Math and Science with Space Food

Students practice math and science skills while they learn about space food. Concepts taught include dehydration and rehydration, measurements, and an introduction to Newton's Second Law of Motion.

LESSON PLAN

Grade Level: 6—8

Ohio Learning Standards/Mathematics (2017)

Standards for Mathematical Practice
Use appropriate tools strategically

6.RP.3: Ratio and proportional relationships
7.RP.3: Proportional relationships
7.EE.3: Solve multi-step real world problems

Ohio Learning Standards/Science (2018)
Expectations for Learning
Nature of Science
Scientific Inquiry, Practice and Applications

Physical Science
6.PS.1: Matter has mass, volume and density
7.PS.2: solutions, suspensions, and colloids
8.PS.1: External field forces
8.PS.2: Forces change motion

Ohio Learning Standards/Technology (2017)
6-8.DT.3.b.: Explain ways that invention and innovation within one field can transfer into other fields of technology

Materials Required:

- Sandwich-sized re-sealable plastic bags
- Variety of powdered drink mixes, both sweetened and unsweetened
- Electronic scale
- Rulers/tape measure
    - Measuring cups or beakers
    - Measuring spoons
- For the extensions:
    - Sugar
    - Artificial sweetener
    - Dry pudding mix
    - Pudding in single serve containers
    - Other dehydrated food options

Learning Objectives

The students will
- Work in teams to complete the lesson
- Hypothesize why many foods used in spaceflight are dehydrated
- Decide what process to use to determine if the hypothesis is correct
- Use measuring skills
- Learn why the physical size of an object and its mass are important in space travel.
- Compare results and express the difference in mathematical terms.

Purpose

In this lesson, students will practice math and science skills while experimenting with a powdered drink mix to determine why some of the foods consumed by astronauts in space are dehydrated.

Background

Providing food for astronauts to eat during spaceflight has been a very challenging task. Food needs to be compact and light weight and provide all the nutrients the astronaut needs to remain healthy. It also needs to taste good and to feel and smell as close to food we eat here on earth as possible. The categories of space food include rehydratable, thermostabilized, intermediate moisture, natural form, irradiated, frozen, fresh and refrigerated. This lesson plan will focus on rehydratable food and will involve math, science, technology and engineering content and skills. It is assumed that the students have a prior understanding that, while in the freefall environment of space travel, astronauts and everything aboard the spacecraft (or space station) will be "weightless" and appear to float – including their food!

Problem
What might be the important advantages to dehydrating beverages to be consumed in spaceflight? [weight and size are both reduced] How can we test this hypothesis? By comparing the product before and after rehydrating.

- Calculate the amount and weight of powdered drink mix required for a single serving size.
- Use measuring skills to calculate the amount and weight of the reconstituted beverage.

Procedures:

- Begin by giving the students a scenario in which they are going to have to carry an object a very long distance, but they have a choice between two different objects—one that is very heavy (lots of mass) and one that is very light (very little mass). Which would they choose and why? The lighter object—the one with less mass—takes less effort to move. [if appropriate: explain that they have just described Newton's Second Law of Motion] The amount of force that it takes to move an object depends on the amount of mass. The more mass, the more force needed. This is a real problem for rocket engineers who need to design a rocket to carry a lot of mass into space. The less mass the better for getting an object launched through our atmosphere into space. In addition, the amount of available storage in a spaceship is always a concern. So, both weight and volume are the issue.
- If necessary, introduce the concept of microgravity/freefall to the students. Also, introduce the vocabulary to be used in this lesson, as appropriate (dehydrate, rehydrate, solution, dissolve).
- The students will work in teams of 4 to 5 students.
- Have the students hypothesize as to why some foods are dehydrated for spaceflight. They should understand that this process will create food that weighs less and takes up less space. These are two crucial elements to rocket engineers! Have the students determine how they can test that theory—by weighing and measuring a food substance that is dehydrated and then again after reconstituting the same amount of food.
- Give the students a container of powdered drink mix and several plastic sandwich bags with pressure seal closures.
- Given the amount of powder needed to create a larger amount (e.g. a quart or a gallon), students will need to determine the correct amount of powder to use for a single serving size (8 ounces). They will then need to measure out that amount of powder.
    - For example, if it takes 1 cup of powder to make 2 quarts of beverage, then it will take 1/8 cup of powder to make an 8 ounce serving [2 quarts = 64 ounces or 8 servings]
- Students will need to then weigh the empty bag and then weigh the bag with the powder inside.
- Determine the weight of the powder by subtracting the weight of the empty bag from the weight of the bag with the powder inside. Record the weight.
- Students should weigh a second empty bag and then again add the amount of powder needed for a single serving. In this bag, the students need to add 8 ounces of water. The bag should be carefully sealed and manipulated to help dissolve the powder into a beverage. Then they should weigh the bag with the reconstituted beverage and subtract the weight of the empty bag to find the weight of the reconstituted beverage. Record the weight.
- Compare the two weights. How much more did the reconstituted beverage weigh? What percentage increase is that? Have the students hold the bag with the dry powder with one hand and the bag with the reconstituted liquid in the other hand to really feel the difference.

