Oklahoma Ag in the Classroom

Making the Most of Milk

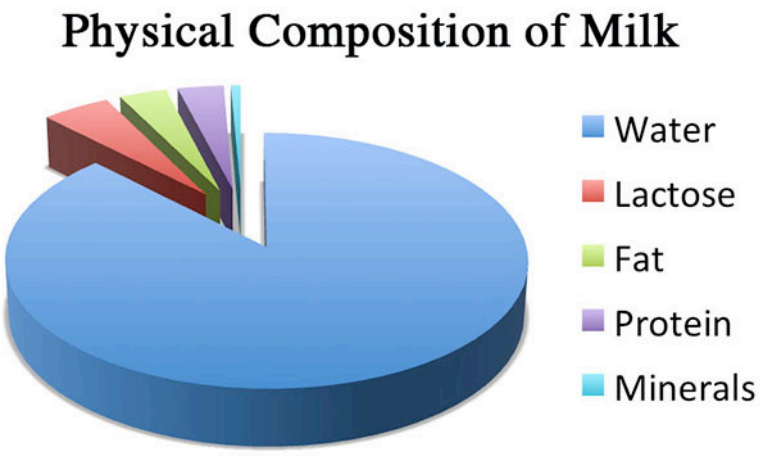
Understanding Lactose Intolerance

Objective

Students will learn what causes lactose intolerance and carry out a laboratory activity to test a treatment for lactose intolerance.

Background

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.



Carbohydrates are made up of molecules called saccharides (sugar molecules). Monosaccharides have one sugar molecule, and disaccharides have two. Without enzymes, metabolic reactions cannot take place. 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. Sucrose is a disaccharide found in soy milk.

Enzymes are substances produced by the body to perform a chemical reaction. Enzymes chemically break down the food we eat and allow our bodies to use the nutrients found in foods. Without enzymes metabolic reactions cannot take place. 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. Sucrase is also an enzyme produced in the small intestine that binds to sucrose and breaks the bond of the disaccharide sucrose into two separate monosaccharides of fructose and glucose so that food

Oklahoma Academic Standards

GRADE 8

Physical Science: 1-3; Life Science: 1-7

GRADES 9–12

Biology I: LS1-6

Materials
for each station

12-well plate (a muffin tin will work.)

milk—cow milk, goat milk, Lactaid milk (dairy milk that is lactose-free), and soy milk

8 glucose test strips (Keto-Diastix Reagent strips for urinalysis, which test glucose)

Lactase tablets (Fast-acting dairy digestive lactase enzyme tablets)

water

can be easily digested.

Without lactase drinking milk or eating cheese and other dairy products can cause a great deal of discomfort. The bacteria in the gut ferments lactose when there is no lactase. The fermentation produces gas which leads to pain and discomfort in the digestive system. in the form of gas, bloating, and/or diarrhea.

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 as teenagers or adults. This causes the condition known as "lactose intolerance." In rare cases infants can develop lactose intolerance.

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

One solution for lactose intolerance is to take the enzyme lactase in liquid or pill form before consuming dairy products. There are also lactose-free milk and dairy foods available for sale. These products were produced on a dairy farm without alterations of any kind. The difference is in the processing. Milk is mixed with 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.

Another dairy product that is available to consumers is goat's milk. While goat's milk does contain lactose, the amount of lactose is about 10% less than cow's milk. The lower level of lactose found in goat's milk can make it a suitable alternative for persons with lactose intolerance.

Dairy free substitutes also exist for those who are lactose intolerant. These substitutes can be made from soybeans, almonds, coconuts, or rice. These substitutes are commonly referred to as soy milk, almond milk, coconut milk, or rice milk even though they are not actually made of milk. Since these "milks" are plant based, they are naturally lactose free.

Background adapted from a lesson by Massachusetts Agriculture in the Classroom.

Procedures

1. Read and discuss background and vocabulary.
2. Provide the laboratory supplies for each group and copies of the Lactose Lab handout included with this lesson.
   —Explain that lactase tablets are an enzyme used as a treatment for lactose intolerance.
   —Students will design experiments to test the enzyme on different milks containing sugars. Students should verify that the enzyme only works on lactose and not on additional sugars. Four milk samples will be tested: cow, goat, Lactaid and soy milk.
   —Students will also determine if the enzyme will stand up to the acidity of the stomach.
   —Students will complete the laboratory procedures and answer the questions on their handout.
3. Students will compare the nutrition labels for cow's milk, goat's milk,

Lactaid milk (lactose-free dairy milk) and soy milk (or another plant-based milk substitute). What are the similarities? What are the differences?

—Create a graph showing the amount of calcium, protein, Vitamins A and D, and iron found in each milk. Compare sugars, total carbohydrates, and other information found on the nutrition labels.

—As a class, students will use this information to discuss which milk is more nutritious and why.

4. Conduct a taste test with these milks to determine which milk students prefer. Prior to tasting, students will predict which milk they will choose. After tasting discuss if preferences varied from predictions.

