
# Advancing Space Nutrition: From Regret Paste to Resilient Food Systems

## Executive Summary

Space exploration requires food that sustains crews over long periods. Current rations, mostly freeze-dried and packaged, lead to nutrient shortfalls, health risks, and low morale. NASA's Veggie system on the ISS shows that plants grown in microgravity lose minerals and face oxidative stress. Gastronaut is developing solutions to grow fresh, nutrient-rich food in space. We use CRISPR to improve crop quality and systems like ORCA to enable growth. This white paper examines the current state of space food, its limitations, and Gastronaut's path forward.

## Introduction

Food in space has a short history. Yuri Gagarin ate pureed meat from a tube in 1961. Today, astronauts on the ISS eat a mix of rehydrated meals, tortillas, and occasional fresh items. For future missions to the Moon or Mars, food must last years without resupply. It needs to deliver calories, nutrients, and some normalcy.

Gastronaut works on this problem. We focus on growing fresh microgreens in space. Our approach combines genetic tools like CRISPR with hardware to simulate gravity. The result is food that supports health and performance.

This paper reviews space food today, its challenges, and how Gastronaut contributes to change.

## The Current State of Space Food

Space food is designed for shelf life and safety. NASA and other agencies use freeze-drying, irradiation, and pouches. Meals include items like beef stew, macaroni, and tortillas. Drinks come in pouches with straws. Calories range from 2,000 to 3,000 per day, with balanced macros. Fresh food is limited. The ISS has a small fridge, but most items are stable at room temperature. Resupply missions bring occasional fruit or cheese.

NASA's Veggie system grows plants on the ISS. It uses LED lights and fabric pillows for roots. Crews have harvested lettuce, radishes, and peppers since 2014. These add variety and test farming.

Veggie provides data on growth in microgravity. Plants yield fresh mass, but results differ from Earth. Microgravity affects water distribution and root orientation. Radiation and cabin air add stress.

Astronauts say Veggie greens taste good. They eat them raw or in salads. Yet Veggie covers only a small area—about 0.3 square meters. It supplements rations, not replaces them.

Other programs exist. China's space station grows rice and tomatoes. Russia's Lada system tested wheat. These show growing interest in on-board agriculture.

## Challenges in Space Nutrition

Long missions reveal limits in current food. Astronauts lose 5–10% body mass over six months on the ISS. This stems from muscle atrophy, bone changes, and diet issues.

Packaged food lacks fiber and fresh water. Rehydrated meals help, but fiber remains low. Gut health suffers. Studies link microgravity to increased intestinal permeability (leaky gut) which impairs absorption and raises inflammation.

The 2025 npj Microgravity paper reviews Veggie crops. Space-grown lettuce shows lower minerals than Earth controls. Calcium drops to 418–642 mg/kg from 928 mg/kg. Magnesium falls to 274 mg/kg from 365 mg/kg.

Nutrient comparison: Ground control vs. orbit-grown crops (from npj Microgravity, 2025). Bars show Ca, Mg, Fe, and other minerals in mg/kg. Orbit values are consistently lower, with red shading for deficiencies. (Source: npj Microgravity,)

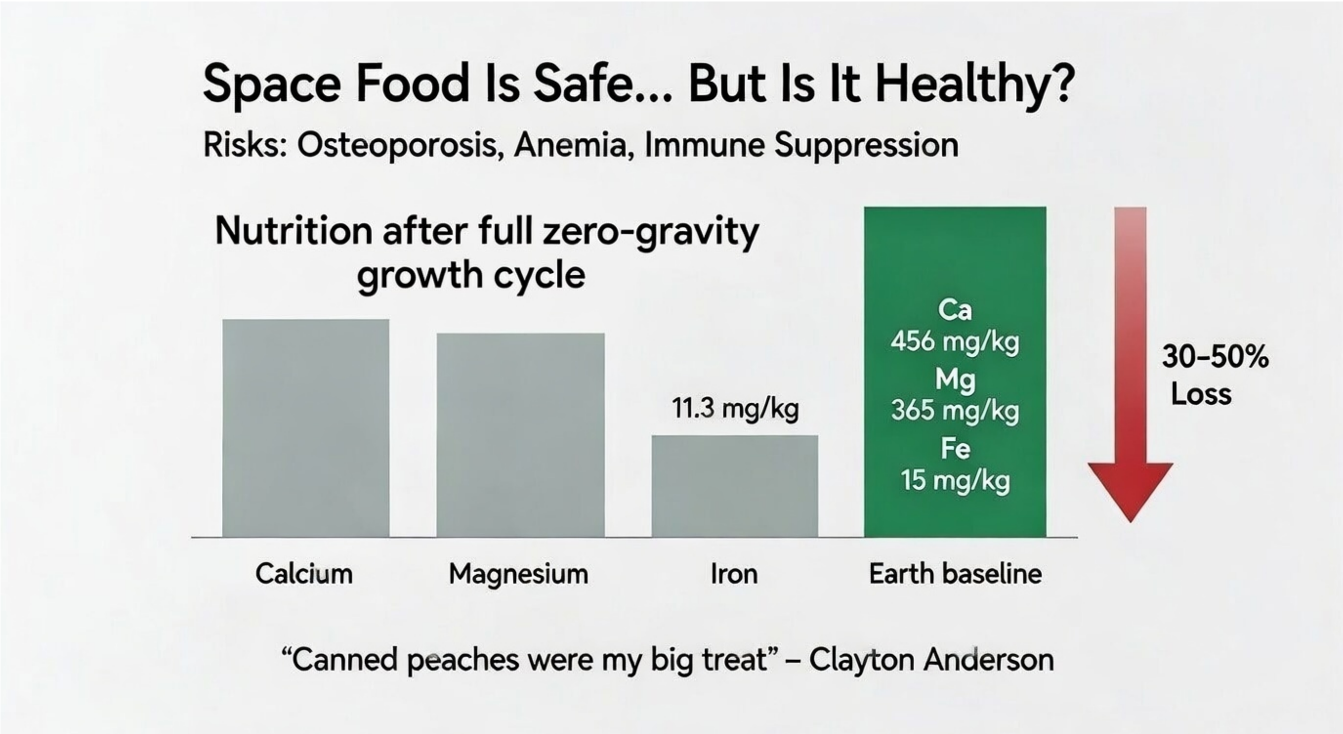
Antioxidants also vary. Phenolics drop below 30 mg/g in some samples. Carotenoids degrade faster.

