



National Agriculture in the Classroom

Relevancy and Engagement: agclassroom.org

Lactose Lab: Some Don't Like it Sweet

Grade Level(s)

9 - 12

Estimated Time

60 minutes

Purpose

In this lesson students will learn the chemistry and composition of milk, identify the difference between a monosaccharide and disaccharide, and carry out a laboratory activity testing the effect of the enzyme lactase on various milks.

Materials

Activity 1:

- *Chemistry and Composition of Milk* PowerPoint
- Computer and LCD projector

Activity 2:

- Ice cube tray (1 per group)
 - You could also use a muffin tin or 8 disposable condiment containers.
- Glucose test strips (8 strips per group of students)
 - These can be obtained through a local pharmacy or online distributor. These test strips are used by diabetics to measure glucose levels in urine. Be sure to choose the test strips which change color and measure a glucose level, not just simply the presence or absence of glucose. *Keto-Diastix Reagent* strips is an example of a brand that works.
- Lactaid tablets (1 tablet per group)
- 100 ml of hot water in a cup or beaker (per group)
- Milk Samples:
 - Cow's milk
 - Goat's milk
 - Lactaid milk (cow's milk that is lactose free)
 - Soy milk

Essential Files (maps, charts, pictures, or documents)

- Lactose Lab Answer Key
[http://naitc-api.usu.edu/media/uploads/2015/11/16/Lactose_Lab_Answer_Key.pdf]
- Lactose Lab Sheet
[http://naitc-api.usu.edu/media/uploads/2015/11/12/Lactose_Lab_Sheet.pdf]

- Chemistry & Composition of Milk PowerPoint

[http://naitec-api.usu.edu/media/uploads/2015/07/15/Chemistry__Composition_of_Milk.pptx]

Vocabulary

disaccharide: a class of sugar whose molecules contain two monosaccharides

monosaccharide: a class of sugar whose molecules contain a single saccharide

lactase: an enzyme produced by the large intestine which breaks down lactose

enzyme: a substance that acts as a catalyst to bring about a specific biochemical reaction

lactose: a disaccharide sugar present in milk which contains glucose and galactose units.

Interest Approach or Motivator

1. Introduce the lesson and assess your student's prior knowledge by asking them the questions below. Questions can be asked in a simple question and answer format with your entire class or you may vary your instruction by dividing the class into groups. Print the questions and give each group a single question and a short amount of time to research the answer. For your reference, the answers can be found in the "Background Agricultural Connections" section of this lesson plan.
 - "Where does milk come from? When do animals begin producing milk?"
 - "After milk is produced on a farm, it is sent to a processing plant to prepare it to be sold. What takes place at the milk processing plant?"
 - "What nutritional benefits do milk and other dairy products such as cheese and yogurt provide?"
 - "What is the name of the carbohydrate found in milk?"
 - "What is lactose intolerance and how can it be managed so people can still consume dairy products?"
2. After discussing these questions, inform your students that they will:
 - review basic facts about the nutritional benefits of milk and dairy products;
 - learn about the physical and chemical properties of milk as it relates to monosaccharides, disaccharides and enzymes;
 - perform a laboratory experiment to determine levels of glucose found in various milk samples; and
 - identify how milk processing methods can provide digestible milk for individuals with lactose intolerance.

Background - Agricultural Connections

Milk, From the Dairy Farm to You

By definition, the word "milk" is an opaque white fluid rich in fat and protein secreted by female mammals for the nourishment of their young. Milk accounts for the making of the foods found in the dairy food group. Milk, cheese, yogurt, ice cream, butter and other dairy products provide abundant calcium and protein to our diets as well as other important vitamins and minerals. In the United States the majority of all fluid milk and other dairy products come from milk produced by a cow. Although all mammals produce milk after giving birth, cattle are the primary source of milk for our food supply due to their efficiency in producing it.

