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PI Name:	Cooper, Maya M.S.		
Project Title:	Functional Foods Baseline and Requirements Analysis		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:	TechPort:	No	
Human Research Program Elements:	(1) HHC: Human Health Countermeasures		
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:			
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No. of Bachelor's Candidates:	0	Monitoring Center:	NASA JSC
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Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Douglas, Grace Ph.D. (NASA Johnson Space Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
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Task Description:	<p>NASA, in planning for long duration missions, has an imperative to provide the necessary nutrition to ensure sustainment of crew health and performance. To this end, the Human Health Countermeasures (HHC) Program has identified several desired nutrients, optimally delivered from food sources, with the potential to benefit health beyond nutritional maintenance. It is expected that these nutrients, and any nutrients identified in the future, will be required to be delivered in the food system to mitigate or prevent health issues, and that determination of compatible formulation, processing, and storage conditions will enable these functional foods to meet shelf life requirements. The purpose of this task is to determine the current concentrations of these previously unmeasured nutrients in the food system and their stability to different processing conditions, formulation matrices, and storage temperatures reflective of potential vehicle architecture to inform functional food capabilities and requirements development for long duration spaceflight.</p> <p>Milestones and Deliverables: The study duration is 3 years. Analysis of existing nutritional data, the assessment of additional nutrients in existing food over time, and characterization of food matrices encompass much of the study and</p>		

	<p>occur concurrently throughout the study. The SharePoint development work will proceed throughout the course of the study with development in the first half and a supported go-live state for the latter part of the study period.</p> <p>At the conclusion of this task, researchers will deliver a baseline assessment of functional foods within the current International Space Station (ISS) food system as well as provide requirements for the development of functional foods in the space food system.</p>
Rationale for HRP Directed Research:	This research is directed because it contains highly constrained research.
Research Impact/Earth Benefits:	This research is on the forefront of establishing functional food concentrations in processed foods whereas the current research focus only considers whole, generally fresh, foods. The data will allow efforts for high nutrition to all populations regardless of access to fresh food. Consequently, the benefits of healthful diet can be extended as well.
Task Progress:	<p>The study hypothesis is that foods will sustain functional ingredients for an extended shelf life if compatible formulation, processing, and storage conditions are achieved. Current spaceflight foods are being evaluated to determine if their nutrient profile supports positioning as a functional food and if the stability of the bioactive compound within the food matrix over an extended shelf life correlates with the expected storage duration during the mission. Twelve foods that were thought to have a significant concentration, or a concentration significantly greater than most spaceflight foods, of bioactive compounds (lycopene, lutein, omega-3 fatty acids, phenolics, sterols, and flavonoids) were selected for the study from the International Space Station food provisions. Recently produced food samples were sent by overnight shipment to the Food Composition Laboratory of the Linus Pauling Institute at Oregon State University (Corvallis, OR) for bioactive compound analysis. Three packages of each product were blended together for the analysis to reduce package-to-package variability. Samples were analyzed initially and after 3, 6, and 12 months of storage, dependent upon storage temperature (4°C, 21°C, or 35°C) within the Space Food Systems Laboratory environmental chambers. Final storage analysis will occur at 2 years.</p> <p>The ability to provision high-lycopene, high-lutein, or high-omega-3 fatty acid foods within the spaceflight food system has been demonstrated by the identification of the foods of this study and their initial chemical analysis. Sterols can be supplied through cumulative diet; however, a single food with adequate sterol content for functionality is unlikely. Total polyphenol delivery appears stable and adequate, however the physiological relevance of the overall stability is currently unknown in relation to the importance and stability of individual phenolic compounds that were not specifically evaluated in this study. The stability of bioactive compounds within the identified foods varies with the bioactive compound and the storage temperature. The data would seem to suggest that some bioactive compounds, like lycopene, lutein, marine omega-3 fatty acids, and rice sterols, plateau at some equilibrium concentration. The anthocyanin stability is greatly related to storage conditions as is lutein stability in leafy vegetables. The sterol stability in nuts would seem to relate to storage duration but not temperature. More data is needed to confirm these observations.</p> <p>Some bioactive compounds can be supplied across the space food system through a variety of foods. However, omega-3 fatty acids, particularly EPA and DHA, and lutein are found in very specific food items. The ISS provisioning menu likely does not have a variety of foods with these specific bioactive compounds to fully institute a meal plan to address those health issues requiring compound-specific mitigation without creating a secondary issue of menu fatigue. It is yet unknown whether the bioactive compounds will remain stable over the extended shelf life of five years required for a Mars mission. The functionality only exists if the chemical stability of the compounds maintains the efficacious structure for a long shelf life. Hence, the viability of functional foods for spaceflight, or stabilization countermeasures if necessary, has yet to be established.</p>
Bibliography Type:	Description: (Last Updated: 04/23/2019)
Abstracts for Journals and Proceedings	<p>Bermudez-Aguirre L, Cooper M. "Functional Foods Baseline and Requirements Analysis." Presented at the 2015 NASA Human Research Program Investigators' Workshop, Galveston, Texas, January 13-15, 2015.</p> <p>Abstract Book, 2015 NASA Human Research Program Investigators' Workshop, Galveston, Texas, January 13-15, 2015. , Jan-2015</p>