

Soybean Drink Laboratory



Introduction

The soybean grain commonly produced by farmers has a grassy or beany flavor. This flavor is not a problem when the grain is used as animal feed, but it can be objectionable to some persons when soybeans are used in food products.



Grades: 6-8
Time Needed: 2-3 days, 45-min class periods

Learning Objectives

After completing this lesson, students will be able to:

1. Distinguish between Lipoxygenase and lipoxygenase-free soybeans.
2. Explain how biotechnology is used to make great tasting soy products.
3. Compare and Contrast the nutritional value of soy milk and cow's milk.
4. Explain why some people might choose cow's milk over soy milk.

CAUTION: Soy allergic students should not participate in the Soybean Drink Laboratory activity.

Next Generation Science Standards (NGSS)

As a result of activities in grades 6-8, all students should develop:

Topic

- **LS2:** Growth, Development & Reproduction

Performance Expectation

- **MS-LS3-1:** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of an organism
- **MS-LS4-5:** Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms

Dimension

Practices:

- Analyzing and interpreting data
- Constructing explanations

Disciplinary Core Ideas:

- **LS3.B:** Variation of Traits

Cross-Cutting Concepts:

- Cause and effect



Materials

- Lipoxygenase and lipoxygenase-free soybeans
- Measuring cup
- Two large bowls or other containers
- Masking tape and marking pen
- (2) kitchen strainers
- (2) 1000 ml beakers
- Electric Blender
- Cheesecloth or coffee filter
- Hot plate or stove
- (2) 2-quart or larger saucepans or glass cookware safe for stove-top use
- Candy thermometer
- Sink or other source of hot, soapy water and water for rinsing
- Spoons for stirring
- Refrigerator or cooler with ice
- Sugar, chocolate syrup, vanilla, or other flavorings
- Labels from traditional cow's milk containers and commercial containers of soy milk.
- 2% milk
- Commercial soy milk products

Iowa teachers can order without charge lipoxygenase and lipoxygenase-free soybeans from Iowa State University's Office of Biotechnology by phoning 1-800-643-9504.



Introductory Background

The soybean grain commonly produced by farmers has a grassy or beany flavor. This flavor is not a problem when the grain is used as animal feed, but it can be objectionable to some persons when soybeans are used in food products.

The beany flavor is the result of the action of an enzyme called lipoxygenase. As the name implies, the enzyme is involved in the oxidation of lipids or fat, which results in the beany flavor. There are three forms of the enzyme, commonly referred to as lipoxygenase 1, 2, and 3. The three forms occur in common soybean varieties grown by farmers.

To eliminate the beany flavor, soybean scientists evaluated varieties from throughout the world in an attempt to find those that did not have one or more of the lipoxygenase enzymes. They found a few varieties that lacked 1, 2, or 3, but no variety lacked more than one of the three forms. By hybridization, mutation, and selection, soybean breeders were able to combine the genes that control the three forms of the enzyme. Soybeans are now available that lack the three lipoxygenase enzymes. These soybeans are being used to produce soymilk and other food products that no longer have the beany flavor of common soybeans.

Note: The soybeans that lack the beany flavor were developed by traditional plant breeding methods. Biotechnologists are using molecular techniques to modify the flavor of crop products. The FlavrSavr™ tomato was the first commercial product developed by molecular techniques to have improved flavor.

Tasting the drinks made from soybeans with and without the lipoxygenase enzymes provides a tangible illustration of the action of genes.



Instructional Process

The day before the activity

Give students handout 1 and ask them to read it. Omit this step if students have already read the handout for the soybean taste test activity. Ask students if anyone is allergic to consuming or handling soy or milk products.

CAUTION: Soy allergic students should not participate in the Soybean Drink Laboratory activity.

