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## PERCENTAGE OF SUGAR IN SOFT DRINKS

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### I. OBJECTIVES:

- To learn about specific gravity and density and how these may be used to gather information about a solution or substance, especially its concentration in percentage by weight.
- To explore the sugar content of various types of soft drinks.

### II. BACKGROUND:

Sugars, especially glucose (**gluco** = sweet, **-ose** = carbohydrate ending), are a major source of energy for all living things. Plants produce glucose by photosynthesis and convert that and other monosaccharides into various disaccharides such as sucrose (table sugar – **sucro** = sugar) or convert it into starch to store it more easily. Animals which eat these plants can make use of this energy source and also are attracted to the sweet taste and smell.

We humans have gone a step farther. We frequently add sugar to foods that normally and naturally do not have it (or have it only in small quantities) just because we crave the taste of it for its own sake. We have fought whole wars because of sugar – there are sources that suggest that the Boston Tea Party was caused not by the British tea regulations, but because of their molasses regulations. As our sugar consumption has risen in western nations, so have our rates of the “stress” diseases: diabetes (**dia** = across, through; **bainein**, **badis** = to go, walk, step) and hypoglycemia (**hypo** = under, beneath; **glyco** = sweet), heart and circulatory problems, dental caries, malnutrition, decreased resistance to infections, etc. which are not nearly as prevalent (if at all present) in the Third World nations. An increasing number of nutritionists and other medical people are now in agreement that refined sucrose (or any sugar) is a mind-altering, addicting drug (if you don’t think so, try doing without, and you will probably experience the same withdrawal symptoms as any drug addict).

As of 1986, when Laurel Robertson, *et. al.* revised their book, Laurel’s Kitchen, Americans were averaging  $\frac{1}{3}$  lb. of sugar per person (including children) per day, which comes to about 127 lb. per person per year. As of 1982, when Francis Moore Lappé revised Diet for a Small Planet,  $\frac{1}{4}$  of the average American’s intake of cane and beet sugar came from soft drinks (pp. 126-127). According to Laurel’s Kitchen, (p.421) soft drink consumption in the U. S. rose from 1.6 drinks per person per year in 1850 to 620 drinks per

person per year in 1981. According to the July 1998 issue of *Better Nutrition*, the average American sugar consumption has risen to 148 lb. per person per year, which is over  $\frac{1}{3}$  lb. or 600 KCal per day! In this experiment, we will analyze a number of types of soft drinks to see how much sugar they contain.

Hopefully you recall from the Accuracy and Precision Lab that **density** is defined as grams of solution per milliliter of solution (gm/mL), and that by definition, the density of water is 0.997 or 0.998 gm/mL at 20 to 25°C – room temperature. If any **solutes** are dissolved in the water, the weight of a given volume of the **solution** increases – the solution becomes more dense. People who have done a lot of swimming probably have heard that a person floats higher in ocean water and especially in very salty water like the Dead Sea or Great Salt Lake. This is because relative to the density of our bodies, these salty waters are more dense (and we less dense). When sugar is added to water, it also makes the solution more dense, thus the weight of a known volume of solution can be correlated to the amount of sugar in it. **Specific gravity** is defined as the density of a substance divided by the density of water at the same temperature, and thus is a unitless quantity. In the metric system, for our purposes, density and specific gravity are equal (but in the English system, this is not true) thus, by weighing equal volumes of water and soft drink, we can determine the specific gravity of the soft drink (wt. of pop per 100 mL ÷ wt. of dH<sub>2</sub>O per 100 mL = wt. of pop ÷ wt. of dH<sub>2</sub>O because the 100 mL/100 mL cancels out). We can, then, look up the percentage of sucrose (**sucro** = sugar; **-ose** = a carbohydrate ending) from a chart or graph of specific gravity versus percent sucrose. From this, it is possible to calculate how much sugar is in a can of soft drink. Note that we are assuming that the other solutes in soft drinks do not occur in large enough amounts to affect the density of the solution very much.

