The Microbiology of Microgreens Grown in Controlled Environment Chambers under ISS Conditions.

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Crop Production at Kennedy Space Center

- The food production team is evaluating a myriad of candidate crop species to deliver a highly nutritious and palatable component to the astronaut's diet in space crop systems.

- An evaluation of microgreens is being done at KSC for nutritional content, organoleptic acceptability, and microbiological quality, for eventual selection for space crop production.

Why study microgreens for space crop production?

- Easily grown and harvested between 7-14 days, well suited for CEA.
- The body of research on microgreens is relatively recent and limited.
- Highly nutritious in phytonutrients like antioxidants, Vitamins C and K.
- Microgreens are harvested as young plants, and only the shoot of the microgreen is consumed, excluding any root material and like other leafy greens, they are usually consumed raw.
- Cultivation methods and consumer culinary practices are considerations for the evaluation of microbiological quality and safety.

Microbiological characterization.

- Surveyed 36 microgreen varieties for bacterial and fungal load.
- Food safety screening for *Escherichia coli*, coliforms, *Salmonella* sp and *Staphylococcus aureus*
- Comparative microbial analysis of similar market available microgreens.
- Methods to reduce microbial risk associated with the quality and consumption of microgreens.
  - Sanitization of seeds in bulk with no loss in seed viability.
  - Post-harvest chemical sanitization methods including a produce wash currently used on ISS grown and consumed produce.
  - Seed density and harvest height on the total microbial load.

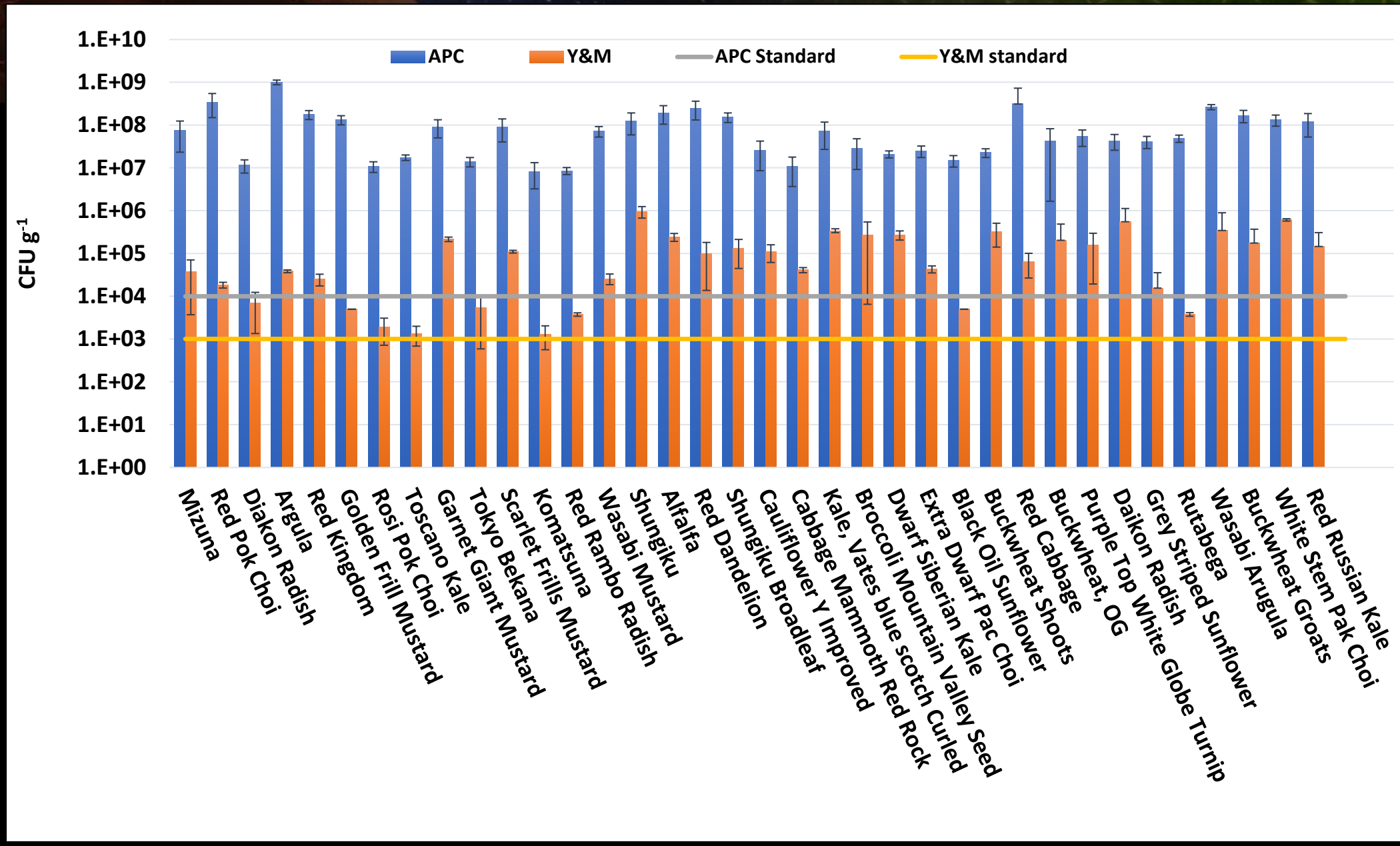
Growing/Harvesting microgreens.

