INTEGRATION OF PRODUCT, PACKAGE, PROCESS, AND ENVIRONMENT: A FOOD SYSTEM OPTIMIZATION

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ABSTRACT

The food systems slated for future NASA missions must meet crew nutritional needs, be acceptable for consumption, and use resources efficiently. Although the current food system of prepackaged, moderately stabilized food items works well for International Space Station (ISS) missions, many of the current space menu items do not maintain acceptability and/or nutritive value beyond 2 years. Longer space missions require that the food system can sustain the crew for 3 to 5 years without replenishment. The task "Integration of Product, Package, Process, and Environment: A Food System Optimization" has the objective of optimizing food-product shelf life for the space-food system through product recipe adjustments, new packaging and processing technologies, and modified storage conditions.

Two emergent food processing technologies were examined to identify a pathway to stable, wet-pack foods without the detrimental color and texture effects. Both microwave-assisted thermal sterilization (MATS) and pressure-assisted thermal stabilization (PATS) were evaluated against traditional retort processing to determine if lower heat inputs during processing would produce a product with higher micronutrient quality and longer shelf life. While MATS products did have brighter color and better texture initially, the advantages were not sustained. The non-metallized packaging film used in the process likely provided inadequate oxygen barrier. No difference in vitamin stability was evident between MATS and retort processed foods. Similarly, fruit products produced using PATS showed improved color and texture through 3 years of storage compared to retort fruit, but the vitamin stability was not improved.

The final processing study involved freeze drying. Five processing factors were tested in factorial design to assess potential impact of each to the quality of freeze-dried food, including the integrity of the microstructure. The initial freezing rate and primary freeze drying temperature and pressure were linked to final product quality in freeze-dried corn, indicating processing modifications that could lead to improved product shelf life.

Storage temperatures and packaging systems were also assessed for the impact to food quality. Reduced temperature storage had inconclusive impact to the progression of rancidity in butter cookies. Frozen storage was detrimental to fruit and vegetable textural attributes but refrigerated storage helped to sustain color and organoleptic ratings for plant-based foods. With regard to packaging systems, the metallized film overwrap significantly decreased the progression of the rancidity of butter cookies as compared to the highest barrier non-metallized film. The inclusion of oxygen scavengers resulted in noticeable moisture gains in butter cookies over time, independent of packaging film systems.

Neither emergent processing technology nor the freeze dry optimization resulted in compelling quality differences from current space food provisions such that a five-year shelf life is likely with these processing changes alone. Using a combination of refrigeration and PATS processing is expected to result in organoleptically-acceptable fruit quality for most fruits through five years. The vitamin degradation will be aided somewhat by the cold temperatures but, given the labile nature of vitamin C, a more stable fortification method, such as encapsulation, should also be investigated to ensure vitamin delivery throughout the product life. Similarly, significant improvement to the packaging film used in the MATS processing, optimization of formulation for dielectric properties, vitamin fortification, and reduced temperature storage should be investigated as a hurdle approach to reach a five year shelf life in wet-pack entrees and soups. Baked goods and other environmentally-sensitive spaceflight foods will require an almost impenetrable barrier to protect the foods from oxygen and moisture ingress but scavengers and reduced storage temperature did not improve baked good shelf life and are not recommended at this time for these foods.