

VEG-04: The Effects of Light Quality on Mizuna Mustard Growth, Nutritional Composition, and Organoleptic Acceptability for a Space Diet

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1. Kennedy Space Center 2. Johnson Space Center 3. Purdue University 4. ORBITEC-Sierra Nevada Corporation

Pick-and-eat salad-crop productivity, nutritional value, and acceptability to supplement the ISS food system

Aim: To examine light quality and fertilizer formulation on crop morphology, edible biomass yield, microbial food safety, organoleptic acceptability, nutritional value, and behavioral health benefits.

Team Components:

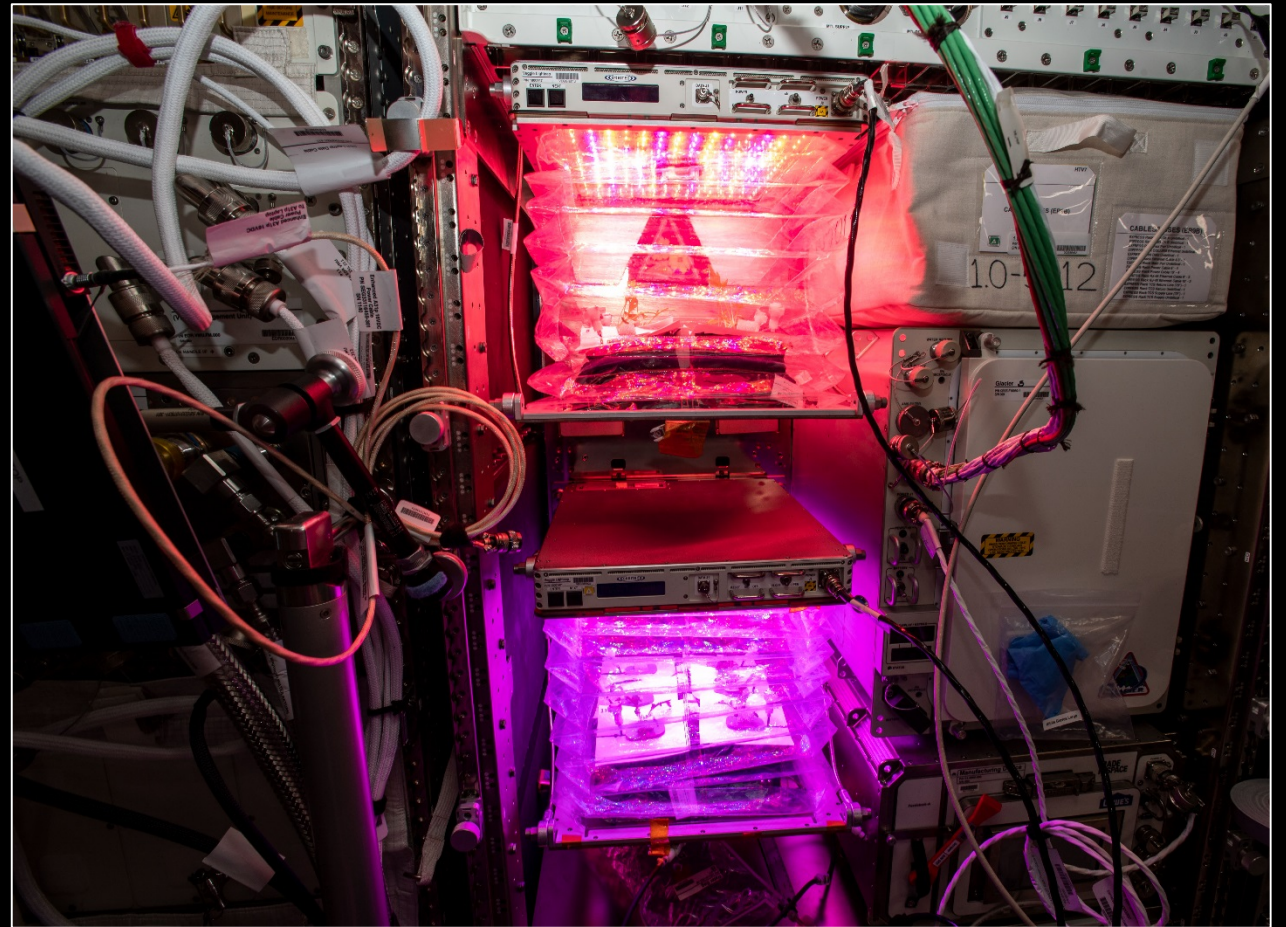
KSC: Crop Testing, Microbiology

JSC: AFT, BHP, Statistics

Purdue: Crop Testing

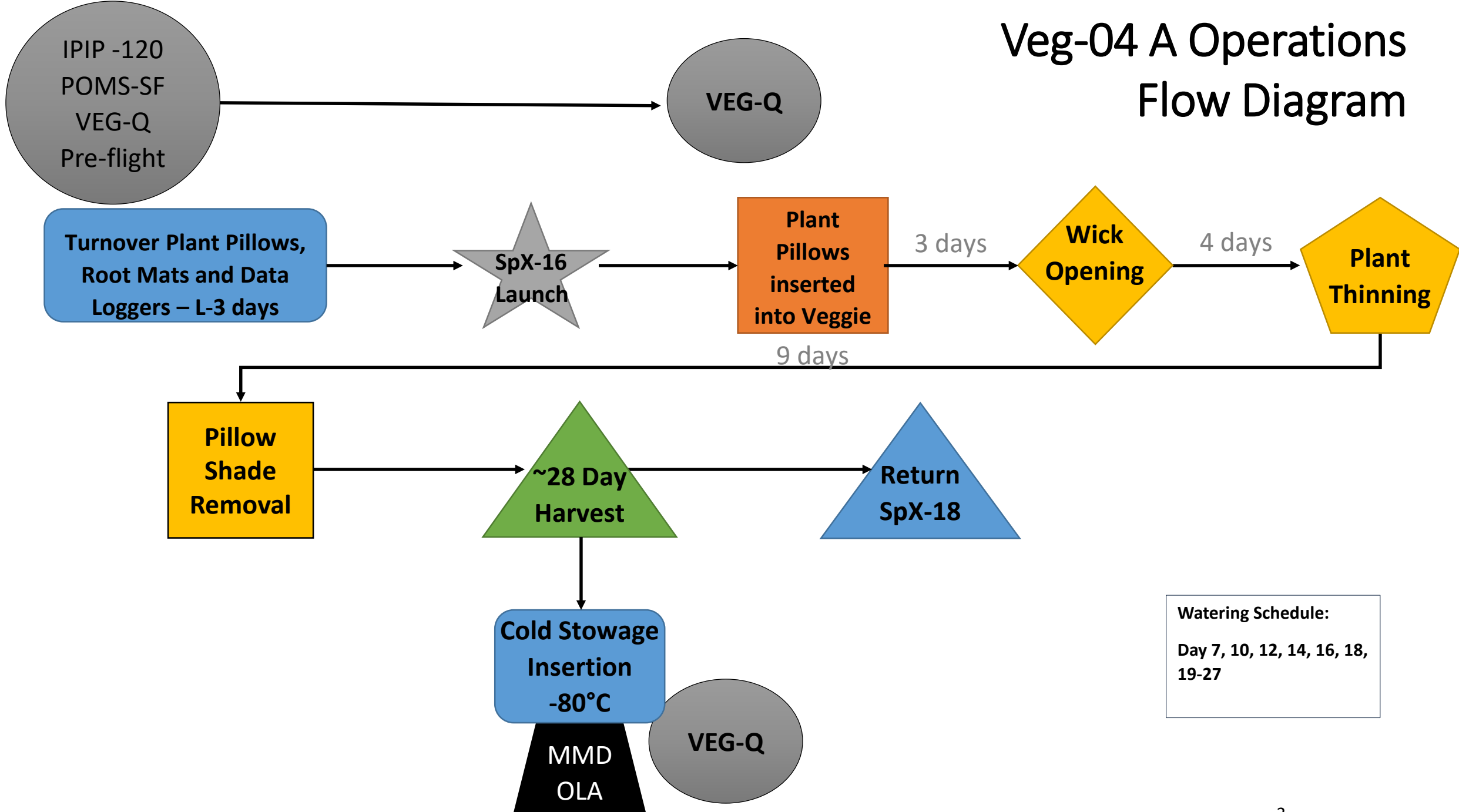
SNC-ORBITEC: Testing, Lighting, Software