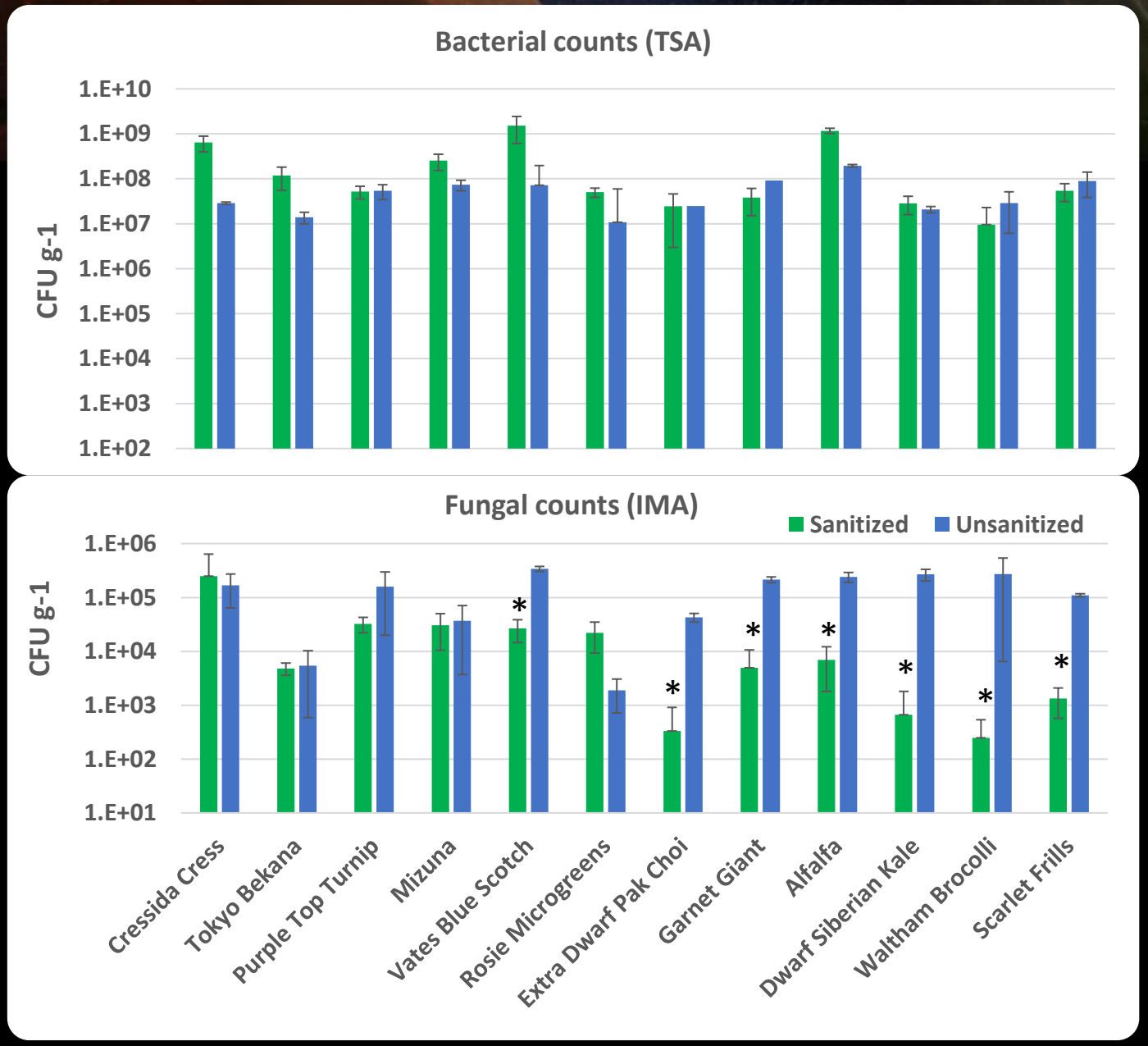
- Seeded onto a sterile hemp mat in a hydroponic tray.
- Seeds weighed and sowed across the mat at consistent pre-determined densities.
- Hoagland's solution (1/2 strength) pumped continuously through the mat.
- ISS like environmental conditions: 23°C, 3000 ppm CO_2 and 50% relative humidity.
- LED lighting: 23% Blue (450 nm), 27% Green (521nm), 50% Red (660 nm), 150 PPFD, 16 hours on/8 off.
- Harvested after 10 days.
- Three, approximately five-gram samples collected for microbiological analysis, after the total yield was weighed.
- For the seed sanitization study, twelve cultivars were used to compare the difference between microgreens sown with sanitized and unsanitized seeds.

