Fiscal Year:	FY 2018	**Task Last Updated:**	FY 02/12/2019
PI Name:	Wheeler, Raymond Ph.D.		
Project Title:	Baseline Microbial Assessment of Fresh Produce		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Microhost**:Risk of Adverse Health Effects Due to Host-Microorganism Interactions		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	raymond.m.wheeler@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	321-861-2950
Organization Name:	NASA Kennedy Space Center		
PI Address 1:	NASA Exploration Research and Technology		
PI Address 2:	Mail Code UB-A		
PI Web Page:			
City:	Kennedy Space Center	**State:**	FL
Zip Code:	32899-0001	**Congressional District:**	8
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	07/31/2017	**End Date:**	09/30/2018
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	5	**Monitoring Center:**	NASA JSC
Contact Monitor:	Douglas, Grace	**Contact Phone:**	
Contact Email:	grace.l.douglas@nasa.gov		
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Massa, Gioia Ph.D. (NASA Kennedy Space Center) Hummerick, Mary (Vencore/ NASA Kennedy Space Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			
	Currently no standards or requirements exist for microbial food safety for space-grown produce (fresh plant foods). Without standards it is difficult to assess options for handling and sanitizing produce on the International Space Station (ISS) and during future exploration missions. We will conduct a literature review of microbial levels on fresh food, and then measure microbial counts on crops purchased from the grocery store or grown in a controlled environment. Products tested will include lettuce, mizuna, cherry tomato, pepper, and radish, all of which are candidate crops for pick-and-eat testing on ISS and near term exploration missions. Growth chamber conditions will be set to mimic an ISS or spacecraft environment. Products will be assayed for specific pathogens (Enterobacteriacea, Salmonella sp., and Aspergillus flavus) and total culturable microorganisms using aerobic plate counts, and total yeast and mold counts will be assessed. Analyses will follow the FDA (Food & Drug Administration) Bacteriological Analytical Manual methods.		

Task Description:	The goal of the project is to establish a baseline for expected microbial levels found on fresh plant foods that might be grown on ISS and near term missions, and develop risk assessment and microbial safety recommendations for these types of fresh foods. SA 1. Review the literature to gather available baseline microbial levels from crops grown in greenhouses or other controlled environments, as well as information on current commercial produce standards. SA 2. Assess store-bought produce to recommend baseline microbial levels for fresh produce in space. SA 3. Grow crops in controlled environments under ISS-relevant conditions and assess baseline microbial levels. SA 4. Compile data from SAs 1-3 and develop microbial safety recommendations for specific types of produce and assess risk of contamination in flight.
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. This study will establish baseline microbial levels for a number of crops being tested or under consideration for spaceflight food production. No current standards or requirements exist for fresh produce grown in spaceflight and this study will provide baseline data to establish those standards. The Kennedy Space Center (KSC) Life Sciences group has unique expertise with vegetable production using the Veggie system, and has on-site controlled environment plant production facilities that enable testing to occur under ISS and Veggie growth conditions. KSC has worked through board certification (MOG, Safety) for produce already consumed in spaceflight on a case by case basis, and standards for this process are needed considering a variety of new crops are intended to be grown on ISS for spaceflight consumption in the next few years. KSC has the expertise and knowledge to complete this task and submit recommendations for fresh produce handling and microbial requirements for board consideration (FACB) prior to planned Veggie production experiments in spaceflight.