Day 1

1. Ask students to clean the measuring cup, large bowls or other containers, kitchen strainer, beakers, spoons, and blender container with hot soapy water before they begin. The teacher/leader may complete this step before class, if preferred.
2. Tell students to measure one cup (150 grams) of soybeans that lack the lipoxygenase enzymes and place them in one of the large bowls/containers.
Direct students to pour at least two cups of room temperature water into the container so the soybeans are completely covered with water. Students should use the masking tape and marking pen to make a “Lipo-Free” label and attach it to the container.
3. Repeat step #2 using soybeans that contain the lipoxygenase enzymes. Label the bowl/container “Lipo.” The soybeans should soak in the water for 18-24 hours. The soybeans should stay covered with water for this entire time, so designated students or the teacher/leader should check the containers periodically. Before leaving for the day, add enough water to cover the soybeans overnight.

Day 2

Divide the class in half. One half of the class will process the soybeans in the “Lipo-Free” container and the other half will process the soybeans in the “Lipo” container. Distribute handout 7, if using it.

1. Tell students to drain the water from the soybeans and rinse them three times with clean water.
2. Add water to the soaked soybeans in a 7:1 (water: soybean) mixture. Do this by telling students to place 700 ml of water in a 1000 ml beaker and add only enough soaked soybeans to bring the water level in the beaker to 800 ml.
3. Tell students to pour the water/soybean mixture into a blender container and grind at high speed for three minutes.



4. While the mixture is grinding, ask students to place cheesecloth or a coffee filter in a kitchen strainer. Direct students to filter the mixture, now a whitish liquid, through the cheesecloth or coffee filter into the saucepan or glass cookware.
5. Students should cook the filtered liquid at 98-100° C (208-212° F) for 15 minutes. Students may take turns stirring the liquid continuously so it does not burn. Students should use a candy thermometer to monitor temperature and begin timing when the temperature reaches 98° C or 208° F.
6. After 15 minutes, tell students to pour the cooked liquid into a clean bowl/container. Refrigerate the liquid immediately after cooking.
7. After the soy milks are cold, students may taste the lipoxygenase-free (high sucrose) soy milk, the lipoxygenase (regular) soy milk, and 2% milk. They can compare the taste of the drink made from soybeans that lack the lipoxygenase enzymes with the drink made from soybeans with the enzymes. After their initial taste test, students may add sugar, chocolate syrup, or other ingredients to the soy drinks for flavor.

Sources

Adapted from the Biotechnology Outreach Education Center: Office of Biotechnology: Iowa State University, Ames Iowa: Mike Zeller author. Web site: www.biotech.iastate.edu/outreach.html.

Soybean Drink Laboratory



Student Sheet

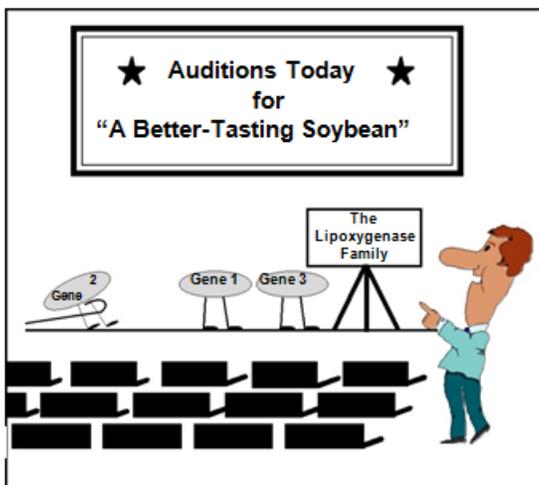
The soybean grain commonly produced by farmers has a grassy or beany flavor. This flavor is not a problem when the grain is used as animal feed, but it can be objectionable to some persons when soybeans are used in food products.

Lipoxygenase

The beany flavor is the result of the action of an enzyme called lipoxygenase (li POX i jen ace). The name of this enzyme reflects what it does. As the “lipo” part of its name implies, the enzyme is involved with **lipids**. Lipids are a class of molecules that includes fats and oils.

The middle part of lipoxygenase is “oxygen.” Lipoxygenase adds oxygen to fats in a process called oxidation. It is this oxidation process that causes the beany flavor in soybeans.