- Students should also measure the two bags to determine if one takes up more space (length and width will be the same—but take a look at the depth). What is the difference in the size of the bags? Give the exact measurements and percentage increase.
- To determine the extent of the savings in both size and weight for beverages alone, students should calculate the total savings in both the size and the weight if the requirement is to launch seven astronauts for two weeks with each having enough packets to make three servings of beverage per day.

Special Note:

Hopefully, your students will come up with the following question: if you have to take both the water and the dehydrated beverage into space, then why wait to combine them in space? Wouldn't the weight and the volume add up to be the same? The answer is yes it would. See if the students can determine why it is still better to wait until they are in space to rehydrate their food. The answer is that the water does not necessarily have to be transported into space. In spacecraft that utilize fuel cells, some of the water would be readily available as it is a by-product of the fuel cells used to power electrical systems (this was the case for the Space Shuttle). On the International Space Station, however, fuel cells are not used—it is more economical and more practical to use solar arrays to convert sunlight into energy. So water does have to be taken to the station. However, they now have an extensive system of re-cycling the water used on the station (as well as water from the air and even recycled urine) to cut back on the amount of water that needs to be taken and stored there. Also, dehydrated food has the extra advantage of easier storage. And the flexible containers used for rehydrated food can be compacted easier in the trash.

Additions or Extensions:

- Have students try different types of food—pudding, for example. Compare the savings in size and weight for the dehydrated powder and for the reconstituted pudding.
- Have the students use a beverage powder that requires the addition of sugar or a sugar substitute. Have some students use granulated sugar and others add an artificial sweetener. Did the baggies with the dry powder weigh the same or were they different? Did the reconstituted beverages weigh the same or were they different? Based on this information alone (not nutrition), which is better for space travel: regular sugar or a sugar substitute? Why?
- Students could research how an astronaut would drink the reconstituted beverage from a bag (astronauts have special beverage bags that contain built-in straws with clips—why do the straws need clips?). How do liquids react in microgravity?
- Have students research the process of dehydration, especially how the powdered drink mixes are made. Perhaps they could dehydrate some fruit for a classroom snack.
- Include a lesson on the chemistry of the mixture created when the water was added to the powder. What type of mixture is it (emulsion, suspension, solution, etc.)? Why?

Resources

Some of these are dated but still provide valuable information, especially about processes and the history of space food):
https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/197687/space-foods/
https://spaceflight.nasa.gov/shuttle/reference/factsheets/food.html
https://www.nasa.gov/pdf/71426main_FS-2002-10-079-JSC.pdf
https://www.nasa.gov/pdf/71427main_Space_Food_Spinoff_FS-2004-08-007-JSC.pdf
https://www.nasa.gov/audience/formedia/presskits/spacefood/index.html
https://www.nasa.gov/audience/forstudents/postsecondary/features/F_Food_for_Space_Flight.html
https://airandspace.si.edu/exhibitions/apollo-to-the-moon/online/astronaut-life/food-in-space.cfm
https://www.nasa.gov/pdf/143163main_Space.Food.and.Nutrition.pdf

Space food of the future:
https://www.nasa.gov/pdf/137398main_FS-2005-10-055%20Cuisine_1.pdf

Microgravity:
https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-microgravity-58.html

Fuel Cells:
https://www.nasa.gov/centers/glenn/technology/fuel_cells.html
https://www.nasa.gov/content/space-applications-of-hydrogen-and-fuel-cells
https://energynews.us/2019/07/15/midwest/nasas-new-moon-mission-reignites-fuel-cell-research-at-ohio-lab/

Water on the International Space Station:
https://www.nasa.gov/content/water-recycling/
https://www.popsci.com/how-iss-recycles-air-and-water/
https://blogs.esa.int/VITAmission/2017/09/01/recycling-water-on-the-iss-an-infographic/