

Can we grow safe and nutritious food in space?

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Abstract

Have your parents ever told you to eat your vegetables because they're "good for you"? Well, vegetables have a lot of nutrients in them that are essential to a balanced diet. While you might get these foods at the store, astronauts rely on processed meals. We wanted to find out if there was a way to grow safe and nutritious salad crops on the International Space Station (ISS) to help supplement their

diets. We used a growth chamber called **Veggie** to grow crops of red romaine lettuce over three different years. We found that our lettuce was safe to eat, although the nutrient content of our lettuce varied slightly each year. For future long-duration space missions, it will be important to make sure that astronauts can create the same growing conditions for every crop of salad.

Introduction

Have you ever wondered what astronauts eat when they're in space? What would they eat if they had to travel all the way to Mars? **A lot of the food astronauts eat is processed because it's simple to eat and easy to transport into space.** Unfortunately, processed foods are sometimes low in essential **micronutrients** like potassium or Vitamin K. Some vitamins can break down if the food is stored for a long time. People can develop health issues if they don't eat a balanced diet.

Growing fresh food in space to supplement the processed food they bring with them might help astronauts stay healthier on long missions. It would also give them more variety! Fresh salad **crops** grown on Earth contain many micronutrients that processed foods do not. We don't know if crops grown in space are the same.

Another concern with growing food anywhere is making sure that it doesn't have any bacteria or fungus on it that could make people sick (sometimes called **foodborne pathogens**). Astronauts need to avoid contaminated food because the immune system doesn't work as well in space.

They could get sick much more easily than someone on the ground.

Luckily, the ISS has a plant growth chamber called Veggie (Fig.1). We used Veggie to find out if it was possible to grow nutritious and safe food in space.



Figure 1:

Red romaine lettuce being grown in Veggie on the International Space Station. The mixture of red, blue and green lights is good for growing plants.

Methods

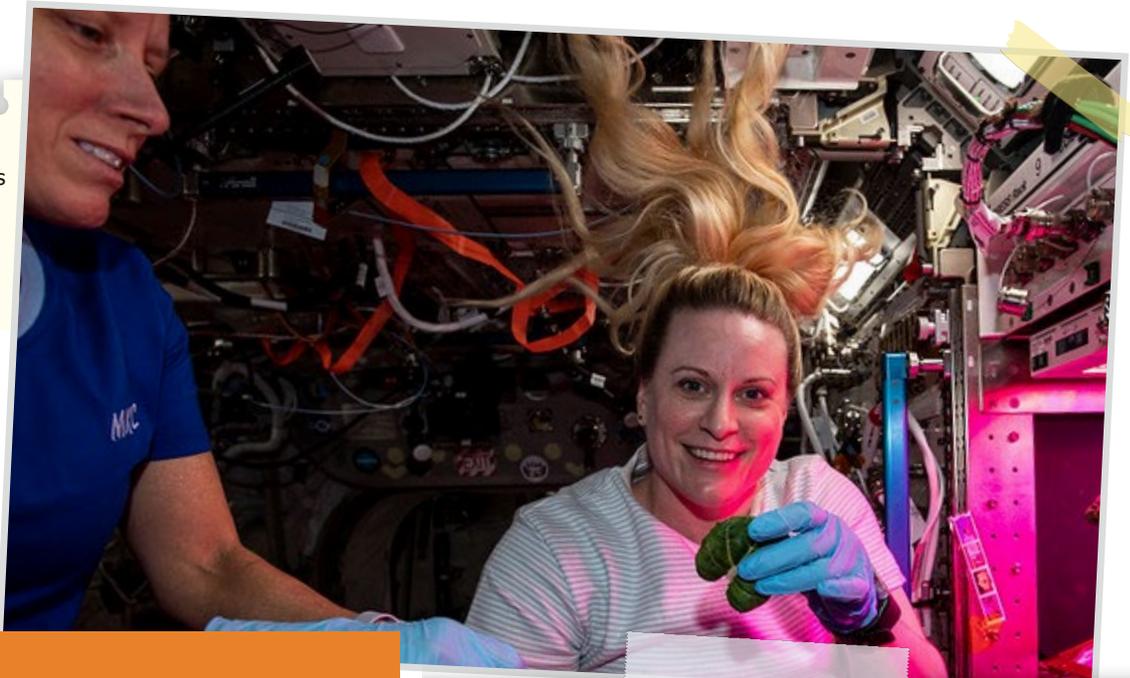
We used Veggie to grow red romaine lettuce on the ISS in three sequential crops over three years. We compared these (ISS-grown) to control crops of red romaine lettuce grown at the same time on the ground (ground-grown). Apart from the presence of gravity, they were grown under the same conditions we measured on the ISS (humidity, carbon dioxide, and temperature). We collected samples from the leaves and roots of all the lettuce plants.

When the mission returned to Earth, we tested all the lettuce for two common foodborne pathogens, *E. coli* and

Salmonella. In the lab, we grew colonies of other bacteria and fungi that we found in our lettuce. We then used DNA isolation techniques to identify bacteria and fungi with the help of national databases. Some species of bacteria and fungi don't grow very well in the lab, so we directly sampled the lettuce for DNA analysis and ran these through the databases.

We also determined the nutrient content of all the lettuce samples we grew.

