# Microgreens for Human Nutrition in Spaceflight

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## Abstract

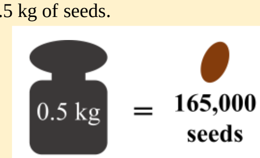
For long-duration spaceflight missions, providing adequate nutritional needs of the crew is a documented risk. This can be mitigated with dietary supplementation of nutrient-dense young vegetables including microgreens. Why microgreens? Traditional crops can take months to mature, but microgreens are ready to harvest in within two weeks, and they can be grown in small volumes. This rapid turn-around time makes them practical for any spaceflight scenario where crew time is limited, or when power, mass, and volume limitations prevent growing crops to maturity. In this poster we will introduce microgreens that have been screened by the USDA for nutritional content, and discuss their nutritional benefits in relation to the specific needs of astronauts, as defined by the NASA Human Research Program. We will specifically highlight the benefits of iron, magnesium, potassium, and carotenoids. We also discuss potential lighting and fertilizer regimens that could be used to further improve nutrient content of microgreens grown in microgravity. Developing microgreens for spaceflight will give us access to crops that are specifically designed to meet crew nutritional needs for future exploration missions.

## Importance:

Microgreens will be especially useful on long-duration spaceflight missions when astronauts cannot obtain regular resupplies of fresh produce from Earth. On platforms like the ISS and Gateway, microgreens can add fresh variety to crew diet. With a 40 $cm^2$ growth chamber, we can produce 26 crops of microgreens per year, and yield >1.9 kg of edible biomass.


It would take 10.9 years to use 0.5 kg of seeds.

If you could supplement astronaut nutrition for over a decade, wouldn't you find a way to pack 0.5kg of seeds?




## Human Nutrition:

- Magnesium improves bone and heart health for astronauts. In conjunction with potassium, magnesium helps with preventing renal stone formation. Magnesium regulates blood pressure.
- Potassium helps with the uptake of calcium, and reduces renal stone formation
- Iron supplementation improves anemia, but levels in spaceflight tend to be too high. It is important that we do not have too much iron supplementation from our crops.
- Carotenoids: beta carotene, violaxanthin and lutein / zeaxanthin are helpful for providing protection against cellular damage from radiation exposure, and improve eye health

Table 1: Mean macroelement (Mg, K), microelement (Fe), and carotenoids (ß-Carotene, Violaxanthin, and Lutein/Zeaxanthin) concentrations in commercially grown microgreens. Table compiled from Xiao et al., 2012 and Xiao et al., 2016.

| | Magnesium (mg/100g FW) | Potassium (mg/100g FW) | Iron (mg/100g FW) | ß-carotene (mg/100g FW) | Lutein/ Zeaxanthin (mg/100g FW) | Violaxanthin (mg/100 g FW) |
|---|---|---|---|---|---|---|
| Arugula | 41 ± 1 | 343 ± 13 | 0.71 ± 0.01 | 7.5 ± 0.4 | 5.4 ± 0.2 | 2.6 ± 0.1 |
| China rose radish | 48 ± 2 | 270 ± 7 | 0.62 ± 0.03 | 5.4 ± 0.5 | 4.9 ± 0.4 | 1.9 ± 0.1 |
| Daikon radish | 60 ± 3 | 176 ± 10 | 0.57 ± 0.02 | 6.1 ± 0.1 | 4.5 ± 0.1 | 1.7 ± 0.0 |
| Mizuna | 29 ± 0 | 354 ± 7 | 0.57 ± 0.02 | 7.6 ± 0.4 | 5.2 ± 0.3 | 2.4 ± 0.1 |
| Peppercress | 33 ± 2 | 320 ± 26 | 0.48 ± 0.03 | 11.1 ± 0.6 | 7.7 ± 0.4 | 3.1 ± 0.2 |
| Purple kohlrabi | 55 ± 2 | 342 ± 7 | 0.75 ± 0.03 | 5.7 ± 0.2 | 4.0 ± 0.1 | 1.5 ± 0.0 |
| Red cabbage | 39 ± 0 | 240 ± 2 | 0.62 ± 0.01 | 11.5 ± 1.2 | 8.6 ± 1.0 | 2.9 ± 0.3 |
| Red mustard | 28 ± 1 | 289 ± 5 | 0.62 ± 0.07 | 6.5 ± 0.4 | 4.9 ± 0.3 | 1.7 ± 0.1 |
| Wasabi | 41 ± 1 | 387 ± 9 | 0.65 ± 0.05 | 8.5 ± 0.2 | 6.6 ± 0.3 | 2.2 ± 0.2 |

## Lighting:

Lighting regimen impacts plant health, biomass yield, and nutritional content.

- Photoperiod – length of time lights are on within a 24 hour period.
- PPFD (Photosynthetic Photon Flux Density) – monitor the light quality.
- Spectral quality – various combinations of white, blue, red, green, far red, and ultraviolet are all possible with modern LED technology.
- Lighting recipes – specific lighting regimens depending on the stage of development, desired nutrient levels, and possibly flavors, for each cultivar.

Garnet Giant Mustard; *Brassica juncea*

Red Cabbage; *Brassica oleracea* var. *capitata*

## Fertilizer:

Without fertilizers, microgreens germinate and grow, but development is suboptimal. Fertilizer choice may impact microgreen nutrition and palatability.

- Slow-release– solid fertilizer that is mixed into the growth substrate
- Hoagland's– common liquid for hydroponic microgreen production

**References:**

- Z. Xiao *et al.*, Microgreens of Brassicaceae: Mineral composition and content of 30 varieties. *Journal of Food Composition and Analysis* **49**, 87-93 (2016).
- Z. Xiao, G. E. Lester, Y. Luo, Q. Wang, Assessment of vitamin and carotenoid concentrations of emerging food products: edible microgreens. *Journal of agricultural and Food Chemistry* **60**, 7644-7651 (2012).