Vocabulary

bacteria— a group of single-celled microorganisms that live in soil, water, the bodies of plants and animals, or matter obtained from living things and are important because of their chemical effects and disease-causing abilities

carbohydrate— any of various compounds of carbon, hydrogen, and oxygen (as sugars, starches, or celluloses) most of which are formed by plants and are a major animal food

digest— to convert food into simpler forms that can be taken in and used by the body

enzyme— any of various complex proteins produced by living cells that bring about or speed up reactions (as in the digestion of food) without being permanently altered

fermentation— chemical breaking down of a substance (as in the souring of milk or the formation of alcohol from sugar) produced by an enzyme and often accompanied by the formation of a gas

intestine— the part of the alimentary canal that is a long tube composed of the small intestine and the large intestine, that extends from the stomach to the anus, that helps to digest food and absorb nutrients and water, and that carries waste matter to be discharged

intolerant— unable or unwilling to endure

lactase— an enzyme that breaks down lactose and related compounds and occurs especially in the intestines of young mammals and in yeasts

lactose— a sugar present in milk that breaks down to give glucose and galactose and on fermentation gives especially lactic acid -- called also milk sugar

nutrient—a substance that furnishes nourishment

primary— of first rank, importance, or value

sugar— any of various water-soluble compounds that vary widely in sweetness and make up the simpler carbohydrates

Name_____

Lactose Lab Sheet

SUPPLIES FOR EACH STATION

- 12-well plate (A muffin tin will work.)
- milk—cow milk, goat milk, Lactaid milk (dairy milk that is lactose-free), and soy milk
- 8 glucose test strips (Keto-Diastrix Reagent strips for urinalysis, which test glucose)
- Lactase tablets (fast-acting dairy digestive lactase enzyme tablets)

INTRODUCTION

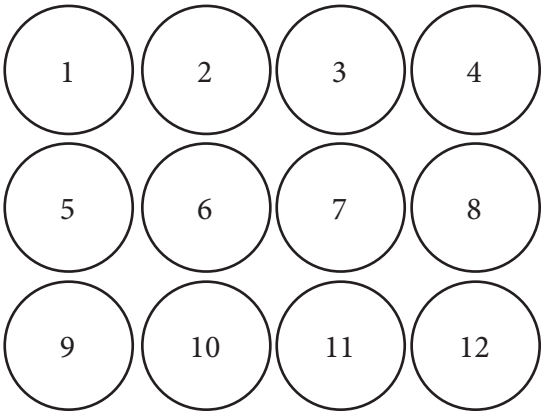
Milk is 87 percent water and contains fat, proteins, and carbohydrates. The primary carbohydrate in milk is disaccharide lactose, made from two monosaccharides, glucose and galactose, that are bonded together. Another common disaccharide is sucrose, which is found in soy milk. Sucrose is made from glucose and fructose which are bonded together. Without the enzyme lactase, lactose cannot be broken down, so neither glucose nor galactose is detectable in milk because the molecules remain bonded together.

PURPOSE

You are a scientist at a pharmacy company. Recently a new treatment for lactose intolerance was developed, Fast-Acting Lactase Tablets. Your job is to determine what the enzyme lactase tablets do to the composition of milk. You need to determine if they will help those who are lactose-intolerant to digest milk.

PROCEDURE

1. Make Enzyme Solution, as follows:
   —Crush one lactase tablet and stir into 100 mL hot water.
   —Let sit for at least five minutes.
   —Label your glucose strips with the well numbers 1-8.
2. Add 20 mL of cow milk to wells 1 and 5.
3. Add 20 mL of goat milk to wells 2 and 6.
4. Add 20 mL of Lactaid milk to wells 3 and 7.
5. Add 20 mL of soy milk to wells 4 and 8.
6. One at a time, dip your test strips into control wells 1,2,3, and 4. After 30 seconds record the amount (mg/dL) of glucose for each well on the chart.



7. Add 5 mL of enzyme solution to wells 5,6,7, and 8. Stir the liquid in each well. Let sit for at least five minutes.
8. One at a time, dip your test strips into test wells 5, 6, 7, and 8. After 30 seconds record the amounts (mg/dL) of glucose for each well on the chart.
9. After all the data has been recorded, clean up your work area and materials.

Oklahoma Ag in the Classroom is a program of the Oklahoma Cooperative Extension Service, the Oklahoma Department of Agriculture, Food and Forestry and the Oklahoma State Department of Education.

RESULTS:

	Cow Milk Amount (mg/dL) Glucose	Goat Milk Amount (mg/dL) Glucose	Lactaid Milk Amount (mg/dL) Glucose	Soy Milk Amount (mg/dL) Glucose
Control	1	2	3	4
Test	5	6	7	8

FOLLOW-UP QUESTIONS

1. Why is it important to have a "control" in your experiment?

2. Which milks contained glucose at the beginning of the experiment? How can you prove that?

3. Which milks contained glucose at the end of the experiment? How can you prove that?

4. What was the difference (if any) in the presence of glucose between the cow's milk, goat's milk, lactaid milk, and soy milk?

5. Did the Lactase Tablet work to break the bond of the disaccharide lactose into two separate monosaccharides of glucose and galactose? Did it break the bond of the disaccharide sucrose into glucose and fructose? If it did not break the bond, explain why you believe it didn't.

6. What are the independent and dependent variables in this experiment?

EXPLANATION:
At the beginning of the experiment, the cow milk, goat milk, and soy milk all should have shown a negative reading for glucose, even though glucose was present in all three milks. This is because the glucose was bonded with galactose in both the cow's milk and goat's milk and with fructose in the soy milk. When the monosaccharides bond to form disaccharides they are no longer present in their individual states. This can be compared to milk that has chocolate powder mixed into it. The powder is no longer present in powder form and the milk is no longer white milk. However, they cannot be separated as lactose can.

Lactase is an enzyme produced in the small intestine that binds to lactose and breaks the bond of the disaccharide lactose into two separate monosaccharides of galactose and glucose so that milk can be easily digested. Sucrase is also an enzyme produced in the small intestine that binds to sucrose and breaks the bond of the disaccharide sucrose into two separate monosaccharides of fructose and glucose so that food can be easily digested.

For this experiment the Lactase was able to break the bond of the lactose so that the glucose could be tested. However, it cannot break the bond of sucrose, because that chemical bond is different. In order to test for the presence of glucose in soy milk you would need to be able to separate the sucrose.

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