

PICK-AND-EAT SALAD-CROP PRODUCTIVITY, NUTRITIONAL VALUE, AND ACCEPTABILITY TO SUPPLEMENT THE ISS FOOD SYSTEM

G.D. Massa¹, R.M. Wheeler¹, M.E. Hummerick², R.C. Morrow³, C.A. Mitchell⁴, A.M. Whitmire⁵, R.J. Ploutz-Snyder⁶, G.L. Douglas⁷

¹ NASA, Kennedy Space Center, FL, USA, ² Vencore-ESC, Kennedy Space Center, FL, USA, ³ORBITEC, Madison, WI, ⁴Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN ⁵Wyle Life Science, Johnson Space Center, TX, ⁶Universities Space Research Association, Johnson Space Center, TX, USA ⁷NASA, Johnson Space Center, TX, USA.

Project 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.

The Veggie light cap contains Red, Blue and Green LEDs. Our goal is to determine the optimum ratio for production of salad crops on ISS.



Veggie is currently on ISS in the Columbus module.



Project Team:

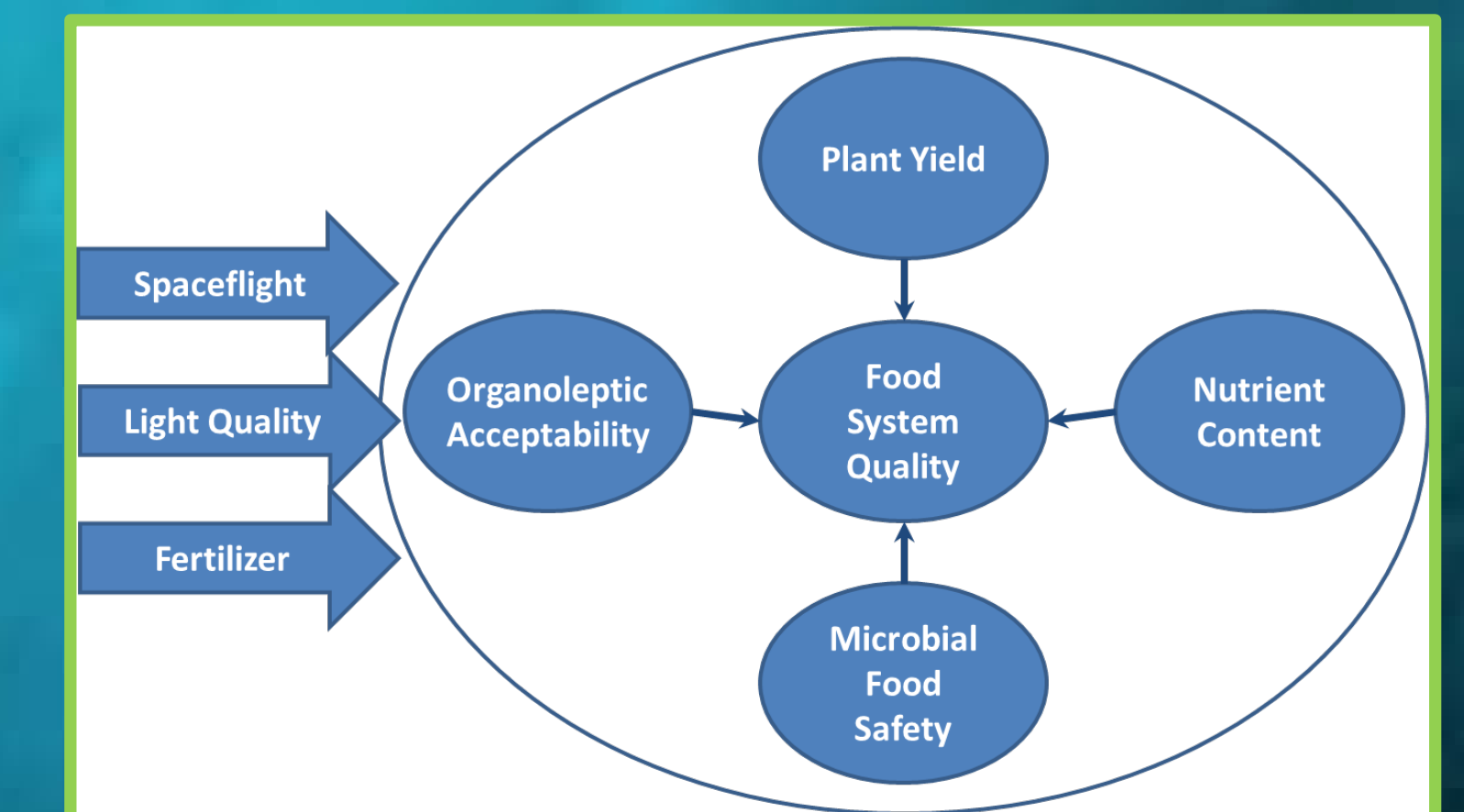
KSC: Food Crop Production, Microbiology

JSC: Advanced Food Technology, Behavioral Health Statistics

Purdue: Food Crop Production

ORBITEC: Food Crop Production, Lighting, Software, Food Safety

Florikan: Fertilizer Consultants



Food system foci to test the factors of spaceflight, light quality, and fertilizer.

