

SUGAR IN CONSUMER PRODUCTS

INTRODUCTION

Studies have shown that Americans consume an inordinate amount of fat, sugar, and salt in their daily diet. The U.S. Department of Agriculture (USDA) reports that added sugar consumption in 1999 was a whopping 158 pounds per person! Added sugars included table sugar (cane and beet sugars; sucrose), corn syrup, high-fructose corn syrup, corn sugar (glucose), and honey. This is a 30 percent rise since 1983. The consumption of sugar has risen every year but one since 1983 as the graph below indicates.

<http://www.cspinet.org/new/sugar.html>
www.cspinet.org/reports/sugar/sugarorigin.html

Sugar now accounts for 16 percent of the calories consumed by the average American and 20 percent of teenagers' calories. In contrast, a government study found that in 197778 added sugars provided only 11 percent of the average person's calories. Almost all soft drinks consist of a sugar solution with a small amount of color and flavor additives. The purpose of today's experiment is to find out how much sugar is in each beverage and if this sugar concentration matches the value quoted on the label.

In this experiment you will determine the sugar content per serving of various beverages that could be found in your local grocery store by measuring the relative density of each beverage using a hydrometer. Remember, from our first experiment, that density is defined as mass (grams) per volume (milliliter). The density of pure water is close to 1.0 g/mL. When a solute is dissolved in an aqueous (water) solvent, the density of the resulting solution is increased. You will first create a series of solutions that contain known concentrations of sugar by weight. Using those solutions you will construct a calibration curve of known sugar concentration vs. density of solution (measured by using the hydrometer). By measuring the height at which the hydrometer floats in solution for selected beverages and plotting these values vs. sugar % on your calibration curve, you will be able to discover the sugar concentration in various soft drinks and fruit juices.

HYDROMETER CONSTRUCTION

A hydrometer is a simple device used to measure the density of a liquid or solution. It is based on the principle that an solid object placed in a liquid displaces a certain volume of the liquid. If the displaced liquid weighs more than the object, then the object will float. This will occur when the object has a density less than the density of the liquid. The height at which a given object floats relative to the surface of the liquid varies with the density of the liquid. The object will float higher in denser liquids and lower in less dense liquids. This idea is the basis for the hydrometer. A hydrometer is simply a floating object which has been calibrated to measure the density of a liquid according to how high it floats in various liquids. Some common hydrometers are used to measure the strength of the acid in a car battery, the strength of antifreeze in a car's cooling system, and the concentration of sugar in a beverage.

In this experiment you will build your own simple hydrometer using the following procedure.

1. Place one small machine nut on a 1-inch nail.

2. Now take a thin-stem plastic pipet and gently push the nail approximately 3/4 of the way into the center of the bottom of the bulb of the pipet.
3. After the nail is in place, do not move it. The goal is to maintain a watertight seal between the nail and the pipet bulb.
4. Fill the pipet approximately 1/2 full of water. You can do this by submerging the hydrometer in the dishpan of water provided.
5. Place the pipet, heavy end down, into a graduated cylinder filled 3/4 full of deionized water. The pipet should float with one or two centimeters of the stem sticking out of the water. If it is floating too low or too high, add or subtract water in the pipet bulb to adjust the height of the hydrometer.
6. Once you are satisfied with your hydrometer be careful not to add or subtract any of the liquid from the pipet during the experiment. Remember that the quality of your results depends on the consistency of the hydrometer used in each solution.

CALIBRATION OF HYDROMETER

In order to estimate the sugar content in our consumer beverages the hydrometer must first be calibrated. To do this you will measure how high your hydrometer floats in a series of known solutions of sugar water (solutions of known sugar concentration). From these experimental data you will construct a calibration curve.