The last three letters of lipoxygenase “ase” are a common suffix that scientists use to name enzymes. If you see a chemical-sounding word with “ase” on the end, the odds are that the word is the name of an enzyme.



There are three forms, or isozymes, of lipoxygenase, commonly referred to as lipoxygenase 1, 2, and 3.

Isozymes are forms of an enzyme that affect the same characteristic of an organism. Lipoxygenase 1, 2, and 3 affect the flavor of soybeans. The three isozymes occur in common soybean varieties grown by farmers.

To eliminate the beany flavor, soybean scientists had to control one or more of the three lipoxygenase isozymes. Soybean scientists evaluated soybean varieties from throughout the world in an attempt to find those that did not have one or more of the lipoxygenase enzymes. They

found a few varieties that lacked enzyme 1, enzyme 2, or enzyme 3, but no variety lacked all three.

Hybridization, Mutation, and Selection

By using the tools of hybridization, mutation, and selection, soybean scientists combined the forms (alleles) of the three lipoxygenase genes that resulted in absence of the lipoxygenase enzyme. Soybeans are now available that lack one, two, or all of the lipoxygenase isozymes. These soybeans can be used to produce soy drinks and other food products that no longer have the beany flavor of traditional soybeans.



Learn the Language

Hybridization – cross-breeding two distinct species types to combine their characteristics in their offspring

Isozyme – one of two or more forms of an enzyme that have different chemical structures but control the same process

Lipids – a class of almost non-soluble molecules that includes fats and oils

Lipoxygenase – enzyme that catalyzes oxidation of lipids

Mutations – genetic changes in DNA that result in changes within species of living organisms. Mutation is a natural process in nature, but it can be sped up by using chemical treatments or other means.

Selection – choosing the offspring that have desired characteristics



Procedure:

Clean all containers and equipment with hot soapy water before beginning the activity.

Day 1

1. Cover one cup (150 grams) of soybeans that lack the lipoxygenase enzymes with water for 18-24 hours. Mark the container "Non-Lipo." It is important that the soybeans stay covered with water.
2. Repeat step #1 using soybeans that contain the lipoxygenase enzymes. Mark the container "Lipo."

This should be enough soybeans for a class of 20-24 students.

Day 2

One-half of the class will process the soybeans in the "Non-Lipo" container and the other half will process the soybeans in the "Lipo" container.

1. Drain the water from the soybeans and rinse them three times with clean water.
2. Add water to the soaked soybeans in a 7:1 (water:soybean) mixture. Do this by placing 700 ml of water in a 1000 ml beaker and add the soaked soybeans until the water level in the beaker reaches 800 ml.
3. Grind the water/soybean mixture in a blender at [high speed](#) for 3 minutes.
4. Filter the mixture, now a whitish liquid, through cheesecloth or coffee filters placed in kitchen strainers.
5. Cook the filtered liquid at 98-100o C (208-212o F) for 15 minutes. Stir the liquid continuously so it does not burn.
6. Refrigerate the liquid immediately after cooking.
7. Taste the drinks after they are cold. Compare the taste of the drink made from soybeans that lack the lipoxygenase enzymes with the drink made from soybeans with the enzymes. After your initial taste test, you can add sugar, chocolate syrup, or other ingredients to the soy drinks for flavor.



Reflect and Apply (Follow-up Questions)

1. Based on your initial taste test, which of the drinks did you prefer? Why?
2. How do soy milk and cow's milk compare nutritionally?
3. Some people cannot consume cow's milk because of lactose intolerance, allergies, or other health reasons. Besides health concerns, for what other reasons might people choose to use soy milk?
4. What food products use soybeans? What other non-food uses can you think of for soybeans?
5. Would you consider the mutation which results in the absence of the lipoxygenase 1, 2, and 3 enzyme a harmful, beneficial, or neutral mutation? Explain your choice.
6. What technologies do we have today that have allowed us to produce better tasting soy based drinks?