### III. MATERIALS NEEDED:

1 can/bottle soft drink of your choice  
100 mL volumetric flask w/ your seat no.

balance  
hot water bath (heat source)

250 mL beaker  
glass stirring rod  
thermometer (use glass – be careful)

Pasteur pipet & bulb  
ice bath

### IV. PROCEDURE:

A. Pour about 125 mL dH<sub>2</sub>O (at room temperature) into a clean 250 mL beaker and insert the thermometer (**thermo** = heat; **meter** = to measure) to check temperature. Please be careful with glass thermometers – they break easily. Obtain the balance for your table number.

B. While the thermometer is equilibrating, weigh a clean, dry 100 mL volumetric flask (the one with your seat number on it) to the nearest 0.01 gm. Record its weight in your lab notebook. You *must* use the same one each time – each flask weighs a different amount. THIS IS THE ONLY CHANCE YOU WILL GET TO OBTAIN A DRY WEIGHT FOR YOUR FLASK.

C. Read the temperature of the dH<sub>2</sub>O. If it is not right on 20° C, use the ice bath to adjust it. Set the beaker in the ice bath, and while constantly moving it, also stir the water with a glass stirring rod (temporarily remove the thermometer so it doesn’t break). Monitor the temperature frequently because it may change rapidly. Remove the beaker from the ice bath when the temperature is just above 20° C, and keep stirring it. As the cold beaker absorbs heat from the water, the water will continue to cool. Note that, if it is close to 20° to begin with, it may only take a few seconds in the ice bath to adjust the temperature.

D. When the water is at exactly 20° C, pour 100 mL into the volumetric flask. To avoid getting air bubbles trapped in the flask, pour the water gently down the side of the flask. Any air bubbles in the flask or excess H<sub>2</sub>O will change the weight. Remember that the bottom of the meniscus should be even with the calibration line on the neck of the flask. Use a Pasteur pipet (medicine dropper) to adjust the volume and then, dry off any excess water droplets.

E. Using the same balance as before (and without any further “adjustments” to it), weigh the flask plus water. Record the weight in your lab notebook. Subtract the weight of the flask alone to determine the weight of the dH<sub>2</sub>O.

F. Pour used dH<sub>2</sub>O into the designated container for “recycling”. Invert the flask to drip dry, supported in a test tube rack, in a location where it will not get knocked over.

G. Pour about 125 mL of your favorite soft drink into the 250 mL beaker. If possible, recap the left-over soft drink to avoid contamination.

H. “De-gas” the soft drink by heating it to about 80°C (It may not get quite that hot).

Place your beaker in the hot water bath and stir it occasionally with the glass stirring rod. Periodically, monitor the temperature with the thermometer. Do not boil your sample or water will evaporate and change the concentration of the solution – you only want to get rid of the carbonation. Stirring gently will speed things up. Heat and stir until there is no more “fizz” left – until the pop is totally flat. Lack of “fizz” is more critical than temperature reached.

I. Place the beaker of sample into the ice bath. As before, gently swirl the beaker and stir the pop with the glass rod. Periodically monitor the temperature as before (CAUTION: thermometers are fragile). When the temperature is a few degrees above 20° C, remove the beaker from the ice bath. Continue swirling and/or stirring until the temperature reaches 20°.

J. Place 100 mL of de-gassed soft drink in the SAME volumetric flask you used before and adjust the level as before. Remember to watch for bubbles and excess droplets.

K. Using the same balance as before, weigh the flask plus soft drink. Record this weight in your lab notebook and subtract to find the weight of the soft drink.

L. Determine the specific gravity of the soft drink by dividing the weight of 100 mL of it (from step K) by the weight of 100 mL of dH<sub>2</sub>O (from step E).

M. Use the provided chart to determine the percent sucrose by weight in your soft drink. This chart was excerpted from a much larger version in one of the chemistry handbooks. What this number means is that your pop contains that percentage of sugar, or for 100 g of pop, that number of grams out of the 100 would be sugar (however, your sample probably did not weigh exactly 100 g).

