboard the Deep Space Gateway: ambient (21º C), refrigerated (4º C), and frozen (-20º C) to ascertain the best storage parameters for preserving and stabilizing the food items for long durations. Samples of the stored food will be brought back to Earth after 1, 3, and 5 years and the returned food samples will be evaluated for changes that include vitamin content (especially vitamins that are known to be labile such as thiamin), oxidation of fats and fatty acids, evaluation of amino acids, and quality impacts to texture, color or taste. A control set of identical food items will be kept on the ground under the same storage conditions (ambient, refrigerated and frozen).

Resources Required: Ideally, all foods in the space food system would be evaluated to validate stability of individual matrices under deep space storage conditions. However, given resource constraints, the minimum number of foods evaluated should include a wide range of foods and matrices. Assuming 6 different categories of food items are flown (fish, meat, vegetable, fruit, bread, and nuts), initial upmass is anticipated to be between 35 kg and 70 kg, depending on the number of storage temperatures tested. This would equate to a volume of about 0.086 m^3 to 0.171 m^3.

References:

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