Reactive oxygen species (ROS) increase 5 times in space plants. ROS damage cells and reduce quality. This links to radiation and lack of gravity.

For crews, these gaps mean diets short on essentials. Low calcium speeds bone loss. Low magnesium causes cramps. Weak antioxidants increase oxidative stress, affecting immunity.

Morale drops. Astronauts call food "wallpaper paste." In 1965, John Young smuggled a corned beef sandwich on Gemini 3. Crumbs floated everywhere, risking equipment. It showed the need for better options.

Veggie data highlights uneven growth. Roots wander without gravity. Water forms blobs, risking mold.




For Mars, resupply takes months. Food systems must close loops. Current tech recycles air and water, but food remains open.

Bar chart of fresh weight (g) for plants under microgravity vs. 1g control (from various studies, e.g., tobacco, soy, wheat). Flight bars are lower or similar, showing growth challenges. (Adapted from NHSJS and related research)


## Gastronaut's Approach

Gastronaut builds systems to grow fresh food. Our model is Nutrition-as-a-Service. Agencies get hardware, data, and support on subscription.

We focus on microgreens. They grow in 3–7 days and pack nutrients. On Earth, microgreens have high vitamins and antioxidants.
CRISPR improves crops. This tool edits genes precisely. We target enzymes like SOD, CAT, and GPX to handle ROS. Edits raise enzyme levels, cutting damage.
We also boost nutrient pathways. CRISPR increases calcium uptake and phenolic content. Crops deliver more for bones and cells.
CRISPR is safe for food. It mimics breeding. No foreign DNA is added.
To grow these plants, we use ORCA. This is a 0.24 square meter drum. It spins at 0.3–0.5g to simulate gravity. Plants sense direction. Roots grow properly.
ORCA uses LEDs and Raspberry Pi controls. Crew time is low; 15 minutes per cycle. It fits station racks.
Tests show results. Over 1,000 cycles, ORCA cuts ROS 40–60%. Calcium rises 140%. Yields reach 0.8–1.5 kg per cycle.
ORCA aids life support. Plants take $CO_2$ and release $O_2$. One unit covers 20–25% of an astronaut's air needs.
We combine CRISPR seeds with ORCA. This creates resilient food. Greens add fiber, water, and texture. They support gut health.
The system scales. Start with ISS pilots. Move to Gateway. For Mars, use fleets to close loops.

## Benefits

Improved food maintains weight and strength. Nutrient boosts protect bones. Antioxidants reduce stress.
Gut health improves. Fiber aids digestion. Inflammation drops.
Morale rises. Fresh food breaks routine. Veggie harvests lift spirits. Sharing salads matters in isolation.
Costs fall. Growing food reduces resupply. Each kg saved is thousands of dollars.
Systems become sustainable. Plants recycle air and water. Waste turns to resources.
Gastronaut leads with NaaS. Agencies pay for results. We partner with researchers. The npj paper guides us. The Veggie Data informs us. Advisors help refine.

## Conclusion

Space food has improved since early tubes. But long missions need more. Veggie data shows nutrient losses. Health risks remain.

Gastronaut offers a path forward. CRISPR enhances crops. ORCA enables growth. Together, they provide healthy food.

We invite interest. Visit gastronaut.earth. Help feed the future.

## References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