Fiscal Year:	FY 2016	**Task Last Updated:**	FY 09/09/2015
PI Name:	Barrett, Ann Ph.D.		
Project Title:	Stabilized Foods for Use in Extended Spaceflight: Preservation of Shelf-Life, Nutrient Content and Acceptability		
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) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Food and Nutrition**:Risk of Performance Decrement and Crew Illness Due to Inadequate Food and Nutrition		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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PI Organization Type:	GOVERNMENT	**Phone:**	508-233-4516
Organization Name:	United States Department of the Army		
PI Address 1:	NSDREC, CFD/PORT, RDNS-CFP		
PI Address 2:	U.S. Army Natick Soldier Systems Center		
PI Web Page:			
City:	Natick	**State:**	MA
Zip Code:	01760-5018	**Congressional District:**	7
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2011 Crew Health NNJ11ZSA002NA
Start Date:	11/01/2012	**End Date:**	10/31/2017
No. of Post Docs:	0	**No. of PhD Degrees:**	1
No. of PhD Candidates:	1	**No. of Master' Degrees:**	4
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	1
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Douglas, Grace	**Contact Phone:**	
Contact Email:	grace.l.douglas@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: End date changed to 10/31/2017 per G. Douglas/JSC (Ed., 12/14/15) NOTE: Changed from NSBRI to NASA-monitored project, per M. Perchonok/NASA JSC (Ed., 2/25/2013)		
Key Personnel Changes/Previous PI:	N/A		
COI Name (Institution):	Froio, Danielle (United States Department of the Army) Richardson, Michelle (United States Department of the Army)		
Grant/Contract No.:	NNJ13HA911		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The objective of this effort is to develop shelf stable, highly acceptable, food with increased nutrient (vitamins) stability for extended space missions utilizing innovative processing and packaging technologies. There will be two research thrusts. For the first thrust area, we will formulate, test, and optimize the quality and nutrient content of a range of fortified shelf-stable foods. The focus will be on extruded/pressed low-water activity bar-type products. Advances in innovative pre-treatment technologies (encapsulation) for vitamins will be assessed, as well as synergy with matrix chemical character. For the second thrust area, different packaging technologies will be investigated with research focused on the interaction of packaging material with various innovative sterilization processes such as microwave heating, irradiation, and high pressure treatment. The availability of highly nutritious and health-promoting food is a factor that is a significant prerequisite for prolonged space travel. The design of feeding and nutritional strategies for multi-year, non-resupplied flights is an undertaking requiring substantial research and development; it is also an endeavor and that could be founded upon our existing, considerable knowledge and experience base at Natick Soldier RD&E (Research, Development and Engineering) Center.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The proposed study will yield strategies for the development of extremely stable, nutrient-dense foods and the development of packaging materials compatible with new quality-preserving sterilization techniques. While this work is specifically important to the health of astronauts, its significance also extends to the research that is critical to the mission of the Natick Soldier Research Development and Engineering Center: to support and promote the nutritional health of the Warfighter on extended missions with little or no means of resupply.
Task Progress:	EFFORT 1: Vitamin Analysis--1 year storage at 100F and 70F. Vitamin analysis was conducted at Covance Co. for compressed bar and dispersed drink mix specimens that had been stored for one year at both 70F and 100F. Both high and low lipid specimens of bars (blueberry granola formulations) and drink mixes (chocolate hazelnut formulations) were analyzed. Vitamin A losses for low and high fat bars and low and high fat drink mixes maintained at 70F were respectively 14.3, 11.1, 15, and 1.2%; Vitamin A losses for low and high fat bars and low and high fat drink mixes maintained at 100F were respectively 27.5, 30.4, 34.8, and 34.4; Vitamin B1 losses for low and high fat bars and low and high fat drink mixes maintained at 70F were respectively 0, 6.7, 1, and 12%; Vitamin B1 losses for low and high fat bars and low and high fat drink mixes maintained at 100F were respectively 5.7, 0, 0, and 18; Vitamin B9 losses for low and high fat bars and low and high fat drink mixes maintained at 70F were respectively 16.1, 11.9, 18, and 6.2; Vitamin B9 losses for low and high fat bars and low and high fat drink mixes maintained at 100F were respectively 18.8, 0, 18.8, and 18.1;Vitamin C losses for low and high fat bars and low and high fat drink mixes maintained at 70F were respectively 10.5, 0, 13.9, and 10.8; Vitamin C losses for low and high fat bars and low and high fat drink mixes maintained at 100F were respectively 10.5, 0, 13.9, and 10.8; Vitamin C losses for low and high fat bars and low and high fat drink mixes maintained at 100F were respectively 19.9, 22.8, 13.5, and 4.4; Vitamin E losses for low and high fat bars and low and high fat drink mixes maintained at 70F were respectively 0, 0, 4.1, and 3.7; and Vitamin E losses for low and high fat bars and low and high fat drink mixes maintained at 100F were respectively 2.2, 1, 0, and 3.4. Statistical analysis and pooling of all pulls showed that: On average, vitamin loss susceptibility follows the sequence, A > B9 > C > B1 > E; while there was low significance of effects due to product fat level, high fat products on average had less loss; there was no significant difference in overall vitamin loss in