7.2: Percent Sugar Procedure

Learning Objectives

- Gain hands-on experience in constructing a homemade hydrometer and calibrating it using solutions of known sugar concentrations.
- Develop skills in accurately measuring the density of various beverages and using this data to determine their sugar content.
- Understand how density relates to the concentration of sugar in a solution.

Introduction

The word carbohydrate comes from "hydrate of carbon", which is derived from the formula $C_n(H2O)_m$. Carbohydrates are the body's most important and readily available source of energy. An adult human consumes between 1200 and 2400 calories just to keep alive. The bulk of this energy comes from burning carbohydrates and fats. Your brain runs on nothing but glucose. The two major forms of carbohydrates are:

- Simple Sugars (Monosaccharides), such as glucose, fructose, galactose, mannose and others found in nutritious whole fruits.
- Complex Sugars and Starches (Disaccharides), such as sucrose, lactose. (Polysaccharides), such as glycogen and cellulose.

The simple carbohydrates in many refined foods (white flour, white rice) as well as fruits are easily broken down and cause your blood sugar level to rise quickly. Foods that are high in added simple carbohydrates (soda and fruit drinks) also tend to be high in calories and low in other valuable nutrients. Today in the United States high-fructose corn syrup (HFCS), a 55% fructose and 45% glucose syrup from maize (corn), is used nearly exclusively as a sweetener because of its lower cost. As a result, a high-sugar diet is often linked with obesity.

The complex carbohydrates found in whole-grain products such; as brown rice, breads, and cereals, as well as, starchy vegetables are broken down more slowly, allowing blood sugar to rise more gradually. Therefore, eating a diet that's high in complex carbohydrates can minimize the risk for developing health problems like diabetes and heart disease.

Good sources of carbohydrates include:

- whole-grain cereals
- brown rice
- whole-grain breads
- fruits
- vegetables
- low-fat dairy

The key is to make sure that the majority of carbohydrates we eat are from sources such as those listed above and to limit the amount of added sugar in your diet.

From a chemical perspective, fruit juices and sodas are basically sugar-water solutions. Sugar added to the water makes the solution denser than pure water. In other words, a cup of pure water weighs less than a cup of sugar-water. Increasing the amount of sugar in the sugar-water solution results in an increase in the density of the solution. Therefore, by comparing the densities of sugar-water solutions you can determine the amount of sugar present in fruit drinks and sodas.

Normally a chemist would use a commercially available hydrometer to compare specific gravities of solutions. The hydrometer measures the relative density of its resting free-floating position in the solution. For example, when it is dropped into a low density solution, the device will sink and come to rest at a low position without touching the bottom.

In this lab you will prepare a home-made hydrometer to determine the densities of various fruit drinks and sodas. To accomplish this you will record the resting positions of your home-made hydrometer (a free-floating pipette) in a set of reference solutions that you will prepare. These will be use to create a calibration curve by plotting the resting positions versus sugar content. You will then match the resting position in the fruit drinks or sodas to the sugar content using the calibration curve.

Procedure

> **Note**
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> Fruit juices and soda need to be left out overnight so that they are flat before you begin this lab. Be sure all fruit juices and soda are at room temperature before you begin. Record the temperatures in the tables provided.

Part I. Preparing a Free Floating Pipette

1. Obtain a plastic pipette, a 25 mL graduated cylinder, a 100 mL beaker and a few paper towels.
2. Pour 40 mL of distilled water into your 100 mL beaker. Record the temperatures in the tables provided.
3. Fill the graduated cylinder to just under the 25 mL mark with distilled water. Tap out the air bubbles. Draw up some water in an empty pipette. Use this to add the few necessary drops to bring the water level to the 25 mL mark. Be sure to look at this at eye level.
4. Fill the pipette completely with distilled water. This can be accomplished by the following steps. Squeeze out as much air as you can from the pipette and place the tip of the pipette into the distilled water in the beaker. Let go and water will flow into the pipette. Turn the pipette upward and squeeze out any remaining air until water begins to leave the tip. (Paper towels come in handy here.) Quickly insert the tip back into the distilled water and allow it to completely fill with distilled water. At this point the pipette should be completely full.
5. Gently drop the pipette into the graduated cylinder. It should sink to the bottom. If it does, carefully retrieve the pipette and squeeze out 2 or 3 drops.
6. Gently drop the pipette into the graduated cylinder again. It should now be floating just off the bottom. Be sure the bottom of the pipette is floating somewhere between the 1 and 5 mL mark. To ensure the pipette is not getting hung up on the sides of the graduated cylinder tap the pipette toward the center of the cylinder to see if the pipette will sink more. Repeat this until the pipette stabilizes.
7. Once the pipette has stabilized, record the level of the bottom end of the bulb at eye level. Record the resting position of the pipette in Table 1 under 0% sugar solution.
8. Remove the pipette and repeat steps 6 and 7 two more times. Find the average of these three readings and record in Table 1. This is known as the relative density of water in this experiment.
9. Remove the pipette and discard the water in the cylinder. Carefully set the pipette aside. A 24-well tray works great as a pipette stand.

