Student Activity
Yams, Soybeans, and Pharmaceuticals: Starch Digestion by Amylase
Companion Web page:
http://www.chemheritage.org/classroom/chemach/pharmaceuticals/index.html

Introduction and Historical Context

Have you ever eaten yams? More likely than not you have eaten sweet potatoes, which are not yams even though they look similar. Sweet potatoes in the United States are often called yams, but they are not related. Historically, it seems as though the word *yam* became attached to sweet potatoes in the southern United States when African slaves used the Senegalese word *nyamis* ("to eat") to name the sweet potato. They were familiar with the true yam found in much of Africa and used for food. But using the yam for food is a bit risky because some yams contain toxins that must be removed, primarily by soaking the yams in water (the root portion) for several days. Sweet potatoes do not need to be soaked: they can be eaten after cooking. But interestingly, certain yams have a toxic chemical (called diosgenin) that can be changed through chemical reactions into useful substances, including the medicine cortisone (used to treat joint pain as in arthritis, allergic reactions like bee stings and rashes, and general body inflammation) and several hormones such as estrogen, progesterone (female), and testosterone (male). The hormones mentioned are in a category called steroids. Perhaps you have heard of steroids as substances used improperly to increase a person's athletic ability (run faster, bigger muscles).

Hormones are substances produced by the ductless glands of the endocrine system in the human body. The endocrine system includes such well-known organs as the pancreas, thyroid gland, ovaries, and testes. These hormones are secreted directly into the bloodstream to act as chemical messengers, that is, substances that circulate in the body and are able to cause (stimulate) specific organs to "do things." "Doing things" includes secreting other chemicals that in turn do new "things." The class of hormones called steroids is produced in the adrenal gland (located on top of our kidneys) and the sex glands, the ovaries and testes. It is this group of steroidal hormones that became of great interest and importance to chemists from the 1930s through the 1960s because they were trying to synthesize these chemicals outside of the human body.

Starting in the late 1930s, several chemists decided to try to use the toxin diosgenin from the Mexican yam as a starting chemical, changing it into different steroids. First was testosterone, then progesterone. A second chemical from the yam was changed to the steroid cortisone. (Just for the record, 66 pounds of fresh yams [from only 2 to 3 yam roots or tubers; they are BIG!] can produce one pound of the diosgenin, from which 2 ounces of cortisone can be produced.) By the 1960s these steroid medicines could be produced from Mexican yams for sale to the public at affordable prices. The story of the synthesis of cortisone and progesterone, a female sex hormone, involved the work of many chemists, including Percy Julian, Russell Marker, and Carl Djerassi (see http://www.chemheritage.org/classroom/chemach/pharmaceuticals/julian-djerassi.html and http://www.botgard.ucla.edu/html/botanytextbooks/economicbotany/Dioscoreamed/).

Purpose

Classroom activities are provided through the generous support of the Biogen Idec Foundation.

To use an enzyme-controlled reaction to convert starch molecules to smaller sugar molecules, monosaccharides and disaccharides, and to qualitatively test for the presence of these breakdown products.

Safety

1. Wear safety glasses throughout the laboratory activity.
2. Be aware of hot water sources; handle hot water containers with gloves.
3. Keep test tubes pointed away from classmates when heating.
4. Do not bring any equipment to your mouth when collecting saliva.
5. Wash hands after completing the lab exercise.

Pre-Lab Questions

1. Starch is a food substance. What are some of its sources?
2. The reaction mechanism to be used in your lab exercise is called *hydrolysis*. What does the word mean in chemical terms?
3. How are the terms *enzyme* and *catalyst* related?
4. Starch and sugar are organic molecules. What is common to all organic molecules?
5. Starch is considered to be a polymer, and a sugar such as glucose is a monomer. What are the meanings of these two terms, *polymer* and *monomer*?

Materials

Lugol's solution

Benedict's solution

5 test tubes

Wax pencil

Metric ruler

Distilled water

Starch solution

Saliva (student-provided!)

Introduction to Procedure
In the experiment that follows, two tests for digestion will be used: the iodine test for the presence of starch and Benedict's test for the presence of the monosaccharide glucose.

1. To test for starch, add 3 drops of Lugol's solution (potassium iodide) to the test tube. If starch is present, a blue-black color will appear.

Classroom activities are provided through the generous support of the Biogen Idec Foundation.

2. To test for sugar, add an equal volume of Benedict's solution to the tube and place it in a *boiling* water bath for 5 minutes. A color change from blue to orange indicates the presence of sugar.

Procedure

1. Label five test tubes #1 through #5, and mark each tube at 1 cm and 2 cm from the base.

2. Fill test tubes #1 through #4 with your saliva to the 1-cm mark. Fill #5 to the 1-cm mark with distilled water.

3. Add starch solution to #1 to the 2-cm mark and conduct the iodine test IMMEDIATELY.

4. Add starch solution to #2 to the 2-cm mark and conduct the Benedict's test IMMEDIATELY.

5. Add starch solution to #3 through #5 to the 2-cm mark and allow the tubes to sit for 30 minutes.

6. After 30 minutes conduct the iodine test on #3 and the Benedict's test on #4 and #5.

Data:

Tube	Test Conducted	Timing of Test	Results of Test
1.			
2.			
3.			
4.			
5.			

Post-Lab Questions

1. What was the purpose of using two tests, iodine and Benedict's? What is each test used for?

2. Why were the tests performed immediately and after 30 minutes? How did they serve as indicators of successful digestion by the enzyme?

3. From what structure in your mouth did you obtain the salivary amylase? Where else in your body could you find amylase?

4. Why do you think that you need two sources of amylase for successful digestion of starch?

5. What specific disaccharide is formed when amylase works on starch? What additional step in digestion needs to occur to fully digest starch into glucose monomers?

6. What is the fate of the glucose monomers digested from the starch?

Classroom activities are provided through the generous support of the Biogen Idec Foundation.