N. Using the decimal form of your percent sucrose (for example, 12% = 0.12), multiply that times the weight of the sample (from step K) to calculate the weight (number of grams) of sucrose in your sample. For example, if your sample weighed 104.34 g and was 11.5% sugar, the sample would contain 12.00 g of sugar.

O. However, a can of soft drink contains more than the 100 mL in your sample. If you look at the side of the can, somewhere it will say that it contains 12 oz, which is equivalent to 355 mL. Thus, the number of grams of sugar in a can of soft drink can be calculated using a ratio:

$$\frac{\text{known grams of sugar in pop}}{100 \text{ mL of pop}} = \frac{\text{unknown grams of sugar in pop}}{355 \text{ mL of pop in a can}}$$

which can be simplified to:  
grams in 100 mL  $\times$  3.55 = grams/can.

P. However, many people don't really have a visual idea of how big a gram is, so a more useful figure might be the number of teaspoons of sugar per can. To allow us to calculate that number, knowing that one cup (1 C) equals 48 tsp., a cup of sugar was weighed. The weight of that cup of sugar, those 48 tsp, was found to be 213.97 g. Thus, each gram of sugar is equivalent to 0.22433 tsp. Thus, to determine the number of teaspoons of sugar in your can of soft drink, multiply the number of grams you calculated per can (from step O) by 0.22433.

Q. Look at the side of the can/bottle to find out how much sugar the manufacturer claims is in "one serving." Beware! If your soft drink is in a can, the manufacturer will tell you a "serving" is 12 oz, but for the same soft drink in a 2 L bottle, suddenly, a "serving" is

only 8 oz. So that we can easily compare the amount of sugar in various soft drinks, we want to convert "everything" to the equivalent of a 12-oz serving. Thus, if a bottle of soft drink claims to have 32 g of sugar per 8 oz "serving", that's equivalent to  $32 \times 12 / 8 = 32 \times 1.5 = 48$  g of sugar per "normal" 12-oz serving.

R. Record data in the computer as indicated.

**S. CLEAN UP AFTER YOURSELF!!!**

Thoroughly rinse all pop off thermometers and stirring rods. Thoroughly rinse out your volumetric flask by gently inserting the water supply tubing up into the flask so clean water will "push" the sticky pop out. Thoroughly rinse all pop out of the beaker. Check your work area and clean up any spilled pop. Any pop that gets left on glassware or table tops makes a sticky mess when it dries.

**V. DATA:**

In your lab notebook, record all data and observations as indicated in the procedure. Take any other notes you feel are important. Draw anything new or that will help you to remember. When everyone has entered data into the computer, the computer will analyze the class data and calculate averages for each brand/flavor of pop used. These data will be xeroxed and distributed to all class members, so save space in your notebook for these data.

**VI. CONCLUSIONS:**

In your discussion, include:

1. Do you drink soft drinks frequently? You may wish to figure out how much sugar you get from soft drinks per day or week or month. For example:

$$\begin{aligned} \# \text{ of cans/day} \times \text{g/can (from step O)} &= \text{g/day} \\ \text{g/day} \times 7 \text{ days/week} &= \text{g/week} \\ \text{g/week} \times 1 \text{ lb}/453 \text{ g} &= \text{lb/week} \\ \text{lb/week} \times 52 \text{ weeks/year} &= \text{lb/year} \\ \text{lb/year} \div 5 &= \# \text{ of 5-lb sacks/year} \end{aligned}$$

Would you put that much sugar in a cup of tea or coffee?

2. As you compare the class data, which soft drinks had the most sugar? You may wish to comment on the implications, healthwise, for someone who drinks a lot of soft drinks.

