Food and Nutrition in Space

Level
Grades 5 and higher

Introduction

Travel over long distances has always required that arrangements be made to provide food along the way. When traveling by car one can, of course, usually just stop at a store or restaurant whenever it's convenient. But a hiker in the forest or a passenger on a plane, train, or ship doesn't have that option and must make sure that food that is needed is carried along. When deciding what food to take, the hiker or the person provisioning the vehicle has many needs, such as nutrition, safety, convenience, taste, volume, and weight that are similar to those of the astronauts. Some of these factors are more important for space travel than on Earth and astronauts must also consider how to package, prepare, and eat food in microgravity.

Astronauts in space take with them prepared foods that are adequate in quantity and nutritional value to sustain them in good health during the flight. But any fresh foods that can be brought along are usually consumed within the first few days and many astronauts have found that they miss the taste, texture, flavor, and aroma of unprocessed food. Some greens or small vegetables to augment their diet might be suitable for astronauts to grow on the ISS using a system like the Space Garden.

In this activity, students will learn about and discuss criteria used in selecting food for astronauts and will use these criteria to select an experimental plant to grow in their classroom Space Gardens. They will learn to distinguish objective criteria, such as plant mass production, from subjective considerations, such as taste, and to evaluate their test plants using these criteria. They will also become familiar with the properties of their Space Gardens and discuss why and how the Space Garden design is appropriate for use in growing plants on the ISS. Students will develop skills in research and critical thinking that are needed in scientific inquiry.

Question

What are some plants that astronauts can grow and eat in space?

Hypothesis

Some plants can be expected to be suitable for growing and eating in space.

Design

Students in small groups will use print and electronic media to discover criteria used by NASA to determine what foods are currently selected for use on the ISS. (They may also find information on how and why some of these choices may be different for the 2-year mission to Mars.) Students will list these criteria and categorize them as objective (measurable) or subjective (preferential).

In small groups, students will examine their Space Gardens. They will note how this system is similar to a container garden on Earth as well as the specific design features that have been added to make it suitable for use in the microgravity environment of the ISS. After examining their Space Gardens, students may wish to include additional plant selection criteria to their list. As a class, the students will discuss the criteria and decide which they feel are most important in choosing food plants to be grown on the ISS. Using this ranking of criteria, the students will select a test plant that will be used as the experimental plant to be grown in Activity 2.

Timeframe

Research into food selection criteria and listing and categorizing those criteria may require one 50-minute class period. An additional 50-minute class period will be needed for examination of the Space Garden, discussion and ranking of the plant selection criteria, and selection of a test plant for Activity 2.

Learning Objectives

By participating in this activity students will:

- Practice research skills by using print and electronic media to discover and list criteria used by NASA to choose foods for astronauts.
- Gain decision-making tools by learning to distinguish between objective and subjective criteria for making choices.
- Improve communications and decision-making skills by discussing plant choice criteria and articulating reasons for ranking those criteria.
- Practice research skills by using print and electronic media to determine how well possible test plants would be expected to meet the established criteria (e.g., size, nutrition, palatability).

Materials

- Classroom Space Garden kits, each containing 5 Space Garden units - At least three Space Garden units for each type of test plant (3-4 students per unit)
- Rulers (metric)
- Computers with internet access and/or access to library materials on living in space
- Seed catalogs (paper and/or electronic) and/or seed packets for possible test plants
- De-ionized or distilled water
- Liquid and dry measures (metric, measuring devices for children's medication or the small measuring cups that accompany liquid medication can be used)

Procedure

Class 1, Activity 1

1. Introduce students to the Space Garden. Measure and record the dimensions, inside and out, of the collapsed and expanded Space Garden. How much additional room for growth is provided by expanding the bellows? This information will be important in choosing an appropriate test plant.
2. Students meet in small groups to "brainstorm" possible criteria[1] for choosing foods for astronauts and to research print or electronic information to confirm or expand their list of criteria.
3. Students meet as a whole to discuss and tabulate the results of their small-group discussion and research. Students should compare their combined list to NASA's stated criteria for choosing astronauts' food (see appendix 1). Have students classify their combined list of criteria as either objective or subjective and then rank each criterion on how important they feel it would be in determining what food plants might be suitable for gardening in space. At the end of the group discussion, students select 4-6 criteria that they feel are most important in choosing space food plants. How many of the chosen criteria are objective and how many are subjective? [2]
4. Have students read the information on the seed packets and/or in the seed catalogs to see if they can determine if the plants they might want to choose will meet the criteria they have established (e.g., size, days to maturity, edible portion). At this point students will have an idea of the plants they may want to try, but caution them to reserve their final decision until they have become more familiar with the features of the Space Garden.

End of Class 1, Activity 1

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[1] Nutrition is a critically important consideration for extended missions in space. The Space Garden activities coordinate well with a more extensive discussion and/or lesson about nutrition, basic food groups, understanding food labels and choosing a balanced diet. (Lesson plans on this topic are available from http://www.nutritionexplorations.org/ and http://www.nal.usda.gov/fnic/pubs/bibs/edu/preschool.html.

[2] The criteria for choosing food plants to be grown in space are not all the same as choosing foods to be carried into and eaten in space. An extra activity might involve drawing a Venn diagram to illustrate where these criteria overlap and where they are different.