The two most common breeds of cattle on a dairy farm are the black and white holstein and the brown-colored Jersey. On average, a female calf, known as a *heifer* will be raised on a farm and give birth to her first calf around two years of age. Once the heifer gives birth, she is now known as a *cow* and enters the milking herd. Milk cows are fed a ration that is specially formulated to meet their nutritional needs. Cows are typically milked two to three times daily for an average of 12-18 months. In time, the cow is bred again and eventually stops producing milk. This is known as a dry period which allows the animal to rest prior to giving birth to her next calf and beginning the cycle of milk production again.

On average, dairy cows produce six to eight gallons of milk each day. Large trucks with refrigerated milk tanks pick up the milk each day and deliver it to a processing plant where it is pasteurized and homogenized. Pasteurization is a process where the milk is heated for a short amount of time to kill any harmful bacteria in the milk.

Homogenization sheers the fat molecules in the milk to prevent the cream from separating from the milk and giving it a consistent texture. The milk is then packaged or processed into cheese, ice cream, yogurt, or other healthy

dairy products.

Chemical and Physical Properties of Milk

What exactly is milk? The physical composition of milk can be broken down as water, lactose, fat, protein, and minerals. Milk composition does vary among species (cow, goat, sheep), breed (Holstein or Jersey), the animal's feed, and the stage of lactation. However, milk typically contains 87.7% water, 4.9% **lactose**, 3.4% fat, 3.3% protein, and 0.7% minerals.

Lactose is a carbohydrate or sugar found in milk. Carbohydrates are made up of molecules called *saccharides*. **Monosaccharides** have one sugar and disaccharides have two. The monosaccharides that are important in health and nutrition are glucose, fructose, and galactose. The **disaccharides** are sucrose (glucose + fructose), maltose (glucose + glucose), and lactose. Lactose, the primary carbohydrate found in milk, is also a disaccharide and it is composed of glucose and galactose.

Enzymes are substances produced by the body to perform a chemical reaction. Enzymes are used to chemically break down the food we eat and to allow our bodies to use the nutrients found in foods. **Lactase** is an enzyme produced by the small intestine that binds to lactose and breaks the bond between galactose and glucose, the two sugars found in lactose.

Lactose Intolerance

Lactose intolerance is a problem for many individuals. Without lactase, drinking milk or eating cheese and other dairy products can cause a great deal of discomfort in the form of gas, bloating, and/or diarrhea. Without lactase the bacteria in the gut ferments lactose. The fermentation produces gas which leads to pain and discomfort in the digestive system.

Most people and animals make lactase as infants. This allows them to process mother's milk. However, some people's bodies stop producing the enzyme leading to the condition of lactose intolerance. In rare cases infants can develop lactose intolerance, but usually it develops during the teen or adult years.

People who are lactose intolerant tend to avoid dairy products and this can be troublesome since these foods are high in proteins and essential nutrients like vitamins A and D, magnesium, calcium, riboflavin, and potassium.

Lactose Free Milk

One solution for lactose intolerance is to take the enzyme, lactase in liquid or pill form before consuming dairy products. You may also have seen milk and dairy foods labeled as, "Lactose Free." These milk and dairy products were produced on a dairy farm without alterations of any kind. The difference in Lactose Free milk comes in the processing. Lactose free milk is mixed with the enzyme, lactase at the processing plant. As a result, the lactose is broken down into the digestible glucose and galactose monosaccharides allowing people with lactose intolerance the ability to consume dairy products without taking medications containing lactase.

Dairy-Free Milk Substitutes

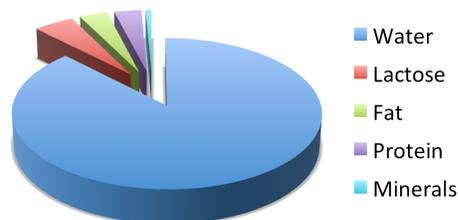
Dairy-free milk substitutes also exist. These substitutes can be made from rice, almonds, coconut, or soybeans. By definition, the word *milk* refers to the substance produced by a mammal's mammary tissue. In contrast, milk substitutes are produced by plants. However, milk substitutes are commonly referred to as soy "milk," almond "milk," rice "milk," and coconut "milk."

