FUEL YOUR GAME DAY - EVERY DAY IS GAME DAY

LESSON 4: THE SCIENCE OF YOGURT

OVERVIEW

In this lesson, which includes hands-on demonstrations and activities, students will learn about the science behind making yogurt with a focus on fermentation (info) and how fermentation changes the composition of milk during the process. Students observe changes in yogurt texture, taste, and pH, and design yogurt-related experiments using the scientific method.

TIME

Two 45-minute classes

OBJECTIVES

In this lesson, students will:

- Describe how fermentation changes milk into yogurt through the introduction of heat and bacteria.
- Identify the two bacteria that are typically used in making yogurt in the U.S. and how they interact in the process of fermentation.
- Observe and record the pH levels of milk and yogurt as it is made in the classroom.

STANDARDS

NGSS

MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

MATERIALS

In addition to common classroom materials and an Internet connection, students will need:

- Science of Fermentation and Yogurt Notes Sheet (or a digital document, e.g., Google doc) for student note-taking
- Access to a microscope with 400x-1000x magnification and two slides (an optional online video is provided in this lesson content if a microscope is not available)
- pH meter or pH strips (possible source), used to measure acidity
- Other materials for classroom demonstrations (see #6 under the Preparation section)
- (Optional) Yogurt toppings for creating yogurt parfaits for student taste-testing

PREPARATION

1. (Optional) Have samples of different kinds of fermented dairy products (e.g., Greek and conventional yogurts, skyr, buttermilk and/or kefir) available for students to taste as an introduction to the lesson, if possible.
2. Arrange the classroom into groups of 3-4 students.
3. Review the Fuel Up to Play 60 lesson Gut Reaction for additional relevant lesson content.
4. Review this resource for teacher background (students will read them during the lesson):
   - Probiotics, Prebiotics, and Fermented Foods
5. Cue up video for the lesson:
   - What are fermented foods?
6. Gather materials needed for classroom demonstrations:

If materials are limited, skip the "Yogurt-Making" demonstration.

"Yogurt-Making" Demonstration Materials:

- large pot for heating milk
- heat source (hot plate; crock/insta pot; stove)
- small container of plain yogurt (with live and active bacteria) or powdered yogurt starter
- teaspoon measuring tool
- bowl for mixing your starter

- milk (whole milk is recommended for first-timers, but you can use low-fat or nonfat options, which will result in slightly less thick yogurt)
- heating pad or tea towels
- incubation source (slightly warm oven (100-110o F) or a cooler with warm water bath)

"Under the Microscope" Demonstration Materials:

- pH meter or pH strips (possible source), used to measure acidity
- Microscope with 400x-1000x magnification and two slides
- Small cup each of milk and yogurt (clear plastic or glass is best)

7. Open a class Google doc, or one Google doc for each small group.

KEY TERMS

In addition to common classroom materials and an Internet connection, students will need:

- **Fermentation:** the chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat
- **Bacteria:** tiny, single-celled, living organisms that are spherical, spiral- or rod-shaped; they can be harmless, they can be good for us, or they can cause disease and spoilage of food
- **Lactose:** a sugar naturally present in milk. It is a disaccharide containing glucose and galactose unitse
- **Lactic acid:** a colorless, syrupy organic acid formed in sour milk and produced in the muscle tissues during strenuous exercise
- **Culture:** the cultivation of bacteria, tissue cells, etc. in an artificial medium containing nutrients

LESSON 4 : THE SCIENCE OF YOGURT

INTRODUCTION

Ask students:
Have you ever tried yogurt as a snack, for breakfast, or as an ingredient in a recipe?

Ask for descriptions of how yogurt tastes and what it feels like in the mouth. Answers will vary but should focus on its tanginess and smooth, creamy texture. If you have provided fermented dairy food samples, allow students the opportunity to taste them.

Then explain:
*Yogurt is made from milk. In this lesson, you will learn about a process called **fermentation** and how it can turn milk into yogurt. You will also learn about the beneficial bacteria in yogurt that can potentially help with digestion.*

LESSON PROCEDURE

Step 1

Have students explore recipes for common fermented dairy foods and, in their small groups, discuss and list characteristics those recipes have in common.

a. Yogurt: https://www.liveeatlearn.com/wprm_print/9850 (more info here)

b. Kefir: https://www.liveeatlearn.com/wprm_print/15833 (more info here)

c. Cheese: https://myfermentedfoods.com/how-make-cheese/ (more info here)

Step 2

Show students the video What are fermented foods?

