

Fiscal Year:	FY 2015	Task Last Updated:	FY 03/31/2015
PI Name:	Cooper, Maya M.S.		
Project Title:	Integration of Product, Package, Process, and Environment: A Food System Optimization		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		TechPort:	No
Human Research Program Elements:	(1) SHFH :Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:			
Project Type:	Ground	Solicitation / Funding Source:	Directed Research
Start Date:	10/01/2010	End Date:	01/31/2015
No. of Post Docs:	0	No. of PhD Degrees:	0
No. of PhD Candidates:	0	No. of Master' Degrees:	0
No. of Master's Candidates:	0	No. of Bachelor's Degrees:	0
No. of Bachelor's Candidates:	0	Monitoring Center:	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date is 1/31/2015 per PI and Element (Ed., 10/22/14) NOTE: Gap change per IRP Rev E (Ed., 3/18/14) NOTE: End date is 4/3/2016 per HRP Master Task List information and PI, as project extends into further aims (Ed., 9/20/2012) NOTE: End date is 10/1/2014 per M. Perchonok/JSC (Ed., 8/17/2011)		
Key Personnel Changes/Previous PI:	John Glass was added as co-investigator in 2011; Grace Douglas was added as co-investigator in November 2011; Monica Leong was added as co-investigator in October 2012. John Glass and Monica Leong ended participation with study in October 2013 and February 2014, respectively. Mayra Nelman was added as a co-investigator in March 2013.		
COI Name (Institution):	Douglas, Grace Ph.D. (NASA Johnson Space Center) Nelman, Mayra (Wyle Integrated Science & Engineering)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

	<p>NASA is working to achieve manned space flights beyond low-Earth orbit within the next 25 years. Specifically, the vision includes a manned mission to Mars, which demands that astronauts survive extra-terrestrially for a minimum of three years. The space foods themselves must maintain quality for up to five years so that the food can be prepositioned on the Martian surface prior to crew arrival if necessary. This product life requirement is beyond the capability of the current stabilized food system used on the International Space Station. Thus, the food system optimization is vital for the viability of all extended duration missions.</p> <p>Optimizing the food system to achieve a five-year shelf life mitigates the risk of inadequate food system during extended missions. Two causes of an inadequate food system are inadequate nutritional content within the food and inadequate acceptability of the food leading to insufficient intake. This study directly addresses those nutrition and acceptability concerns. Nutritional content and food quality, particularly as products age, are indicative of the food matrix, history, and storage environment. For example, a high availability of oxygen in a food package can be detrimental to product shelf life. The oxidative reactions that cause rancidity also lead to the degradation of vitamin C, vitamin A, folic acid, and thiamin (Gregory 1985: Gregory JF. 1985. Chemical changes of vitamins during food processing. In: Richardson T and Finley JW, editors. Chemical Changes in Food During Processing. Westport (CT): AVI Publishing Company, 373-408). Likewise, a product subjected to high heat in processing may undergo nonenzymatic browning, but broad vitamin degradation should also be expected after thermal processing. By establishing the proper recipe, process, package, and storage condition, the product is better positioned to sustain nutrition and acceptability over the product life. The chances of performance decrement or illness due to insufficient nutrition or poor food intake decreases with implementation of this integrated food system.</p> <p>Hence, "The Integration of Product, Package, Process, and Environment: A Food System Optimization" seeks to optimize food product shelf life for the space food system through product recipe adjustments, application of new packaging and processing technologies, and modified storage conditions. Specifically, the research aims are: Aim A. To summarize the available packaged food technologies that would offer significant barrier or antioxidant property improvements over current space packaging.</p> <p>Aim B. To complete a risk-benefit analysis on the usage of the space environment for cold food storage.</p> <p>Aim C. To provide recommendations as to the formulation changes, processes, packages, and environments for each space food product that would result in a five-year shelf life for that product.</p> <p>Aim D. To identify the technology needs associated with implementing any of the aforementioned integration recommendations.</p> <p>At the study conclusion, a course to shift the space food products to a five-year shelf life will be proposed. Overall system or category changes will be clearly identified, and products with little chance of meeting the five-year shelf life hurdle will be delineated for replacement or removal from long duration menus. The required future work to deliver this postulated integration for the food system will be identified.</p>
Rationale for HRP Directed Research:	This research is directed because it contains highly constrained research, which requires focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal.
Research Impact/Earth Benefits:	The implications of the study go beyond future space missions in that successful optimization would raise the food quality and simplify food logistics for International Space Station provisions and for food rations used terrestrially for relief efforts and military applications.
Task Progress:	<p>The study is complete.</p> <p>In this study the space food system was divided into five food category modules – thermostabilized fruits, thermostabilized vegetables, thermostabilized entrees, freeze-dried foods, and baked goods. Through hypothesis-driven experimentation alternative storage, processing, and packaging technologies were evaluated to achieve better sensory, color, texture, and nutrient quality. None of the experiments singularly resulted in five-year shelf life, but important evaluation of the technologies was achieved as indicated in the following key results. Thermostabilized fruits have significant quality issues when stored at ambient temperatures, but colder temperatures alone did not drive enough stabilization in the assessed products to reasonably achieve a five-year shelf life through storage modifications. Pressure-assisted thermostabilization (PATs) resulted in better color and texture of the fruit, but not vitamin stability, as compared to traditional retort. The greatest challenges with thermostabilized vegetables, nutrient degradation and textural softening, were not alleviated by microwave-assisted thermal stabilization (MATs) of the Carrot Coins. The MATs process did produce carrots with brighter color and better texture initially, but due to inadequate packaging barrier, improvements were not sustained over the shelf life of the product. Similarly, the MATs process did not provide a significant, sustained improvement for the evaluated entree, Sweet and Sour Pork. In the freeze-dried food module, the rehydration of freeze-dried items appeared to be most affected by the moisture content of the food. Even slight changes in moisture resulted in noticeable shifts in the amount of water absorbed. Finally, in the baked goods module the evaluation of Butter Cookies demonstrated that the initial development of off-flavors in baked goods may not be the direct result of fat reacting with residual oxygen but the rancidity and chemical activity that comes with higher moisture.</p> <p>This study addressed Advanced Food Technology (AFT) Gap 4 and the methodology to produce a food system that meets the shelf life necessary for design reference missions. Because the five-year shelf life was not fully achieved, future research will focus on a hurdle approach, a likely stability solution for most of the foods. Cold storage has the capability to slow the chemical reactions that cause color darkening and vitamin degradation as well as slow the enzymatic reactions that lead to textural degradation. Hence, alternative processing technologies, along with colder storage, improve the probability of getting a five-year shelf life for thermostabilized space foods. Opportunities exist to alter freeze-dried product quality by optimizing process parameters and tightening end product specifications. Processing the food precisely and protecting the food against moisture ingress should result in 5 years of shelf life in freeze-dried items. Moisture control should be the focus area of future baked goods work. Refrigeration or freezing should be considered for baked goods as the colder temperatures slowed moisture and oxygen ingress. Encapsulated vitamins should be considered for all food items.</p>

Bibliography Type:	Description: (Last Updated: 04/23/2019)
Abstracts for Journals and Proceedings	Cooper MR, Douglas GL. "Integration of Product, Package, Process, and Environment: A Food System Optimization." 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015. 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015. Abstract #0226. , Jan-2015
Abstracts for Journals and Proceedings	Cooper MR. "Optimizing Space Food to Achieve a 5-Year Shelf Life." 2014 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-13, 2014. 2014 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-13, 2014. http://www.hou.usra.edu/meetings/hrp2014/pdf/3029.pdf ; accessed 4/1/2015. , Feb-2014