Mark Kozubal

How Much Sugar is in Food?

Grade Level	7^{th} -10^{th}
Subject Areas	Biology, Health and Nutrition, Experimental Design, Plants, Scientific Method
Skills	This activity will use observation, comparison, data analysis, scientific method, critical thinking, and math skills to determine the amount of glucose in various foods and feedstock substances.
Duration	The activity will take one 45 minute period for background lecture and to brainstorm foods, plant material etc., a second 45 minute period to set up and run the experiment, take measurements and observations and a third period to discuss and compare the results as a group
Setting	Classroom setting with typical biological laboratory and lecture room with white board
Vocabulary	Glucose, spectrophotometer, cellulose, starch, glycolysis, energy, ATP, Benedict's test, colorimetric methods
Standards Addressed	MT Content standards 1 and 2
Objectives	**Students will:** **● Understand glucose as a source of energy through ATP generation** **●Understand that many food sources have glucose as a simple sugars and in the form a polymer starch** **● Observe how much glucose is in various food sources even those that may be surprising such as "health" drinks** **● Understand that plant materials are made of cellulose which is a polymer of glucose much like starch but humans cannot break the bond which is much stronger than starch** **●Hypothesize how much glucose may be in various common food sources such as soft drinks, snacks, fruits and vegetables; and in cellulosic materials such as wheat straw, grass and leaves** **●Test their hypothesis by measuring glucose content by the Benedict's colorimetric test** **●Understand how Benedict's solution interacts with glucose to change color** **●Become exposed to colorimetric analytical methods and understand many chemicals in biological and natural systems are analyzed through similar methods** **●And understand that there are <u>many</u> other analytical methods for determining chemicals in biological and natural**

systems

Materials

●Benedicts solution
●50 ml beakers
●Hot Plate
●Clean 13x100 mm test tubes
●Spectrophotometer
●A variety of glucose sources that the students brainstorm
●10 ml graduated cylinder
●1 ml pippetor and pipette tips
●Test tube holders

Background

The activity should take place after the students have learned the basics of how cells use glucose to make ATP. Students should understand that the energy source in many cells (all animals and many prokaryotes) is glucose and this is converted to ATP which is the final energy molecule in ALL cells. If the students have a background in microbiology it would be a good time to reinforce that many microorganisms use inorganic chemicals (hydrogen, ferrous iron, sulfur, and even arsenic) and or a variety of organic chemicals (peptides, cellulose, lignin, petroleum, gasoline and even hazardous waste organics like pesticides and polychlorinated biphenyls) that can be converted into ATP because they all have energy. Students should also be taught that glucose is not enough for humans to survive. We need minerals, water and vitamins which are extremely important for proper health.
In addition, students should understand that glucose can be in multiple sources including simple sugars such as sucrose which is table sugar, and polymers such as starch (spaghetti) and cellulose (plant materials). Students should understand that cellulose and starch are bonded together in polymers and that the bonds are similar but humans cannot break apart cellulose for energy but many grazing animals can. We can still get energy from plants but only the soluble sugars are available to us. Would be a good exercise for them to name animals that can live off of cellulose such as bison, elk and cows. The reason is ultimately because of microorganisms in the animal's rumen and this should be stressed. The students should be taught the basics about the field of analytical chemistry and why it is important to determine how much of various chemicals are in our body. The method used in this study is a colorimetric method which uses the Benedict's dye to bind glucose at high temperature which causes it to change color and this color change can be observed visually, compared to other samples and measured quantitatively by using a spectrophotometer to measure light absorbance at a particual wavelength.

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Procedure	1. After the background of glucose, ATP, cellulose and the Benedict's test has been given, have the students brainstorm a variety of food, and plant sources that can be tested in the classroom. Try to have a variety of junk foods (coke, straight sugar, cookies, and candy), healthy foods (vegetables, health drinks, and milk), foods with starch (noodles) and cellulosic materials found in the area like wheat straw and alfalfa. 2. Come up with a few problem questions together as a group. For instance, they may come up with "How much glucose is in a variety of food sources we eat daily?" and "Are there foods that taste great but have less sugar than candy?" and "Which common plants around Montana have the most measurable glucose?" 3. Divide students into groups of 2-4 and have each group do 3-4 different substances. Label a clean 13x100 mm test tubes for each substance. 4. Add about 100 ml of water to 250 beakers and heat to boiling on hot plate. One hot plate for 4-8 students should be fine 5. measure exactly 0.5 grams of each substance and add to the test tubes 6. Add 4 ml of water 7. Add 1 ml of Benedict's solution with a pippettor. 8. Place the tubes the water bath with a test tube holder. CAUTION! The water is hot. 9. Incubate the tubes for 20 minutes. 10. Remove your test tubes and allow them to cool. 11. The color of the solution will turn red while heating and the more red the color the more glucose. The experiment can stop here by comparing the different substances to each other visually 12. If time permits, remove the upper layer and measure absorbance at 735 nm with a spectrometer. 13. Write observations and measurements from all tubes in the class 14. On white board, list each substance in order of glucose levels
Assessment	To evaluate learning, results and conclusions should be discussed at the end of the experiment. The students should have an understanding of the glucose levels in junk food and may be surprised at how much sugar is in a variety of foods. Comparing the glucose level in a variety of vegetables compared to fruits is also interesting. It is important for the students to understand the process of using glucose to make ATP. If time permits, the instructor can ask students to research how other chemicals are tested and ask them why it is important for doctors, chemists, environmental scientists etc. to measure chemicals in our body, and environment.
Extension	A good extension would be for the students to learn about how the human body regulates blood sugar levels. They can use glucose

	meters and measure their blood glucose levels before and after eating a cookie or drinking a soft drink. As part of a unit, the students should learn about photosynthesis and autotrophy (carbon fixation). They should learn how glucose is made from CO_2, water and light energy to build plants. A good experiment is to monitor CO_2 levels in a vessel with spinach exposed to light with a CO_2 meter. This would require more CO_2 in the vessel than the 0.03% in the atmosphere which could come from respiration under dark conditions or even from burning some leaves. A final activity would tie the respiration, photosynthesis and burning fossil fuels to understand the rise of CO_2 in the atmosphere and global climate change.
Resources	The Benedict's solution can be purchased at Ward's scientific website. There are numerous web and text book sources on ATP and glucose. Analytical chemistry methods can be found in basic chemistry textbooks.