compressed bars compared to dispersed beverage bases; while there was low significance of differences in loss of water soluble vitamins vs. fat soluble vitamins, water soluble vitamins on average were better protected in high fat systems; losses after storage at 100F for 6 months were slightly higher than, but not significantly different from, losses after storage at 70F for 1 year; at 70F losses, vitamin B9 had decidedly better retention in high fat matrices ($p = 0.02$); Vitamin E is extremely stable regardless of its surrounding matrix; and Vitamin A apparently has the highest susceptibility to high temperature storage. All samples stored at 70F maintained sensory acceptability (manifested by an overall quality score > 6.0 on a 9 point hedonic scale); specimens stored at 100F for one year exhibited loss of flavor quality. Documentation for analysis of specimens after 2 years storage at 70F is being prepared, with sample withdrawal scheduled for November 2015. EFFORT 2: Processing and packaging research. The objective of this effort is to investigate innovative multilayer packaging materials for compatibility with novel food sterilization methods and assess food quality as a function of processing method and package type. In this effort various food processing methods, such as Microwave Assisted Thermal Sterilization (MATS), Pressure Assisted Thermal Sterilization (PATS), Irradiation, and Retort were studied to determine the effect on pouches utilizing three different and novel high barrier coating technologies and a control aluminum foil (AF) Retort Pouch. The pouches were filled with Creamy Cajun Chicken, and subjected to the various processing methods. Pre- and post-processing pouch integrity was analyzed. During FY15, barrier testing, layer analysis, sensory acceptance, and vitamin analysis were completed for Effort 2. Oxygen transmission rate (OTR) and water vapor transmission rate (WVTR) were tested before and after processing using a MOCON® Ox-Tran 2/21 and a MOCON® PermaTran 3/31 following ASTM D3985 and F1249, respectively. Measurements were taken at 23ºC and 50% RH and 37.8ºC and 90% RH, for OTR and WVTR, respectively. Optical microscopy was employed to conduct layer analysis, and utilized a Nikon Microscope and DXM1200 Digital Camera at 20x magnifications. Film cross-sections were analyzed with and without an iodine staining technique, which allows for easier detection of nylon layers within the film structure. Twelve-member trained technical panels evaluated sensory appearance, odor, flavor, texture and overall quality of the Creamy Cajun Chicken, using a 9-point hedonic scale and Sensory Information Management System (SIMS) acquisition/processing of data. Vitamin analysis of vitamins A (retinol), C (ascorbic), E (a-tocopherol), B1 (thiamin), and B9 (folic acid) was conducted by Covance using Nutritional Labeling and Education Act (NLEA) nutrient sample analysis. Six replicates of each sample were tested. Barrier testing shows that of the test pouches, Pouch B (Toppan aluminum oxide coating with protective overcoat) has the lowest initial OTR and WVTR, and is able to maintain these low transmission rates after retort, MATS, and irradiation. However, Pouch B, undergoes a substantial increase in OTR and WVTR after PATS, as does Pouch C. Barrier performance of the Retort pouch is virtually unaffected by the retort, PATS, and irradiation processing methods. Cross sectional layer analysis shows no occurrence of delamination between the layers of the film structure after processing, and are representative of all pouches pre- and post- processing. A clear trend of higher overall quality for Creamy Cajun Chicken processed utilizing MATS, PATS, and Irradiation, as opposed to the conventional retort method, was observed. Similar trends were reported for appearance, odor, flavor, and texture. Sensory analysis did not reveal any difference in attributes, with respect to the pouch type. Vitamin loss after 9 months (based on initial calculated concentration) for Pouch B samples, processed using the various methods, is as follows: Folic Acid 9-44%, Vitamin C 30-45%, Vitamin A 30-34%, and Thiamin 91-97%. Vitamin analysis shows no clear trend in vitamin loss with respect to processing method. A down-selection of 3 pouch/processing combinations was conducted based on the results obtained to date, which includes mechanical integrity, barrier performance, seal strength, layer analysis, and sensory data. The pouch/process combinations

	include Pouch B/MATS, Pouch B/Irradiation, Pouch B/Retort, and a control foil pouch/retort. The action to exercise options under the current contract with Ameriqual have been made, and should be finalized in the coming months. Processing trials at Ameriqual and their sub-contractors are tentatively planned for November 2015.
Bibliography Type:	Description: (Last Updated: 08/25/2020)
Abstracts for Journals and Proceedings	Froio D, Barrett A, Richardson M. Mohr L, Bhagat K, Cheney S. "A study of novel food processing methods and the effect on high barrier packaging and food quality." Presented at the 2015 Annual Meeting of the Institute of Food Technologists, Chicago, IL, July 11-14, 2015. Abstracts, 2015 Annual Meeting of the Institute of Food Technologists, Chicago, IL, July 11-14, 2015. http://ift.planion.com/Web.User/AbstractDet?ACCOUNT=IFT&ABSID=12065&CONF=IFT15&ssoOverride=OFF&CKEY= ; accessed 9/10/15. , Jul-2015
Abstracts for Journals and Proceedings	Barrett A, Richardson M, Froio D. "Stabilization of vitamins for long term space flight." Presented at 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. , Jan-2015
Articles in Peer-reviewed Journals	Barrett A, Richardson M, Froio D. "Vitamin stabilization for long term spaceflight." Food Technol (Chicago). 2015 Apr;69(4):44-51. http://www.ift.org/Food-Technology/Past-Issues/2015/April.aspx , Apr-2015