Florikan: Fertilizer Consultants

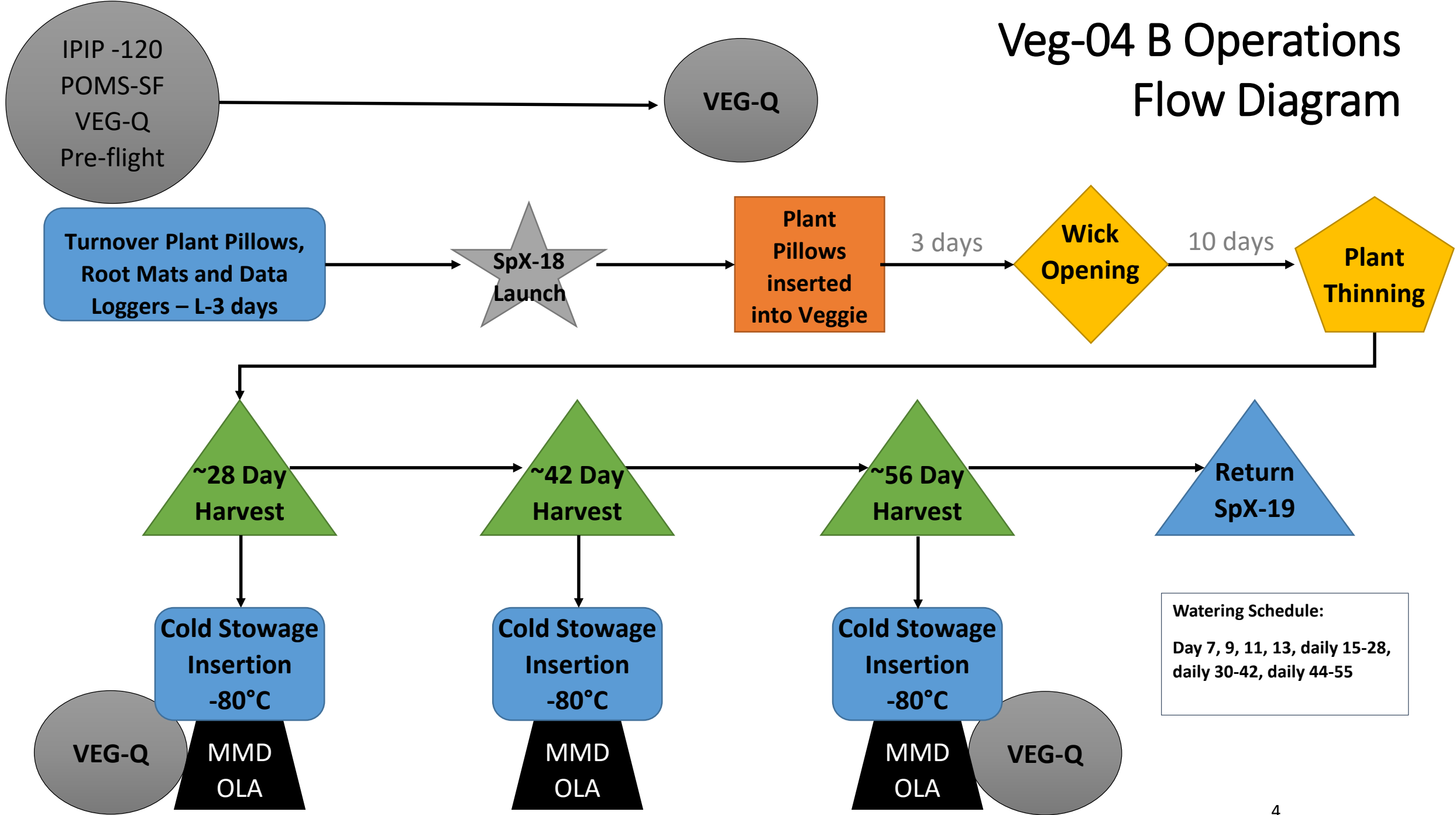


Veggie plant chambers currently on ISS in the Columbus module.

