Fiscal Year:	FY 2013	**Task Last Updated:**	FY 10/15/2012
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
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Flight Program:			
Flight Assignment:	NOTE: End date is 1/31/2015 per PI and Element (Ed., 10/22/14) 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 (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:	The NASA Human Research Program Science Management Office gave the Authority to Proceed (ATP) with the experimental portions of the project on April 19, 2012. In line with that ATP, the planned experimental phases have shifted in timing and, in some cases, have been compressed to maintain end deliverable dates.The study is on track to be completed winter in 2014. In the first experimental module, thermostabilized Spiced Apples and Mixed Fruit were stored at -80°C, 4°C, and 19°C and analyzed at 2 and 9 months of storage. Color darkening over time was noted in the L-axis results for the spiced apple products regardless of storage condition. The required shear force initially increased in both fruits stored in ambient and refrigeration conditions due to pectin gel formation but the firmness was not sustained over time. Ultra cold freezing conditions reduced fruit firmness immediately through irreversible ice damage to the cell structure of both fruits. Results from the study show that 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 5-year shelf life through storage modifications. In contrast, the comparison of 3.5-year-old pressure-assisted thermostabilized (PATS) fruits with equally-aged retorted fruits showed that the high pressure, lower temperature method of stabilization does circumvent much of the harm to internal cellular structure during processing. The PATS products had better color and firmer texture across the four products examined. 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 considered to ensure vitamin delivery throughout the product life. The experimental research will continue along a three-year evaluation of 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.
Bibliography Type:	Description: (Last Updated: 04/23/2019)