Fiscal Year:	FY 2018	**Task Last Updated:**	FY 01/23/2018
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:**	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: Element change to Human Health Countermeasures; previously Space Human Factors & Habitability (Ed., 1/19/17) 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 M.S. (United States Department of the Army) Richardson, Michelle M.S. (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:	VITAMIN LOSSES AFTER 3 YEARS AT 70F Vitamin levels in relatively low and high fat content compressed bars and dispersed drink mixes, fortified with twice the Space Flight Requirement for vitamins A, B1, B9, C, and E, were analyzed after three years storage at 70F. Vitamins in relatively low fat products had been encapsulated in a lipophilic coating; vitamins in relatively high fat products had been encapsulated in a starch-based coating. Vitamin contents were measured by Covance Co., with n=6. Losses for the vitamins after 3 years storage at 70F are as follows. Vitamin A: low and high fat bars—15 % (both); low and high fat beverage bases—17% and 16%, respectively. Vitamin B1: low and high fat bars—23% and 8.5%, respectively; low and high fat beverage bases—4.8 and 23%, respectively. Vitamin B9: low and high fat bars—26% and 21%, respectively; low and high fat beverage bases—30% and 26%, respectively. Vitamin C: low and high fat bars—11% and 5.7%, respectively; low and high fat beverage bases—4.8% and 7.4%, respectively. Vitamin E: low and high fat bars—4.9% and 3.7%, respectively; low and high fat beverage bases—4.6% and 8.4%, respectively. Results show that vitamin loss susceptibility after 3 years storage, on average, followed the sequence, B9 > A > B1 > C > E. Overall effects of product form (i.e., compressed bars vs. powders) and of relative product fat level were calculated using paired two-sample T-test comparisons of pooled data, with populations of 60 values/replicates in each data set. In general, percent losses were higher (~25%) in the dispersed particulate beverage bases, with moderate statistical significance. Compacted bars may be slightly more stable against oxidation-induced degradation of vitamins due to inhibited contact of packaging-entrained oxygen with the interior of the products. While, on average, lower fat products exhibited slightly less (~12%) vitamin degradation than did high fat products, this effect had low statistical significance. Testing of pouches and food product at time 0, 3, and 6 months at 100F and time 0 and 6 months at 70F has been completed. Samples have also been pulled for 1 year at 100 and 70F, and testing of food and package is currently underway. Testing of food components included sensory, vitamin, color, and water activity analysis. Package testing included barrier, seal strength, mechanical, and burst testing. Prior to package testing, food product was emptied from pouches and pouches were cleaned with soapy water and dried. Sample identification for package testing is as follows: (1) the control sample is the unfilled and unprocessed pouch, (2) t=0 samples represent pouch data immediately after processing, (3) t=3 months and t=6 months indicates samples that were pulled at the respective time intervals. Pouch integrity testing shows that Pouch B/retort undergoes a 10-14% decrease in seal strength after processing (t=0); however, seal strength begins to slightly increase after storage at 100F. Pouch A (MATS/retort/irradiation) shows a slight increase in seal strength going from control (unprocessed pouch) to t=0 (after processing), then drops back down to a value close to the control value at 3 months (100F) and 6 months (70F), before increasing to maximum value at 6 months (100F). ED. NOTE (June 2021): Project continues with Principal Investigator (PI) Danielle Froio-Blumsack continuing work initiated with PI Dr. Ann Barrett, whose work covered the first 3 years of this contract with U.S. Army. See "Stabilized Foods for Use in Extended Spaceflight: Preservation of Shelf-Life, Nutrient Content and Acceptability (Froio-Blumsack)" for subsequent reporting.
Bibliography Type:	Description: (Last Updated: 08/25/2020)
Articles in Peer-reviewed Journals	Lane HW, Bourland C, Barrett A, Heer M, Smith SM. "The role of nutritional research in the success of human space flight." Adv Nutr. 2013 Sep 1;4(5):521-3. https://doi.org/10.3945/an.113.004101 ; PubMed PMID: 24038244; PubMed Central PMCID: PMC3771136 , Sep-2013
Articles in Peer-reviewed Journals	Barrett AH, Richardson MJ, Froio DF, Connor LFO, Anderson DJ, Ndou TV. "Long-term vitamin stabilization in low moisture products for NASA: Techniques and three-year vitamin retention, sensory, and texture results." J Food Sci. 2018 Aug;83(8):2183-90. https://doi.org/10.1111/1750-3841.14218 ; PMID: 30059142 , Aug-2018