Veg-04 A Operations Flow Diagram



Veg-04 B Operations Flow Diagram



Veggie Questionnaire (VEG-Q) for BHP

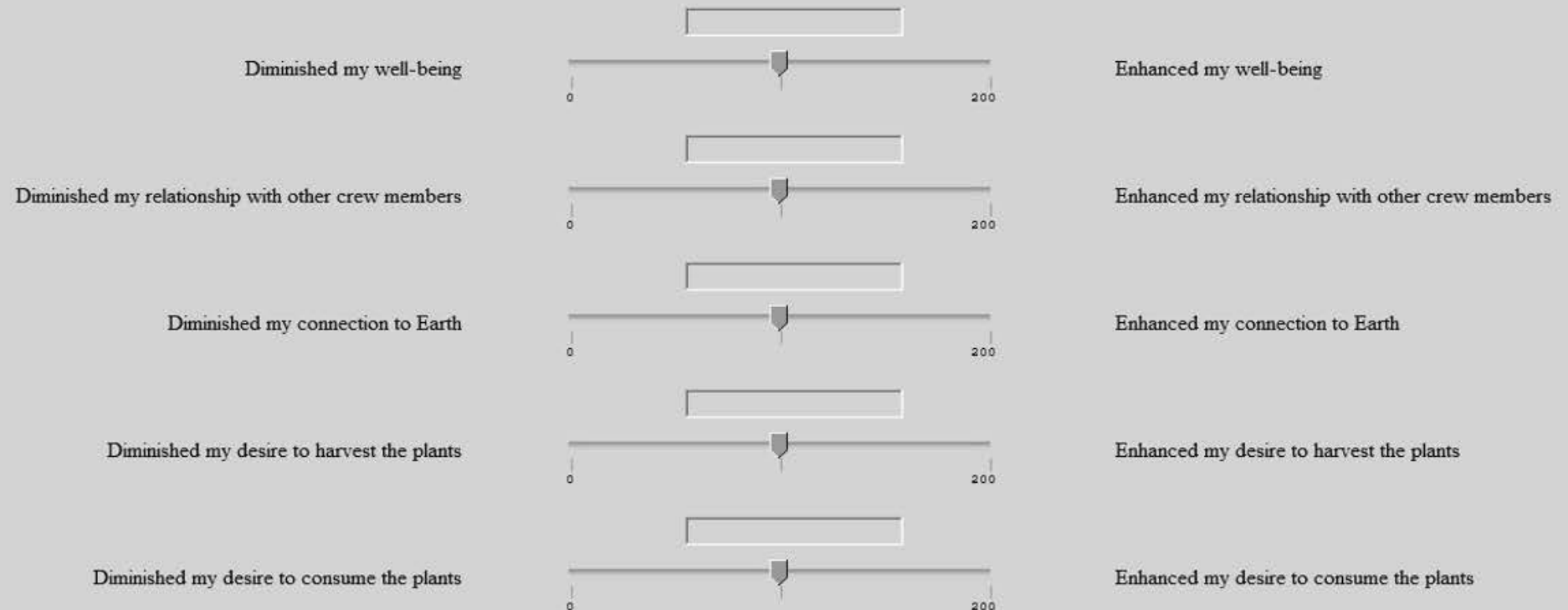
In a typical week on orbit, how many servings of fresh fruit and vegetables do you consume (think of one serving as an apple)?

1-5



COMMON
DATA
COLLECTION
APPLICATION (CDCA)

Throughout the time since your last Veggie Questionnaire, interacting with Veggie was...



If any of the plants struggled or died, please describe this experience.



11 Days after
Initiation
Plants 20 cm
below lights

28 Days after
Initiation
Plants 10 cm
below lights



VEG-04 Harvest



VEG-04A at 35 DAI



VEG-04B at 29 DAI



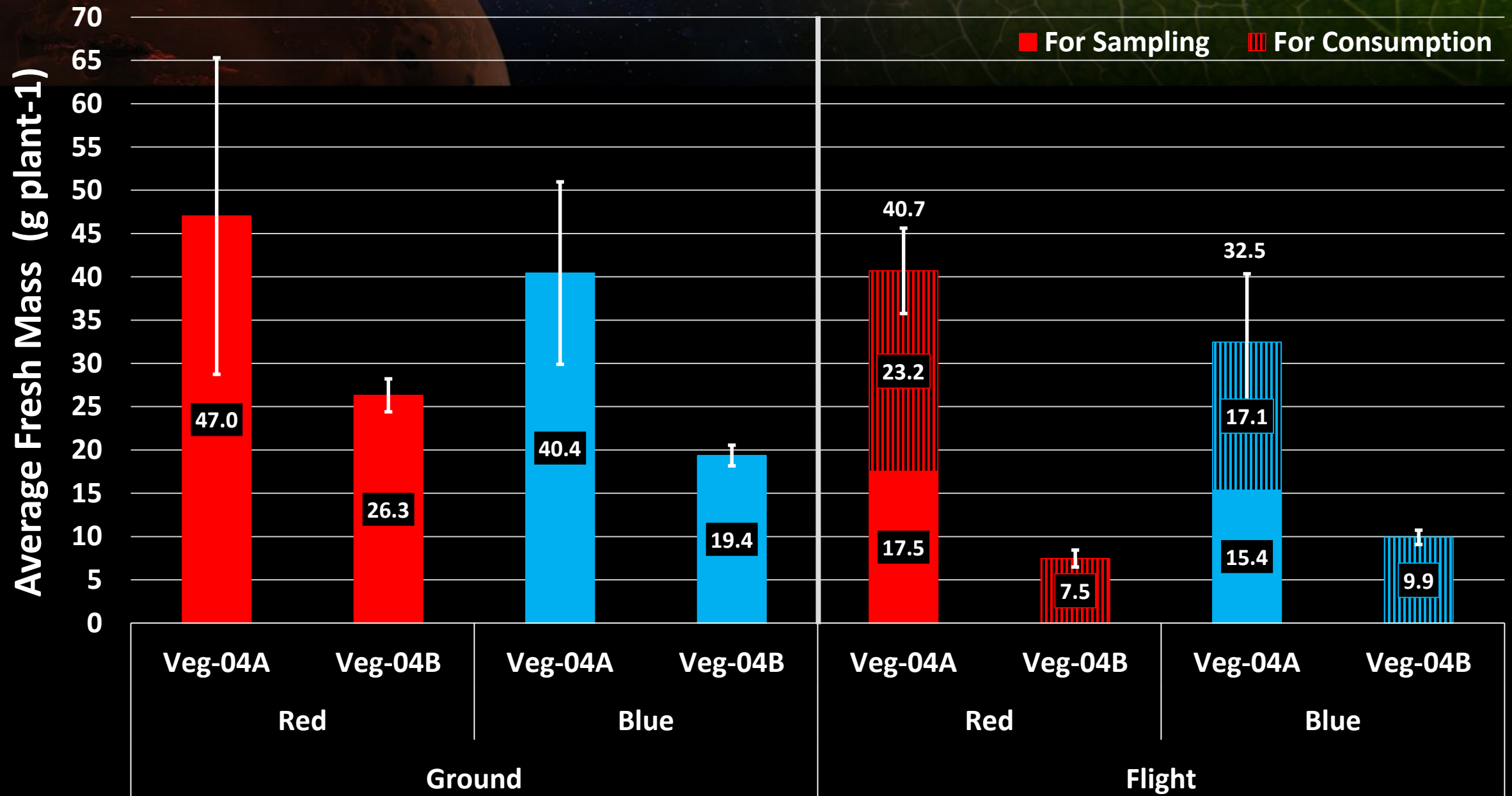
Organoleptic Evaluation (OLA)