Procedures

Activity 1: Chemistry and Composition of Milk

1. Open the "Chemistry and Composition of Milk" PowerPoint. Provide a method for your students to answer multiple choice questions. Options include:
 - Use a classroom response or "clicker" system if you have one.
 - If mobile devices, tablets, or iPads are available, use a free app or website to allow your students to answer each question. [Poll Everywhere](#) and [Socrative](#) are examples, but many programs exist.

Physical Composition of Milk



- If digital devices are not available or time does not permit, have students answer using hand signals. A=hold up 1 finger, B= hold up 2 fingers, C=hold up 3 fingers, D=hold up 4 fingers, E=hold up 5 fingers.
2. Use slides 2-4 to establish some basic facts about milk. Use the questions to help students understand that all female mammals produce milk after giving birth and that in the United States cattle provide the majority of our milk supply. Though all mammals can produce milk, cows produce the most milk when you consider the cost to produce each gallon (labor, feed, housing, healthcare, etc.).
 3. Using slide 5, ask your students, "What is milk?" We have established that the milk in our food supply typically comes from cows. Your students know it is white and they pour it on their cereal in the morning, but what is it? Explain to your students that milk contains water, lactose, fat, protein, and minerals.
 4. Use Slide #6 to review the nutritional benefits of consuming milk and dairy products.
 5. Use slide #7 to break down the typical percentages of each milk component. These percentages represent cow's milk. Milk from other species will vary in it's content. For example, goat milk has less lactose than cow's milk.
 6. Using slides 8-11 teach or review basic chemistry principles about enzymes, monosaccharides, disaccharides, and lactose. Use the same formative assessment method used in step 1.
 7. Using slides 12-14, teach students about lactose and it's enzyme, lactase.
 8. Summarize and apply what students have learned by teaching them about lactose intolerance. Use the information found in the "Background Agricultural Connections" section to prepare them for the next laboratory activity.

Activity 2: Lactose Lab

1. To introduce the lab, show your students a [commercial for lactose-free milk](#). Ask your students to use what they now know about enzymes, lactose, and lactase to guess how milk can be made lactose-free.
2. Divide students into lab groups.
3. Provide the laboratory supplies for each group and 1 copy of the *Lactose Lab* handout to each student.
4. Give students adequate time to complete the laboratory procedures and answer the questions on their handout.
5. Once students have completed the laboratory activity, return to your question from step 1. *How can milk be processed so that it is lactose-free?* Have students use what they have learned in this lesson to answer the question.

Conclusion

After conducting these activities, review and summarize the following key concepts:

- Milk and milk products provide important nutrition to our diet.
- Milk contains the disaccharide, lactose.
- Food production systems are influenced by consumer's choices. As lactose intolerance has become more prevalent, the agriculture and food processing industries use science to find solutions such as lactose free milk.

Essential Links

- National Dairy Council-Lactose Intolerance Website

[<http://www.nationaldairyCouncil.org/educationmaterials/healthprofessionaleducationkits/pages/lactoseintoleranceanddairy.aspx>]

Enriching Activities

- Have students compare the nutrition labels for cow's milk and other plant-based milk substitutes such as rice milk, soy milk, and almond milk. Have students write a summary comparing the differences. What are the similarities and differences? Are the vitamins and minerals listed on the nutrition label contained naturally or were they fortified?

Suggested Companion Resources

- **Bringing Biotechnology to Life (Activity)**
[<http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=282>]
- **Brittlelactica: Planet in Need (Multimedia)**
[<http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=87>]
- **Consider the Source- Cheese (Multimedia)**
[<http://www.agclassroom.org/teacher/matrix/resources.cfm?rid=276>]

Sources/Credits

- Laboratory idea in Activity 2 from Massachusetts Agriculture in the Classroom.
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