Class 2, Activity 1

5. Distribute Space Gardens to each small group and ask for general discussion. Is the Space Garden similar to anything with which the students are familiar (e.g., a terrarium)? Discuss how the Space Garden is different from most earth-bound plant growth systems.[3] Point out the Space Garden's special features, such as its expanding bellows, variable opening to the ambient environment, "underground" watering mechanism with a narrow injection port (the flight version also has a valve to prevent leakage), soil containment mechanism, and special growth medium ("soil"). Why are these features important for growing plants in microgravity? Answers might include solid and liquid particle containment (loose particles may disrupt equipment or be inhaled by astronauts); light weight (every pound at liftoff to the ISS costs approximately $10,000); small volume (an obvious advantage) but expandable to optimize available light and accommodate growing plants.
5. Open the Arcillite[4]/fertilizer mix and circulate a small amount (about 15 cc) among the class. How is this growth medium different from outdoor garden dirt (e.g., no micro flora/fauna, coarse granular texture) and commercial potting soil (e.g., coarse granular texture, very little dust, no obvious organic matter)? How do these characteristics help to make Arcillite suitable for use as a rooting medium in microgravity?
6. Tip the dish with the measured Arcillite from side to side and note how it slides around. Now add approximately 15 ml of distilled water and mix it thoroughly with the Arcillite. Tip the dish again and note that the movement is eliminated or greatly reduced. Also, there should be no free water to spill (this is approximately the appropriate degree of wetness for planting the Space Garden.). This demonstrates the

[3] The Classroom Space Garden is also different from the Astronaut Plant Bags used in space. The design and functionality are the same, but some of the materials are different. NASA standards for flammability and environmental interactivity require the use of much more costly components.

[4] Arcillite is heat-treated clay. On Earth it has several current applications in industry and even in cosmetics. It is often used as a non-clouding, non-nutritive rooting medium for ponds and aquariums. It is also sometimes used as an additive to improve the aeration, water-holding and nutrient-holding capacities of potting media. Historically, Arcillite (also known as fuller's earth) was used in the textile industry to absorb oils and dyes. In space Arcillite has been successfully used as a substrate for growing wheat and *Brassica rapa*. Hartz brand kitty litter or Oil Absorb can be used as a substitute for Arcillite.

cohesive[5] (particles stick to each other) and adhesive (particles stick to the container) qualities of the moistened Arcillite.

7. Holding the moistened Arcillite over another container, turn the dish upside down. Of course, it falls out! This is why the Space Garden is equipped with additional means (the foam pad and the base of the bellowed chamber) of holding the rooting medium in place.
8. Have students place the foam cover under the bellows module (They should be able to see where the foam "fits").
9. Estimating the amount of water required to start the Space Garden: Students should pour Arcillite into the bottom of their Space Gardens to reach the top. Then pour the Arcillite into a beaker to measure its volume. If 15 cc Arcillite required 15 ml water, how much water should be required to wet the amount in the Space Garden? Pour the dry Arcillite back into the base of the Space Garden. If you expect to plant the Space Garden within the next day or two (better to wait on the next step if planting will be delayed), the students can slowly add water through the port with the graduated syringe until the Arcillite appears uniformly wet but there is no visible free water. If free water appears after the unit has settled for a few minutes, it can be withdrawn through the port using the syringe. Compare the estimated amount needed with the actual amount used.

Concluding Activities and Further Questions

Test the hypothesis: Are there plants that can be expected to meet the criteria for successful growth in the Space Garden (in space) and consumption (by astronauts)? Now that the students have decided on criteria for choosing a test plant and are familiar with characteristics of possible test plants and features of the Space Garden, have them discuss why or why not certain plants might be more suitable than others.

- Make a final list of the criteria to be used in choosing the test plant. (This list will be

[5] Water molecules, which are polar and strongly attracted to each other, are highly cohesive. They are constantly forming and breaking hydrogen bonds that are weak enough to allow water to flow, but strong enough to prevent individual molecules from rapidly dispersing. This is a very useful quality in micro-gravity, especially if some water should happen to "escape." Surface tension of water is the result of hydrogen bonding.

the basis for gathering data during Activity 2 and for evaluating the test plant's suitability for space gardening.)

- Why were these criteria chosen over other possible criteria?
- Are the chosen criteria objective or subjective?
- Is there more than one type of plant expected to meet all of these criteria? If so, the hypothesis is true. If not, the hypothesis is not true, at least for the current choice of criteria and available plants.
- Choose a test plant that is expected to meet all or most of the selected criteria from among the available seeds (or decide what seeds to order). (Not all choices may be ideal - sometimes compromises are needed.)

Extension

- What foods are currently available for astronauts?
- Study the food pyramid and design a sample menu for a week for an astronaut on the ISS
- What plants have been grown in space? Why?

End of Class 2, Activity 1

Appendix 1

NASA considerations in selecting food for space flight: [6]

FOODS

- Safe
- Nutritious
- Light weight
- Compact
- Appealing (i.e., good taste, smell, appearance and texture)
- Easy to eat in microgravity
- Easy to digest
- Diet has variety
- Causes no gastroenterological problems
- Causes no hygiene problems (e.g., rotting waste parts)
- Able to withstand temperature, acceleration ,and vibration of spaceflight
- Does not require large amount of water for rehydration

PACKAGING

- Light weight
- Compact
- Provides protection and stability for food for extended periods
- Allows easy food preparation with little crew input
- Allows easy disposal of waste food and packaging
- Able to withstand temperature, acceleration, and vibration of spaceflight

Additional possible considerations for food plants:

- Seeds light weight
- Plants compact
- Plants fast growing
- Easy to grow in microgravity
- Does not require large amounts of water or added nutrients
- Nutritious
- Safe
- Appealing (i.e., good taste, smell, appearance, and texture)
- Adds variety to the diet
- High ratio of edible parts to waste

[6] http://liftoff.msfc.nasa.gov/academy/astronauts/food-constraint.html