	Not Crisp At All	Not Crisp Enough	Just About Right	Somewhat Too Crisp	Much Too Crisp
*7. Crispness	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Not Tender At All	Not Tender Enough	Just About Right	Somewhat Too Tender	Much Too Tender
*8. Tenderness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Not Bitter At All	Not Bitter Enough	Just About Right	Somewhat Too Bitter	Much Too Bitter
*9. Bitterness	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Please provide any comments you would like to share regarding the Mizuna sample.	<div>Mizuna comment1</div>				
<div>Select Next Page and return to Crew Procedure</div> <div>Select Next Page to continue with survey</div>					

Hazard Analysis Critical Control Points (HACCP) Plan

Process Step/Control Point	Food Safety hazard	Methods to reduce hazard	CCP
Ground processing-pillows	Introduction of microbes via handling and materials.	Sterilize components, aseptic technique used while assembling	1
Ground Processing-Seed	Introduction of microbes via handling and indigenous microbes present on seeds	Disinfection. Certification of pathogen free seed. Use of sanitary handling practices	2
Packing	no		
Transport	no		
Integrate with Veggie hardware	Introduction of microbes via handling.	Use of sanitary handling.	3
Watering	Introduction of microbes via water supply or unsanitary handling	Water is potable quality and treated with biocide.	4
Grow	Potential contamination from air and human presence, increase in indigenous flora due to availability of nutrients.	Use of sanitary handling. Minimize handling of plants before harvest.	5
Harvest	Introduction of microbes due to harvest procedures/human handling.	Sanitized instruments should be used and gloves worn.	6
Post-harvest	Microbial presence established during plant growth and introduction via handling.	Crops should be sanitized before consumption following procedures. Veggie facility should be thoroughly sanitized.	7

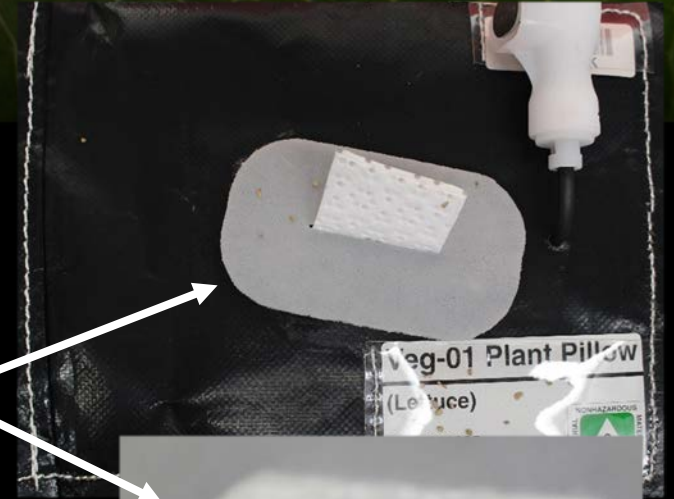
Fresh Biomass at 1-month Harvest



Microbiology Methods

- Post harvest:
- Samples taken from both ground and flight
 - Plant surfaces, Root zone
 - Wicks and Substrate
- Heterotrophic bacterial & fungal plate counts
- Media specific screening
 - *E. coli*
 - *Salmonella sp*
 - *Staphylococcus aureus*
- Microbe Identification

