Fiscal Year:	FY 2014	**Task Last Updated:**	FY 09/27/2013
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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Zip Code:	77058	**Congressional District:**	22
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
Contact Monitor:	Douglas, Grace	**Contact Phone:**	
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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.		
COI Name (Institution):	Glass, John (MEI Technologies) Douglas, Grace Ph.D. (NASA) Leong, Monica (Lockheed Martin)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	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. 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. 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. Aim B. To complete a risk-benefit analysis on the usage of the space environment for cold food storage. 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. Aim D. To identify the technology needs associated with implementing any of the aforementioned integration recommendations. 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.
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:	To evaluate alternative processing as a means to extend the life of entrees and vegetables, Sweet and Sour Pork and Carrot Coins were processed using either microwave-assisted thermal stabilization or traditional thermostabilization (retort) and then stored at 22°C, 32°C, and 37°C for 6 months. While microwave-assisted thermal stabilization did produce product with brighter color and better texture initially, the advantages were not sustained over the shelf life of the product. After 6 months, the vitamin stability in products was not substantially different between Microwave-Assisted Thermal Sterilization (MATS) and traditional thermostabilization. Color changes in Sweet and Sour Pork were impacted by artificial coloring in the food. However, significantly more color difference was noted in the MATS Carrot Coins as compared to the color difference in thermostabilized Carrot Coins after storage. Textural degradation proceeded after MATS processing at the same rate as textural degradation after thermostabilization. The food will be reevaluated after one year and after 18 months of storage. Freeze-drying optimization studies were conducted with Rice Pilaf and Corn. Corn rehydration was significantly impacted by the initial freezing rate and the internal cellular structure was impacted by the freezing rate and the primary drying conditions. Rice pilaf did not present significant differences in moisture or rehydration within the window of operating parameters. Rice alone showed differences in porosity, directly related to the primary drying pressure. One set of operating parameters caused significantly different compression resistance in cooked, freeze-dried rice grains. Impacts to texture acceptability would need to be measured to determine final optimal parameters. Neither the microwave-assisted thermal stabilization processing 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. However, the evaluation of the food is still in progress. The knowledge of how these alternative processing methods and/or procedures impact food quality is important for both the consideration of hurdle technology to achieve a five-year life and to evaluate feasibility of achieving a five-year life. The experimental research will continue for another year to evaluate alternatively formulated, processed, and stored foods and packaging materials. Representative foods will be chosen and tested; the data will be used to draw conclusions on how to best impact shelf life for the larger food system. The study is on track to be completed winter in 2014.
Bibliography Type:	Description: (Last Updated: 04/23/2019)

Abstracts for Journals and Proceedings	Cooper MR, Leong ML, Glass JW, Douglas GL. "Optimizing Space Food to Achieve a 5-Year Shelf Life." 2013 NASA Human Research Program Investigators’ Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators’ Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013