Have students use the Science of Fermentation and Yogurt note-taking sheet included in this lesson to summarize key points of the videos. Let students know that they will add to their answers in subsequent readings and activities, so they do not have to have an answer for every question. Have them share their notes within their original small groups and reflect on common characteristics they noted in the recipes along with notes from the videos.

Lead a brief class discussion on the fermentation process and how fermentation in yogurt encourages the growth of "good" bacteria, that is, bacteria that can ferment the milk while preventing other, harmful, bacteria from growing. "Good bacteria" is also believed to help aid digestion and grow healthy bacteria in the human gut. Have students add new findings to their note-taking sheet. Note: the U.S. FDA requires the use of two specific bacteria in commercial yogurt production: *Lactobacillus delbruekii sp. bulgaricus (L. bulgaricus) and Streptococcus thermophilus (S. thermophilus).*

Step 3

Next, divide each group into two sub-groups and have each sub-group read and take notes on Fermentation of Yogurt and the Chemistry Behind It. They should use the same note-taking sheet they used for review of the videos, adding to their previous answers. Challenge them to summarize their understanding of the chemistry of yogurt in a brief continuation of your class discussion.

Step 4

Perform one (or both!) of the following classroom demonstrations:

Yogurt-Making Classroom Demonstration:

In this demonstration, students learn how to make a batch of yogurt. Gather the materials, review the notes and follow the steps below.

Materials:

- large pot for heating milk
- heat source (hot plate; crock/insta pot; stove)
- small container of plain yogurt (with live and active bacteria) or powdered yogurt starter
- teaspoon measuring tool
- bowl for mixing your starter
- milk (whole milk is recommended for first-timers, but you can use low-fat or nonfat options, which will result in slightly less thick yogurt)
- heating pad or tea towels
- incubation source (slightly warm oven (100-110o F) or a cooler with warm water bath)

Notes:

- This will require two classroom sessions (the end of day one and the beginning of day two) with one night between them. The most ideal timing would be to start the yogurt in a timeframe where you can move it to the cooling stage within 6-8 hours, with or without students present for that phase. You can let it incubate longer, but beyond 12 hours or so you risk letting it separate.
- Select your recipe amounts based on budget and what you wish to do with the yogurt when complete (i.e., student taste tests or student creation of more robust dishes such as breakfast bowls, parfaits, or smoothies).
- As you go through the steps, have students use pH strips or a pH meter to check the acid levels of the milk, the starter culture (if using yogurt vs. powdered starter), and the final product.
- The recipe and instructions in the link assume the use of either a powdered culture starter or a store-bought container of plain yogurt with live bacteria.

Steps

Day One:

1. Have each student group use a pH strip to check the acidity of the milk before heating.
2. Heat the milk until the thermometer reads 180-185° F. Stir while heating to avoid scalding the milk.
3. Maintain this temperature for 15-20 minutes to denature the milk, which will create a thicker yogurt. Students can take turns stirring the milk during this time.
4. Remove the milk from the heat and allow it to cool to 108-112°F. You can speed this process by putting your pot in an ice bath.
5. Take one cup of the milk out of the pot and put it in a bowl. Combine this milk with 2-3 teaspoons of store-bought yogurt (or an amount of powdered starter directed on the package if you are using that) for each cup of milk in the full batch.
6. Once blended, return the milk/yogurt starter solution to the pot and stir gently to combine.
7. Transfer your solution of milk and starter into clean, lidded containers, then “incubate them” in one of these three ways:
    - Wrap the containers in a heating pad set to 100°F.
    - Wrap the containers in towels and place them in a warm oven set to 100°F.
    - Place them in a cooler with a warm water bath or lined with a heating pad.
8. Let sit for 6-12 hours and then transfer to a refrigerator.

Day Two:

1. Have student groups make observations about the cooled yogurt, including its consistency, and using a new pH strip to check the acidity level, while comparing these observations to those of the milk from the day before.
2. Spoon the yogurt into cups or bowls for students to taste test, adding any optional toppings you may have provided. Lead a discussion on how the milk changed as it fermented into yogurt. Have students refer to and add to their notes from the previous day.

Under the Microscope Classroom Demonstration:

Gather the materials and follow the steps below for this classroom demonstration in which students identify changes in yogurt through observation using pH testing and a microscope.