Wick
Material



Plant Leaves



Substrate
& Root
Zone

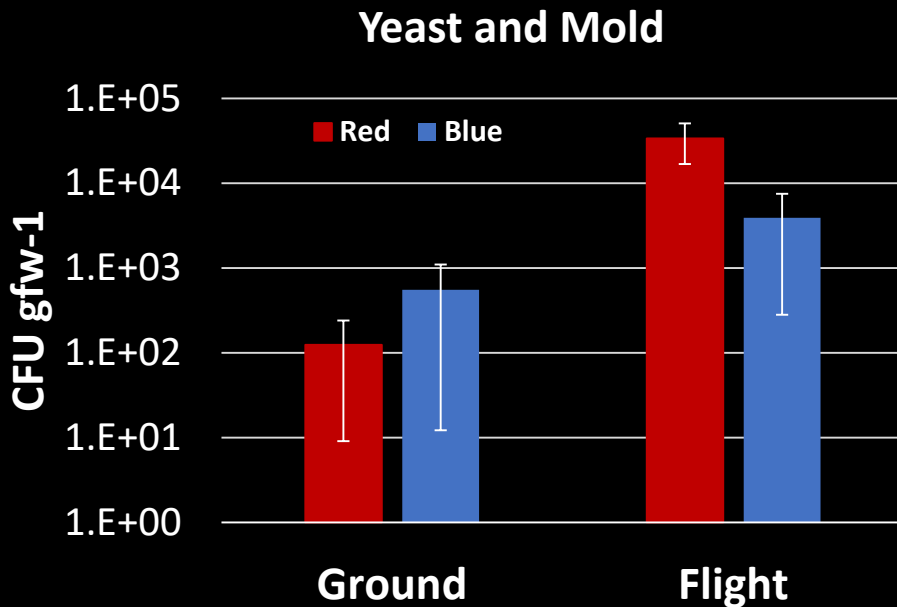
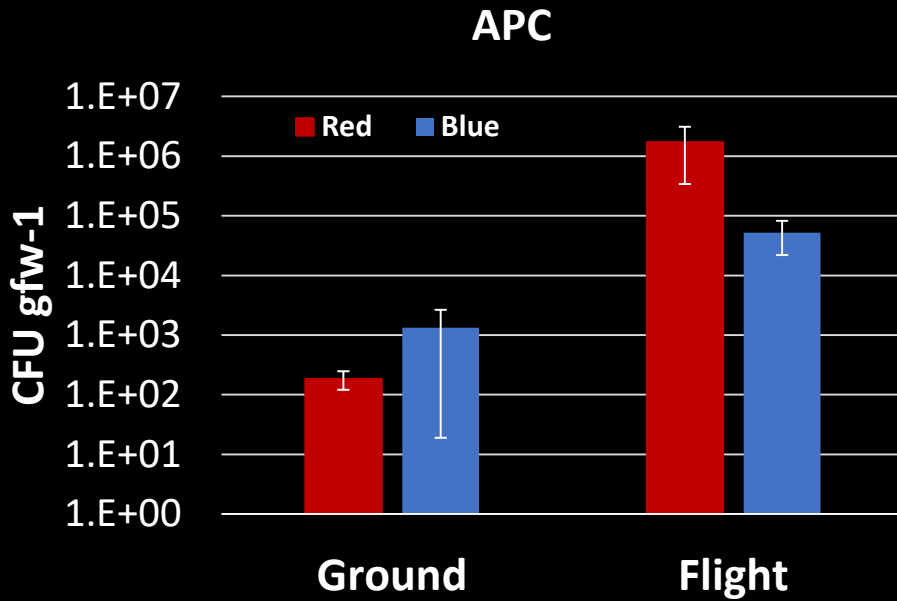