SAMPLE CALCULATIONS:	
wt. of flask + H <sub>2</sub> O:	161.55
wt. of flask	61.83
wt. of H <sub>2</sub> O	99.72
wt. of flask + pop:	166.17
wt. of flask	61.83
wt. of pop	104.34
wt. of pop $\div$ wt. of H <sub>2</sub> O:	
104.34/99.72 =	1.0463
(specific gravity)	
from the chart, 1.0463 corresponds to	
11.5% sugar	
11.5% = 0.115	
0.115 $\times$ 104.34 g (wt. of pop) = 12.00	
g of sugar per 100 mL	
$\frac{12.00 \text{ g}}{100 \text{ mL}} = \frac{x \text{ g}}{355 \text{ mL}}$	
x = 3.55 $\times$ 12.00 = 42.60 g sugar/can,	
and then,	
42.60 g/can $\times$ 0.22433 tsp./g =	
9.56 tsp of sugar/can of pop	

Specific Gravity of Sucrose Solutions at 20°/20° C							
sp. gr.	% sucrose	sp. gr.	% sucrose	sp. gr.	% sucrose	sp. gr.	% sucrose
1.00000	0.0	1.01490	3.8	1.03010	7.6	1.04582	11.4
1.00039	0.1	1.01530	3.9	1.03050	7.7	1.04625	11.5
1.00078	0.2	1.01570	4.0	1.03090	7.8	1.04668	11.6
1.00117	0.3	1.01610	4.1	1.03130	7.9	1.04711	11.7
1.00156	0.4	1.01650	4.2	1.03170	8.0	1.04754	11.8
1.00195	0.5	1.01690	4.3	1.03211	8.1	1.04797	11.9
1.00234	0.6	1.01730	4.4	1.03252	8.2	1.04840	12.0
1.00273	0.7	1.01770	4.5	1.03293	8.3	1.04882	12.1
1.00312	0.8	1.01810	4.6	1.03334	8.4	1.04924	12.2
1.00351	0.9	1.01850	4.7	1.03375	8.5	1.04966	12.3
1.00390	1.0	1.01890	4.8	1.03416	8.6	1.05008	12.4
1.00429	1.1	1.01930	4.9	1.03457	8.7	1.05050	12.5
1.00468	1.2	1.01970	5.0	1.03498	8.8	1.05092	12.6
1.00507	1.3	1.02010	5.1	1.03539	8.9	1.05134	12.7
1.00546	1.4	1.02050	5.2	1.03580	9.0	1.05176	12.8
1.00585	1.5	1.02090	5.3	1.03621	9.1	1.05218	12.9
1.00624	1.6	1.02130	5.4	1.03662	9.2	1.05260	13.0
1.00663	1.7	1.02170	5.5	1.03703	9.3	1.05302	13.1
1.00702	1.8	1.02210	5.6	1.03744	9.4	1.05344	13.2
1.00741	1.9	1.02250	5.7	1.03785	9.5	1.05386	13.3
1.00780	2.0	1.02290	5.8	1.03826	9.6	1.05428	13.4
1.00819	2.1	1.02330	5.9	1.03867	9.7	1.05470	13.5
1.00858	2.2	1.02370	6.0	1.03908	9.8	1.05512	13.6
1.00897	2.3	1.02410	6.1	1.03949	9.9	1.05554	13.7
1.00936	2.4	1.02450	6.2	1.03990	10.0	1.05596	13.8
1.00975	2.5	1.02490	6.3	1.04032	10.1	1.05638	13.9
1.01014	2.6	1.02530	6.4	1.04074	10.2	1.05680	14.0
1.01053	2.7	1.02570	6.5	1.04116	10.3	1.05723	14.1
1.01092	2.8	1.02610	6.6	1.04158	10.4	1.05766	14.2
1.01131	2.9	1.02650	6.7	1.04200	10.5	1.05809	14.3
1.01170	3.0	1.02690	6.8	1.04242	10.6	1.05852	14.4
1.01210	3.1	1.02730	6.9	1.04284	10.7	1.05895	14.5
1.01250	3.2	1.02770	7.0	1.04326	10.8	1.05938	14.6
1.01290	3.3	1.02810	7.1	1.04368	10.9	1.05981	14.7
1.01330	3.4	1.02850	7.2	1.04410	11.0	1.06024	14.8
1.01370	3.5	1.02890	7.3	1.04453	11.1	1.06067	14.9
1.01410	3.6	1.02930	7.4	1.04496	11.2	1.06110	15.0
1.01450	3.7	1.02970	7.5	1.04539	11.3	1.06153	15.1