Materials:

- pH meter or pH strips (possible source), used to measure acidity
- Microscope with 400x-1000x magnification and two slides
- Small cup each of milk and yogurt (clear plastic or glass is best)

Steps:

1. Have students watch this brief video about how yogurt is made.
2. Prepare your two samples, one each of milk and yogurt, and hold them up so students can see them, tipping them slightly from side to side. Have students write descriptions of each in their notes. If your cups are not clear, walk around the room showing your samples so students can take note of the difference in consistency of each sample.
3. Use a pH strip or meter to test the acidity of each sample. Allow students to observe your results either by holding them up or by walking around the room so students get a clear view of the different readings.
4. Prepare two slides for the microscope, one with a small drop of milk and one with a small drop of yogurt (preferably one with some of the yogurt liquid). Have students form a line and take turns observing the samples under the microscope.
   - The most efficient way to do this is to have all students observe the first slide and then come through the line again to observe the second slide.
   - If you don't have materials available for a live look through a microscope, you can show students these videos:
     - Dairy Milk Under a Microscope
     - Bacteria in yogurt under the microscope
5. Ask students to record what they observed in each of the samples as far as changes in consistency, pH, and appearance under the microscope. Then, lead a discussion of their various descriptions.

- Explain that the round spots they likely observed in the milk under the microscope were fat globules.
- Ask what types of shapes they observed in the yogurt under the microscope. Students should identify both rounded and rod-shaped bacteria. Explain that these are the bacteria responsible for turning milk into yogurt.
- See other relevant lesson content in this unit which includes information for students to read about how the two primary "good" bacteria in yogurt interact to create lactic acid, as well as the health benefits of good bacteria to the gut.

Step 5

Ask students to reflect on the information they've learned, the classroom demonstrations they've observed, and the videos they've watched. Open the discussion by having them share their observations about how heat and bacteria work together to create yogurt.

Ask them what questions they have about either the material or what they'd like to learn more about? Spend 5-10 minutes brainstorming what they want to learn more about in the fermentation and yogurt-making process, or in studying bacteria. You can do this as a whole class or in students' original small groups. Have students create a group Google document so each student can contribute questions they'd like to have answered. Provide prompts if needed:

- What other starters might work to make yogurt?
- What would happen to the consistency and taste if I used X (i.e. whole fat milk instead of nonfat milk)?
- Would adding fruit or coloring during fermentation change the pH or consistency of the final product?

Step 6

Give the groups a few minutes to talk about the questions raised and select one they would like to answer. Then, have them work together to design an experiment that can try to answer the question, using the Scientific Method (with Yogurt!) sheet provided in this learning unit.

REFLECTION

Journal Question: Reflecting on what you've learned, how do you feel about eating a food that has bacteria in it? Explain.

ASSESSMENT

Have students create a TikTok-style or YouTube video explaining how fermentation works and how yogurt is created. It can be a time-lapsed demo of the students making yogurt at home, a green-screen explanation of the process, or even a "story time" about how their experiment went wrong! The presentation should be engaging for a middle school audience and include information about:

- the chemistry of fermentation
- the importance of heat in creating yogurt
- how starter cultures impact the final product (including any health benefits)

EXTENSIONS

1. Have students read Fermentation of Yogurt and the Chemistry Behind It in their groups and use a tablet and online drawing tool (or traditional poster board and markers/colored pencils) to:
   - Create an avatar for each of the bacteria highlighted in the lesson (students may search for images online to use as background for this): *Lactobacillus delbruekii sp. bulgaricus (L. bulgaricus) and Streptococcus thermophilus (S. thermophilus).*
   - Create a diagram of the positive interaction between *S. thermophilus* and *L. bulgaricus* in the fermentation process.
2. For additional relevant lesson content, see the other lesson materials from this unit: Fuel Your Game Day – Every Day Is Game Day.
3. For further reading: Students can learn about different Types of Yogurt Around the World.
4. Students can learn more about pH and bacteria here.
5. Students with a more advanced interest in chemistry can learn about the chemical formulas and processes of fermentation here and here.

Vocabulary

- **Fermentation:** the chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat
- **Bacteria:** tiny, single-celled, living organisms that are spherical, spiral- or rod-shaped; they can be harmless, they can be good for us, or they can cause disease and spoilage of food
- **Lactose:** a sugar naturally present in milk. It is a disaccharide containing glucose and galactose unitse
- **Lactic acid:** a colorless, syrupy organic acid formed in sour milk and produced in the muscle tissues during strenuous exercise
- **Culture:** the cultivation of bacteria, tissue cells, etc. in an artificial medium containing nutrients