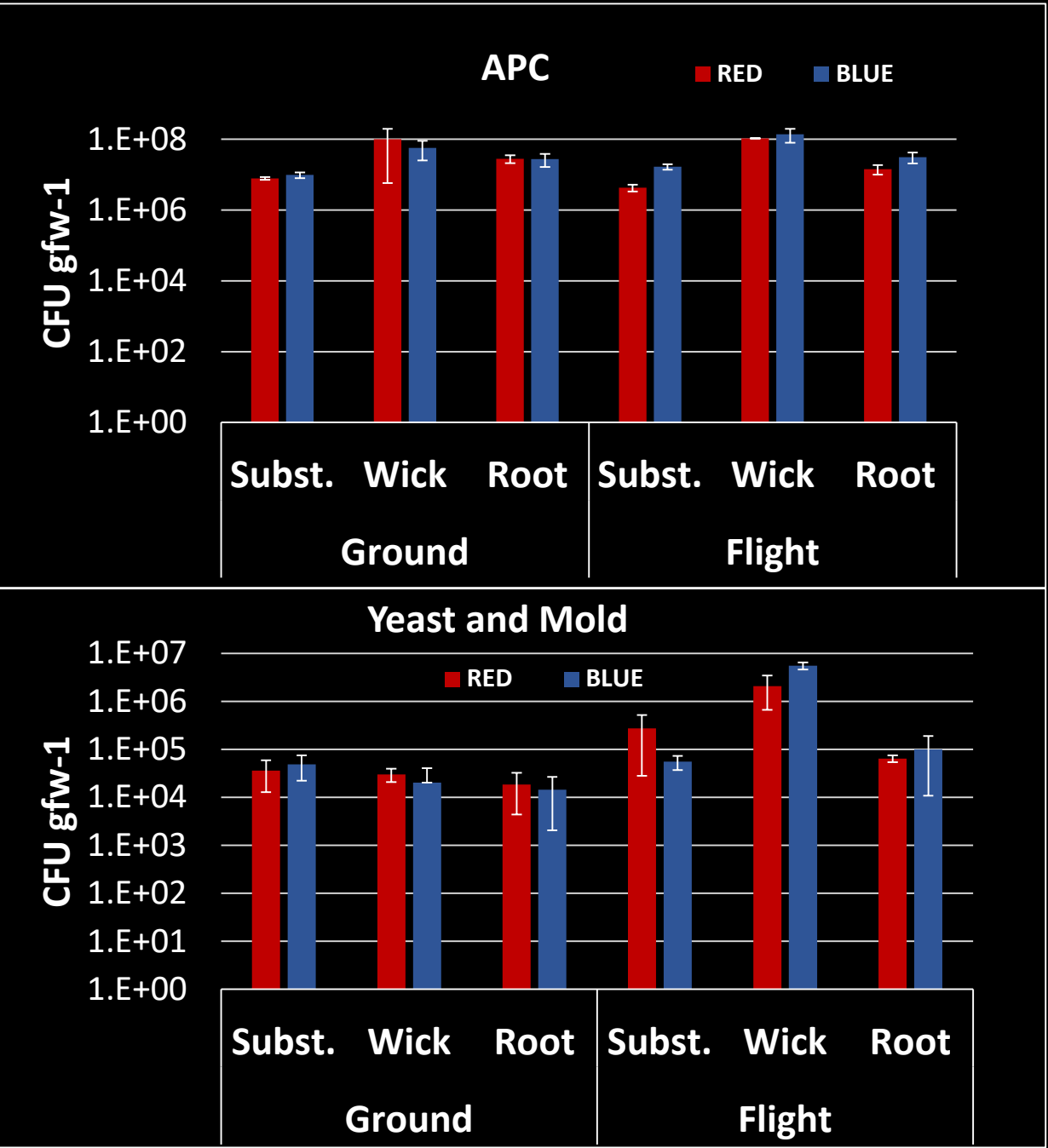


VEG-04A Produce Microbiology from red-rich and blue-rich light treatments

Aerobic bacterial (APC) and yeast and mold plate counts on harvested mizuna leaves. (n=3 except n=5 for flight red-rich light treatment samples).

- Flight leaves have higher bacterial and fungal counts than ground ($p<0.01$).
- Flight leaves under red-rich light treatment have higher counts than all other sample sets ($p<0.01$).
- Bacterial and fungal counts exceed NASA limits for thermostabilized food but pathogen screening was below detection limit for *S. aureus*, *E. coli*, coliforms and *Salmonella sp.*






VEG-04A Pillow

Microbiology from red-rich and blue-rich light treatments

Aerobic bacterial (APC) and yeast and mold plate counts on Veggie **pillow component.**

- Fungal counts are higher on the wicks from the flight pillows



	VEG-04 A Tissue Average Elemental Content (ug/g DW)											
	Al	B	Ca	Cu	Fe	K	Mg	Mn	Na	P	S	Zn
Red-Rich (Ground)	22	74	4,318	12	64	28,962	5,432	^*166	630	4,139	4,542	34
Red-Rich (Flight)	23	93	6,292	8	67	38,762	8,375	*306	828	5,077	6,929	38
Blue-Rich (Ground)	24	85	5,175	10	62	26,873	6,408	^213	479	3,648	4,542	26
Blue-Rich (Flight)	23	124	5,645	11	85	34,029	7,476	248	613	5,154	6,922	40