Research Impact/Earth Benefits:	
Task Progress:	Currently no standards or requirements exist for microbial food safety for space grown produce (e.g., fresh salad crops). Without standards it is difficult to assess fresh produce options and develop viable sanitization solutions for use on the ISS and in future exploration missions. The evaluation of baseline microbial levels from the literature, microbial levels on grocery store produce, and microbial levels on controlled environment-grown crops should provide some of the data necessary to develop salad crop handling and microbial requirements for fresh produce grown in environments similar to the ISS Veggie plant chamber. This project evaluated and compared baseline microbial levels of controlled environment (similar ISS conditions) grown lettuce, mizuna, cherry tomato, radish and green peppers, with comparable retail produce purchased at local grocery stores. In addition, these data were compared to crops actually grown in Veggie on ISS and in other ground experiments related to Veggie. This evaluation aligns to the Human Research Program (HRP) Task “Pick-and-eat salad crop production for the ISS” and should help drive requirements for future food systems development beyond ISS. Five different edible crop types from both retail (grocery store) and controlled environment chamber grown sources were evaluated for microbial counts. In addition, a review of some published findings on microbial counts for food crops was done. Our goal was to assess the relative microbial quality of these crops grown under different conditions, with the hope of developing guidelines for space grown foods, such as the Veggie chamber on the ISS. Microbial contamination of field grown produce can happen in the processing from farm to table. Sources of foodborne pathogen contamination can be present pre-harvest including untreated irrigation water, the use of organic fertilizers like compost and manure, and proximity of wildlife and livestock to the field (Steele, M et.al. 2004, Beuchat, L. R. 2006, Delaquis, P. et.al. 2007). Postharvest sources of contamination include operations during handling, i.e., contaminated handlers and surfaces, cleaning solutions, and packaging. Most of these sources of contamination are eliminated from space grown crops like those grown in Veggie but the spaceflight environment may present unique mechanisms for microbial contamination and risk to humans that are not fully understood. The data collected in this study show that Veggie grown crops to date do not exceed the levels of bacteria and yeasts / molds found on retail produce and E. coli, Salmonella, S. aureus, and A. flavus were not detected using culture based screening methods. There are a few areas that should be considered in systems like Veggie where microbial contamination could be introduced. The data collected in this study also provide evidence of potential risks that they could be mitigated before consumption by the crew on ISS, or before the health and quality of the crop is affected. By considering the inputs that contribute to the microbial load in Veggie/Space station-grown crops, risks can be defined from negligible to high. These rankings are subjective based on protocols in place for the preparation of the Veggie facility for plant cultivation and harvest as well as microbiological data collected from the Veggie facility and plants. A formal quantitative risk assessment is planned that will include an evaluation of the data compiled in this study. Historical microbiological data from ISS potable water and air would be valuable information to include in a risk assessment of produce grown in the Veggie facility. In this study, we found that the number of bacteria and fungi on growth chamber and ISS-grown produce are no higher than market produce from field settings. While the sample size for Veggie plant samples is low, a possible upward trend in the microbial counts was seen with VEG-03D leafy greens, mizuna, and ‘Outredgeous’ lettuce. This could indicate that the Veggie facility itself is developing a higher microbial load with time. Under these circumstances, steps could be taken to minimize further microbial contamination such as increased decontamination of surfaces with sanitizing wipes and the removal of unnecessary materials. Microbial monitoring of inputs into the plant growth systems and the plants is important and should enable detection of any trends indicating increased microbial presence. Surface swabs, water samples, and air samples are invaluable in controlling points were contamination is possible. Based on testing that was performed, all the produce sampled in this study indicated no specific microbiological risks associated with a particular type of product. In general the edible fruits, tomato, and pepper had the lowest counts, while radish, a storage root had the highest, with no difference between the market and chamber grown crops. Radish and similar types of crops are in close proximity of moist soil or wicking material that would support microbial growth. Further development of best practices for space-grown crops should allow routine safe consumption of these items. References Steele, M., and Odumeru, J. 2004. Irrigation water as source of foodborne pathogens on fruit and vegetables. J. Food Prot. 67: 2839-2849.

	Beuchat, L. R. 2006. Vectors and conditions for preharvest contamination of fruits and vegetables with pathogens capable of causing enteric diseases. British Food Journal, 108:38-53. Delaquis, P., Bach, S., Dinu, L. 2007. Behavior of Escherichia coli O157:H7 in Leafy Vegetables. J Food Prot. 70: 1966-1974.
Bibliography Type:	Description: (Last Updated: 02/08/2019)
Abstracts for Journals and Proceedings	Hummerick ME, Massa GD, Johnson CM, Scotten J, Spencer L, Wheeler RM. "Baseline Microbial Assessment of Fresh Produce." 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. , Jan-2019