Part II. Preparing Reference Sugar Solutions and Determining their Resting Positions.

If your instructors were trapped on a deserted island with only a 50 mL graduated cylinder and a 200 mL beaker, we would prepare 100.0 mL of a 20.0% (w/v) solution as follows. (To recall information from CH 105, a 20.0% (w/v) solution means 20.0g of solute per 100.0 mL of solution.)

- Weigh 20.0 grams of table sugar and place in a clean dry beaker.
- Add about 30-40 mL of distilled water and stir until dissolved.
- Transfer this solution to a 50 mL graduated cylinder and carefully bring to the 50.0 mL mark with distilled water.
- Pour the contents of the graduated cylinder into a clean dry 200 mL beaker.
- Add another 50.0 mL of water to the graduated cylinder.
- Add this 50.0 mL to the beaker and swirl. Now you have 100.0 mL of a 20.0% (w/v) solution.

Your challenge is to make 50 mL of a 20.0% (w/v) reference sugar solution.

1. Describe how you made the 20.0% (w/v) solution. This should be about one paragraph reported in your post-lab.
2. Make 25 mL of a 15.0% (w/v). (Hint: $\mathrm{C_1V_1 = C_2V_2}$ using your 20.0% solution)
3. Fill your well rinsed 25 mL graduated cylinder with 25.0 mL of the 15.0% (w/v) sugar solution.
4. Gently drop the pipette filled with distilled water you created in Part 1 into the graduated cylinder. To ensure the pipette is not getting hung up on the rim of the graduated cylinder tap the pipette toward the center of the cylinder to see if the pipette will sink more. Repeat this until the pipette stabilizes.
5. Once the pipette has stabilized record the level of the bottom end of the bulb at eye level. Record the resting position of the pipette in Table 1 under 15.0% sugar solution.
6. Remove the pipette and repeat steps 5 and 6 two more times. Find the average of these three readings and record in Table 1.
7. Be sure to rinse your pipette well with water and wipe dry before going on.

8. Make 25 mL of a 10.0% (w/v). (Hint: $C_1V_1 = C_2V_2$ using your 20.0% solution)
9. Repeat steps 5-9 using the 10.0% (w/v) solution.
10. Make 25 mL of a 5.0% (w/v). (Hint: $C_1V_1 = C_2V_2$ using your 20.0% solution)
11. Repeat steps 5-9 using the 5.0% (w/v) solution.

Part III. Establishing a Calibration Curve of Sugar Solutions

Plot your data using excel or sheets with average resting position on the y-axis and Percentage of sugar on the x-axis. Add a linear trendline and the equation of the line to the graph. This is your calibration curve.

Part IV. Determining Resting Position of pipette in Fruit Drinks or Soda

1. Be sure all fruit juices and soda are at room temperature before you begin. Record the temperatures in the tables provided.
2. Record the 3 types of drinks you will be testing in Table 2.
3. Using the pipette filled with distilled water you created in Part 1 determine the resting position for each drink. Do this 3 times and find the average of these three readings and record in Table 2.

Part V. Using your Calibration Curve

1. Print out the graph you made in Excel. Copy this graph into your lab report form at the appropriate place.
2. Use the equation of the trendline to determine the % sugar in the 3 types of drink you chose. Show your calculations in the post-lab.
3. Record the percentage sugar reading in Table 3. This in the sugar content of your drink.