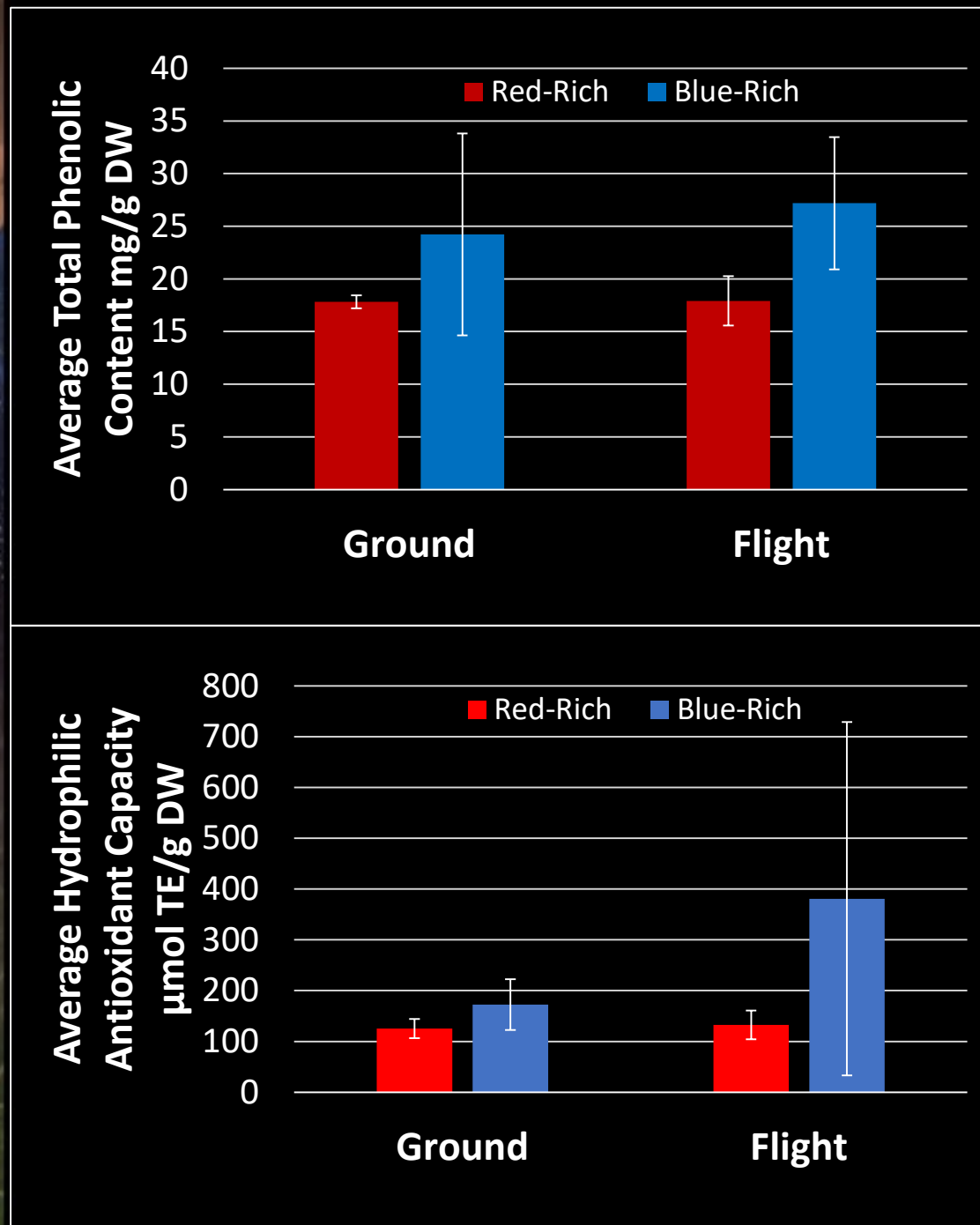
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Average elemental analysis, red and blue light treatments

- Manganese - * indicates significant difference between ground and flight Red-rich samples.
- [^] indicates significant difference between Red-rich and Blue-rich ground samples.

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VEG-04A chemistry from red-rich and blue-rich light treatments

- Average Total Phenolic Content
 - Total phenolic content is higher in blue-rich light in both Ground and Flight plant samples. This difference is significant in flight samples.
- Average Hydrophilic Antioxidant Content
 - These are preliminary data. Flight samples (n=2) will be re-analyzed to confirm this large variability.



Next Steps

- Complete VEG-04B growth tests on ISS with the final harvest around Thanksgiving
- Identification of microorganisms from VEG-04A samples
- Continue chemistry of VEG-04A samples
- Continue crew surveys
- Samples from VEG-04B will be returned and analyzed following undock of SpaceX-19 (estimated January 2020)

Thank you!

- Veggie and VEG teams at KSC, JSC, and SNC-ORBITEC
- Astronauts Christina Koch, David Saint-Jacques, Nick Hague, Jessica Meir, Drew Morgan, and Luca Parmitano
- Payload Operations and Integration Center
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