

PICK-AND-EAT SPACE CROP PRODUCTION FLIGHT TESTING ON THE INTERNATIONAL SPACE STATION

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Growing fresh, nutritious, palatable produce for crew consumption during spaceflight may provide health-promoting, bioavailable nutrients and enhance the astronaut dietary experience as we move toward longer-duration missions. However, requirements to support consistent growth of a variety of high-quality crops under spaceflight environmental conditions remain unclear. This study explores the potential to grow crops for consumption on the International Space Station (ISS) using Veggie, NASA's vegetable production chamber system. VEG-04A and VEG-04B were two flight tests with ground components conducted with the leafy green crop mizuna mustard. In each location, mizuna was grown in two Veggie units simultaneously, with the chambers set to different red-to-blue-to-green light formulations. Preflight verification testing with various lighting treatments was conducted to down-select two treatments that contributed to the best desirable growth and sensory qualities in mizuna mustard. For the flight tests, one Veggie was programmed as "red-rich" with an average of $270 \mu\text{mol m}^{-2} \text{s}^{-1}$ of 630 nm red light, $30 \mu\text{mol m}^{-2} \text{s}^{-1}$ of 455 nm blue light, and $30 \mu\text{mol m}^{-2} \text{s}^{-1}$ of 530 nm green light. The second Veggie was "blue-rich" with an average of $150 \mu\text{mol m}^{-2} \text{s}^{-1}$ of 630 nm red light, $150 \mu\text{mol m}^{-2} \text{s}^{-1}$ of 455 nm blue light, and $30 \mu\text{mol m}^{-2} \text{s}^{-1}$ of 530 nm green light. Light quality is known to impact plant growth, nutrition, microbiology, and sensory characteristics on Earth, and the Veggie flight tests examined how these impacts might differ in microgravity. VEG-04A, a 35-day growth test with a single harvest, was initiated in June and harvested in July 2019. VEG-04B, a 56-day test with three harvests from the same plants, assessed sustained productivity. Preflight testing for VEG-04B was conducted after the VEG-04A flight test to improve the operations, approaches, and watering requirements, which resulted in better crop establishment in the VEG-04B flight test. VEG-04B was initiated in October 2019 with harvests at four, six, and eight weeks after initiation. At all of the harvests, the astronauts froze half of the edible plant tissue to return to Earth and weighed the remaining half using the Mass Measurement Device (MMD). Weighed samples were then cleaned with produce-sanitizing wipes, and consenting crew members participated in sensory evaluations of the fresh produce. The remaining sanitized produce was available for crew consumption as desired. Frozen flight samples were returned to Earth for chemical and microbial analyses to assess nutritional quality and food safety. Flight-grown mizuna was generally more acceptable to the crew and had higher nutrient levels, although mizuna grown in the ground control performed better in terms of higher yield and lower microbial load. This presentation will focus on results from the nutritional and sensory analyses, including how nutrients identified as key for supplementing the crew diet varied across lighting treatments, harvest approaches, and spaceflight versus ground conditions. It is our hope that these tests on the ISS will help mitigate the risk of an inadequate food supply for long-duration missions by adding fresh vegetables to the crew diet. This study was supported by NASA's Human Research and Space Biology Programs through the HERO NNJ13ZSA002N-ILSRA grant solicitation.