Methods

- Seed Sanitization: A larger volume chamber method was developed to enable bulk sanitization.
- Post-harvest Sanitization Testing: 1% H2O2 or 1% Pro-San (Microcide, Sterling Heights, MI) wipe or foam tested.
- Harvest Height and seed density:
  - Two varieties of microgreens, Tokyo Bekana and Black Oil Sunflower harvested at 7, 10 and 14 days with consistent harvest height.
  - Seed planting density: 2/3 and 1/3 density, grown for 10 days

Bacterial and Fungal load





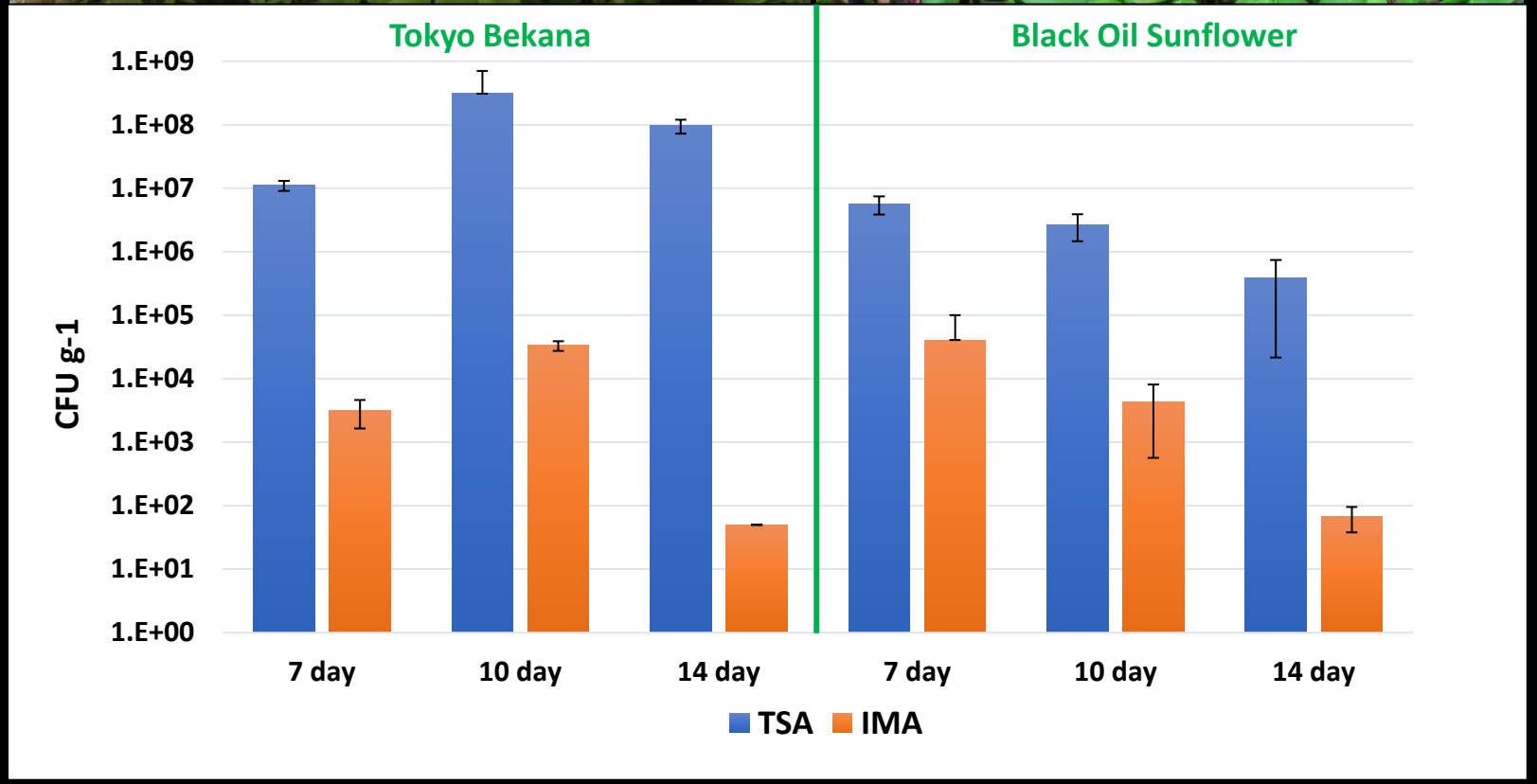
Bacterial and fungal counts (CFU g^{-1}) on microgreens grown with and without seed sanitizing. *Significantly lower fungal counts.

Market vs. Chamber grown microgreens

	APC (CFU g^{-1})		Fungi (CFU g^{-1})	
	Market	Chamber	Market	Chamber
Radish	1.8×10^8	1.2×10^7	5.1×10^3	6.8×10^3
Cilantro	3.7×10^7	1.7×10^8	4.1×10^3	ND
Kale	6.8×10^7	2.1×10^5	1.6×10^3	2.7×10^5
Pea	1.0×10^8	2.9×10^4	8.8×10^2	8.2×10^3
Broccoli	4.1×10^8	2.1×10^5	9.8×10^2	2.8×10^5

Efficacy of sanitizers (ND=no data).

	Log reduction (Bacterial CFU/g)					
	Water	1% H_2O_2 1 min	1% H2O2 3 min	ProSan Foam 1 min	ProSan Foam 3 min	ProSan wipe
Tokyo Bekana	0.59	1.06	0.25	0.89	0.94	0.58
Cressida Cress	0.39	0.69	ND	1.13	ND	0.49
Broccoli	0.67	0.93	ND	0.96	ND	0.91



- A significant difference between day 7 and day 14 harvests from both crops could be seen in the fungal counts.
- Bacterial counts were lower on the sunflower microgreens.

Bacterial (TSA) and fungal counts (IMA) (CFU g^{-1}) Tokyo and Black Oil Sunflower microgreens harvested at the same height (40mm) from the cotyledons at 7, 10 and 14 days. N=3, bars represent standard deviation.

Conclusion

- We describe the microbiological quality of microgreens and possible practices to minimize microbiological risks to the consumer and the quality of the crop.

- We show that seed sanitizing reduces the fungal load on the edible portion of the plant and that some horticultural practices, such as harvest height may impact microbial load.

- These data will contribute to defining critical control points in the cultivation of microgreens for space agriculture.

Thanks!

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