NASA astronauts Shannon Walker and Kate Rubins collect salad leaves from Veggie.
Photo: NASA



Results

We found:

- Frequently, greater numbers of bacteria and fungi on ISS-grown leaves (Fig. 2).
- Similar numbers of bacteria and fungi on roots regardless of where they were grown.
- Our lettuce all tested negative for *E. coli* and *Salmonella*.
- A higher diversity of bacteria and fungi on the roots than on the leaves of our lettuce.

We did not find any differences in nutrient content between ISS-grown lettuce and ground-grown lettuce. There were some differences in nutrients between the crops we grew in different years.

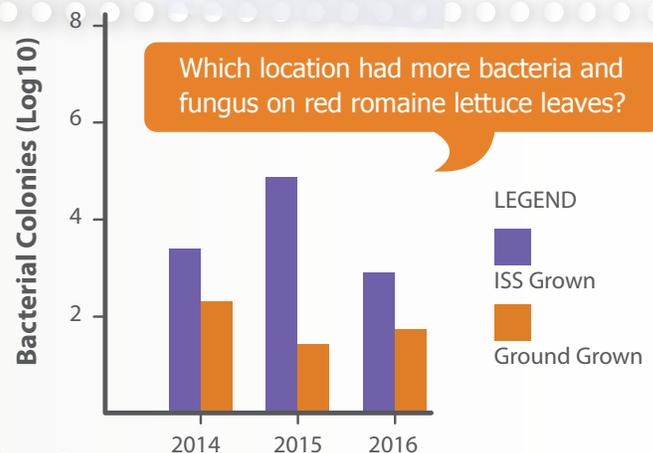


Figure 2: Number of bacteria grown in the lab from red romaine lettuce leaves. The Y-axis uses a Log10 logarithmic scale, which makes it easier to display a very large range of values.

Discussion

Our study shows that it is possible to grow food on the ISS that is safe for astronauts to eat. All of our lettuce had relatively low amounts of bacteria and fungi compared to grocery store produce. Our lettuce also tested negative for common foodborne pathogens. This means that astronauts should be able to eat salad crops grown in Veggie without worrying about getting sick.

Even though our lettuce was safe to eat, we were surprised to find greater amounts of bacteria and fungi on ISS-grown lettuce. These results could be explained by:

- technical difficulties we had with the air circulation in Veggie. Lots of bacteria and fungi grow well in wet environments.

- additional bacteria and fungi that came from the ISS water supply, air, or astronauts who accidentally transported them onto the lettuce.

We think that environmental conditions could have changed the nutrient content in the lettuce we grew in different years. Plants can respond strongly to too much or too little water, and it is hard to water plants in zero gravity. We need to make sure that growing conditions are consistent in Veggie. Then astronauts can be confident about the nutrients in their food on long-duration missions.

Conclusion

Astronauts will need innovative ways to provide themselves with safe and nutritious food as space exploration expands and missions get longer. But astronauts aren't the only ones who need safe and nutritious food to stay healthy.

There are lots of ways you can make sure you're eating safe and nutritious food here on Earth!

- Wash your produce before eating it, and don't let leftovers stay in the fridge for too long.
- Start your own garden at home.
- Try out new vegetables – you might find a variety you really like.
- Talk with friends and family about eating a balanced diet.
- Eat more fresh foods at home instead of going out to eat.

REFERENCES

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NASA Space Station Research: Seven ways the ISS helps study plant growth.

https://www.nasa.gov/mission_pages/station/research/news/Seven-Ways-the-ISS-Helps-Study-Plant-Growth

Discover Magazine: How do scientists build the best diet for astronauts?

<https://www.discovermagazine.com/the-sciences/how-do-scientists-build-the-best-diet-for-astronauts>

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Glossary of Key Terms

Crop – a plant that is grown as food; also, an amount of such a plant harvested at one time.

Diversity – the variety of different species of organisms occupying the same habitat. Higher diversity indicates there are more species present in an area.

DNA isolation – a technique used to separate DNA from the rest of a cell's contents. Cells are first broken apart to reach that DNA in the nucleus. Then the DNA is separated from the rest of the cell parts using chemicals that force the DNA to clump together. Finally, the unwanted cell parts are washed away, leaving only DNA.

Foodborne pathogens – bacteria, viruses or other microorganisms that grow on food and can cause illness in the humans who eat them. The Food and Drug Administration (FDA) tests for common foodborne pathogens like *E. coli* and *Salmonella* in commercially available food.

Micronutrients – vitamins and nutrients that organisms need in very small amounts. Examples are calcium, iron, zinc, potassium, vitamin K, vitamin C and manganese.

Veggie – plant growth chamber on the International Space Station where light and airflow can be automatically controlled.

Check your understanding

- 1 What benefits would astronauts get from growing their own food in space?
- 2 Why is it important to test foods for bacteria and fungus before eating them?
- 3 What evidence in this study supports the claim that food grown in space is safe to eat?
- 4 The researchers in this study found some unexpected results. What did they think some of the problems might have been in their study design? Can you suggest some solutions to these problems?
- 5 Do some research online. What does it mean to have a balanced diet? What types of foods would you need to eat to maintain a balanced diet? Design a meal plan for one day and identify the key nutrients you would consume.