Preliminary Research

Leafy Greens Candidates

- 'Tye' spinach
- 'Flamingo' spinach
- 'Outredgeous' red romaine lettuce
- 'Waldmann's green' leaf lettuce
- 'Bull's Blood' beet
- 'Rhubarb' Swiss chard
- 'Tokyo Bekana' Chinese cabbage
- Mizuna



Dwarf Tomato Candidates

- 'Red Robin' tomato
- 'Sweet 'n' Neat' tomato
- 'Mohamed' tomato
- 'Patio Princess' tomato
- 'Tiny Tim' tomato
- 'Tumbler' tomato



Crop Selection Factors

Horticultural factors

- Amount of growth (food), Size, Percent moisture, Germination*, Ease of growth*, Days to fruit^T, Trueness to type^T (consistency of dwarf character), Mass per fruit^T

Dietary factors

- Elemental Factors - Composition of key elements (K, Fe, Ca, Mg)
- Nutrient Factors - Beneficial phytonutrients (Vitamin K, Lutein, Zeaxanthin, Antioxidants, Phenolics^T, Anthocyanins^T, Lycopene^T)

Organoleptic factors

- 9-pt Hedonic Scale: Overall taste, Appearance, Color, Flavor, Bitterness*, Texture*, Aroma^T
- 5-point Just About Right Scale: Crispness*, Tenderness*, Sweetness^T, Juiciness^T, Tartness^T

* indicates leafy green-specific criteria and ^T indicates dwarf tomato-specific criteria

Top Scoring Candidates

'Tokyo Bekana'
Chinese cabbage



Flight testing of top leafy candidate in Veggie as VEG-03 validation test to fly on Sx-8



'Red Robin' tomato

Planned Ground Research and ISS Flight Testing

Plant Testing

- Red and Blue LED light & fertilizer testing with top leafy green and tomato candidates
 - Testing at NASA KSC, Purdue, ORBITEC
- Four light regimes will be assessed: (R=Red, B=Blue)
 - 90% R: 10% B, 70% R: 30% B, 50% R: 50% B, split treatment over time with ¾ growth duration 90% R : 10% B + ¼ 50% R : 50% B
- Three fertilizer release treatments will be assessed:
 - 100% 180-day release, 66% 180 d: 34% 100 d, 50% 180 d: 50% 100 d
 - 18-6-8 (N-P-K) formulation for leafy crop, 14-4-14 for tomato
- Plants assessed for growth, nutrition, and sent to JSC for taste tests
- Ground testing will identify top fertilizer treatment and top 2 light treatments
- Second Veggie unit will be flown and then each crop will be tested under top 2 light treatments on ISS
- VEG-04 (Chinese cabbage) tests scheduled for 4/2017, VEG-05 (Tomato) scheduled for 4/2018

Space Food Safety Testing

- Hazard Analysis and Critical Control Point (HACCP) Plan
 - Assess risks
 - Evaluate operating parameters
 - Set controls to mitigate risk
- Task will involve
 - Assessment of crop microbiology
 - Work to develop standards for space-grown produce
 - Work with stakeholders to implement regular crew consumption

Behavioral Health Aspects

- A highest priority stressor anticipated for a long duration mission is lack of sensory stimulation due to isolation and confinement
- Plants have potential countermeasure benefits:
 - Dramatic visual relief
 - Growth and development provide cues to time passing
 - Tending plants can be relaxing
 - Fresh vegetables add flavor, texture and dietary variety
 - Scents, colors and textures augment environment
- Flight approach: Questionnaires with Visual Analog Scales to minimize time required. Also open-ended options.

Acknowledgements This research was co-funded by the Human Research Program and Space Biology (MTL#1075) in the ILSRA 2015 NRA call. We appreciate the support of Bridgit Higginbotham, Brian Gore, and De Antae Cooper. We would like to thank Jeff Richards for help with the poster. Gary Stutte, LaShelle Spencer, and Jeff Richards were critical in the crop selection aspect of this research.