To do this you first must make a series of solutions with known concentrations of sugar. This will be done using a mass % equation as described below.

$$\text{Mass \%} = (\text{mass of solute} / \text{mass of solution}) \times 100$$

For example if you have 50 grams of sugar dissolved in 200 mL of water the mass % would be as follows (remember the density of water is 1 g/mL).

$$\text{Mass \%} = (50 \text{ g sugar} / 50 \text{ g sugar} + 200 \text{ g H}_2\text{O}) \times 100 = 20\% \text{ sugar solution by weight}$$

1. Now it is your turn! Put on your thinking caps and use the above equation to calculate how many grams of sugar you need to make a 4% by mass sugar solution in a total volume of 75 mL of water. Do the same for 8%, 12%, and 16% sugar solutions.
2. Once your calculations have been approved by the instructor, carefully weigh out the correct mass of sugar, place in a 200 mL beaker, and then dissolve each in 75 mL of water. Be sure that all of the sugar has dissolved before proceeding further.
3. Now fill a 50 mL-graduated cylinder with pure water. This will be your 0% sugar solution and the first point on your calibration plot.
4. Place your newly created hydrometer in the graduated cylinder with the bulb end down. Make sure the hydrometer is floating freely.

5. Carefully measure the height of the hydrometer stem sticking out of the fluid using a ruler. The hydrometer should float freely and not be touching the sides of the container. Be sure to record the height to the nearest millimeter. There are many ways you can make this measurement, the key is to be sure that you are CONSISTENT in all measurements.
6. The differences in height will be small, so be sure that both lab partners agree on the height measurement. Once you agree, record the height in a data table next to the appropriate weight percent for the solution.
7. Now replace the 0% sugar solution with the 4% sugar solution. Be sure to empty your graduate cylinder completely and rinse with a few milliliters of the new solution. This will insure that the concentration of the solution is not compromised.
8. Using the same procedure as described above, measure the height of the hydrometer in your different solutions. Record the height of each in your data table.

CONSTRUCTION OF CALIBRATION CURVE (can be done after all data are collected)

As described in experiment 1, graphs are used to help us understand the data we collect in the laboratory. On a sheet of graph paper use our rules of graphing to plot weight % of sugar vs. hydrometer height. If you are fuzzy on these rules, refer to experiment 1. Remember to plot the independent variable on the x-axis and the dependent variable on the y-axis. Once you have plotted all five points examine them carefully and draw a line through the points that represents the best fit.

SUGAR CONTENT OF CONSUMER PRODUCTS

1. Now that your calibration plot has been created you are ready to examine the sugar content in various consumer products such as soda and fruit juices. All carbonated beverages have been decarbonated because the bubbles tend to stick to the hydrometer and add buoyancy to your device, providing an error in your reading.
2. Each lab partner should choose two different samples to test. Use the procedure described in the calibration part to carefully measure the height of the hydrometer stem. To avoid contamination of the different solutions be sure to wash the graduated cylinder each time and then rinse with a few milliliters of the solution currently being tested.
3. Record the data along with label information from the product (amount of sugar) in a table.
4. To determine the percent sugar in a consumer beverage, locate the hydrometer height for that sample on the y-axis scale and draw a horizontal line until it intersects the calibration line. From that point, draw a vertical line down the horizontal axis and read the percent sugar in your consumer product from the horizontal scale. Read as many significant figures as possible.
5. When you have done this for all four of your consumer products, share the results with other members of the lab. Try to assess the degree of agreement among different measurements of the same samples.

* Reference: American Chemical Society, *Chemistry in Context 2nd edition Laboratory Manual*, ed. Wilmer Stratton.

Section _____ Name _____

PRE-LAB QUESTIONS. (10 pts) Answer on this page, before coming to lab.

1. Use the web links above to find where most of the added sugars enter our diet.
2. What percentage of the graph consists of soft drinks and fruit juices?
3. Find the molecular formula and molecular weight of sugar (sucrose).
4. So how much sugar is in a 12-ounce can of soda?

Section _____ Name _____

Beginning questions & ideas: *What do you want to know or already know?* (4 pts)

Tests & Procedures: *What did you do to answer your questions or prove your idea?* (4 pts)

Observations: *What did you observe from each test and procedure?* (10 pts)

Claims: *What are the answers to your questions or the ideas that you claimed? (6 pts)* _____

Evidence: *What evidence supports your claims? (4 pts)* _____

Reflection: *What have you learned from this activity? (2 pts)* _____

POSTLAB QUESTIONS (10 pts)

1. Which beverage tested has the highest sugar content?
2. How do fruit juices compare to soda in terms of sugar content?
3. How could you modify your hydrometer to increase its accuracy?
4. Pick one of the soda samples you tested and using the sugar % find how many grams of sugar are in a 100 mL sample.
5. Now compare the result found in number 6 with the value quoted on the label on the soda. How do they compare? Can you explain the differences?