Is There Hidden Sugar in Your Drink?

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Motivation

- I have a big passion for the medical field, showed by last year’s project.
- Food labels and nutrition have caught my eye and are important when eating.
Research Question

How do glucose levels in different drinks change after adding an invertase enzyme?
Hypothesis

Given that the invertase enzyme breaks down sucrose, glucose levels will rise after adding the enzyme because the sucrose will convert to glucose and fructose.

Coca Cola will have the most glucose because it has the most calories of each drink.
Glucose

- Chemical compound in the body
  - $C_6H_{12}O_6$
- Comes from food and drink
  - Generally rich in sugars/carbohydrates
- Used for many purposes:
  - Used to make energy (ATP) in cellular respiration
  - Stores energy
  - Used to build carbohydrates
Chemical Reaction

- A chemical reaction transfers a set of compounds into another
  - **Reactants**: Enter into a chemical reaction
  - **Products**: Compounds produced by the reaction
  - **Catalyst**: Speeds up the rate of a chemical reaction
    - **Enzyme**: Biological catalysts; usually proteins

The formula for this experiment is:

Sucrose + Water $\xrightarrow{\text{Invertase}}$ Glucose + Fructose

$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{Invertase}} C_6H_{12}O_6 + C_6H_{12}O_6$
In the Body

- The most common sugar is eaten as sucrose.
  - Also known as table sugar
- It is broken down in the body into glucose and fructose through a chemical reaction during digestion.
  - Fructose: Contains the same elements as glucose, but has a different chemical construction
    - Often used to make more glucose
- The reaction is catalyzed by an enzyme named sucrase.
  - Modeled by invertase in experiment
- The pancreas monitors blood sugar, or amount of glucose in the body.
  - It releases insulin to allow glucose to enter different organs, similar to a lock and key system.
The Calorie

- The calorie is used to measure the amount of energy in food
  - Raises temperature 1ºC every gram of water
- Through cellular respiration, glucose gets converted into Adenosine Triphosphate (ATP)
  - Provides energy for the body
- The glucose in drinks provide its energy, therefore the calories can indicate the amount of glucose in a drink

Calories in Drinks Tested Per Serving Size:

**Water:** 0 calories  
**Coca Cola:** 180 calories (also considered a sugary drink)  
**Diet Coke:** 0 sugar and 0 calories  
**Milk:** 124 calories (mostly contains lactose, rather than glucose)  
**Orange Juice:** 110 calories (fruit juice, yet has artificial flavoring)  
**Gatorade:** 140 calories
Possible Problems

- **Hypoglycemia**: a condition where not enough glucose is in the body to perform everyday functions
  - They often eat and drink what is rich in sugar to get their glucose.

- **Hyperglycemia**: a condition where there is too much sugar in the body
  - Can be a sign of **Diabetes**:
    - **Type I**: not enough insulin is being made in the body
    - **Type II**: the body is not responding to the insulin being made
Variables

- Independent Variable
  - Type of Drink
  - Invertase Enzyme

- Dependent Variable
  - Amount of glucose

- Control
  - Water

- Constants
  - Temperature
  - Amount of each drink
  - Amount of Invertase Enzyme
  - Time of glucose strip in sample
  - Linear Time Point
  - Testing/ Environmental Conditions
Materials

- Sugar Metabolism Kit
  - Graduated Cylinder (100mL)
  - Invertase Powder (1g)
  - Glucose Powder (30g)
  - Urinalysis Test Strips Measuring Glucose (60)
  - Graduated Transfer Pipettes (3mL)
- Disposable Cups
- Sharpie
- Knife and Spoon
- Food Coloring
- Distilled Water
- Tap Water

- Metric Measuring Graduated Cylinder
- Phone Timer
- Sucrose/ Table Sugar
- Metric Digital Scale
- Bottle Caps
- Drinks to Test:
  - Milk (2%)
  - Processed Orange Juice
  - Coke
  - Diet Coke
  - Gatorade (Orange Flavor)
- Latex Gloves
- Apron
- Goggles
Testing the Glucose Strips

- Label six cups with different concentrations of glucose
  - 2%, 1%, 0.5%, 0.25%, 0.125%, and 0.0625%
- Add 200 mL of tap water and 4 grams of glucose powder to the 2% cup and stir until dissolved
- Add 4 drops of red food coloring
- Add 100 mL of tap water to the other 5 cups
- Measure 100 mL of the 2% solution and add it to the 1% solution and stir well
- Measure 100 mL of the 1% solution and add it to the 0.5% solution and stir well
- Repeat this process for the remaining dilutions
- Fill another cup labeled 0% with 100 mL of tap water
- Dip a test strip in each of the seven cups
  - After 2 seconds, take the test strip out and match the color shown to a color on the bottle
  - Record data
Testing Invertase Activity

- Prepare the invertase enzyme before the experiment
  - Add 25 mL of distilled water to the bottle with 1 g of powdered invertase
  - Shake the bottle and refrigerate when not in use
- Fill a cup with 60 mL of tap water and 6 g of sucrose
  - Mix until dissolved
  - Makes a 10% sucrose concentration
- Take 15 mL of this solution and pour it into another cup
- Use a glucose strip to measure the amount of glucose in the solution
- Add 15 drops of the invertase enzyme to the solution and stir well
- Start stopwatch and record glucose readings every 5 minutes for the first 20 minutes and every 10 minutes afterward
- Stop taking readings when the glucose levels are the same for 20 minutes
  - 3 glucose readings without an increase
- Record data and calculate **linear time point**: when sucrose is being converted at a constant rate
Testing Different Drinks

- Label three cups for each of the selected drinks
  - Milk, Water, Orange Juice, Diet Coke, Coca Cola, and Gatorade
  - Ensure that these drinks are all at room temperature
- Add 15 mL of each drink to the labeled cups
- Record glucose readings of each sample before adding the invertase
  - If reading is above 2%, perform a tenfold dilution
    - Take 2.5 mL of the sample and mix it with 22.5 mL of water to record accurate glucose reading
    - Use diluted sample for all glucose measurements
- Add 15 drops of invertase to each sample and set timer to linear time point
- Once the time point is reached, record new glucose measurements of all samples
- Record, analyze, and makes graphs of data
Experimentation
## Glucose Testing

<table>
<thead>
<tr>
<th>Glucose Concentration</th>
<th>Test Strip Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>0.5%</td>
<td>0.75%</td>
</tr>
<tr>
<td>0.25%</td>
<td>0.625%</td>
</tr>
<tr>
<td>0.125%</td>
<td>0.125%</td>
</tr>
<tr>
<td>0.0625%</td>
<td>0.05%</td>
</tr>
<tr>
<td>0%</td>
<td>0% (negative)</td>
</tr>
</tbody>
</table>
Invertase Activity

The increase of glucose production levels off due to **product inhibition**
- 70 minutes

**Linear time point**: When glucose production is steadily increasing
- 35 minutes
# Glucose in Drinks Tested vs Invertase Enzyme

<table>
<thead>
<tr>
<th>Drinks Tested</th>
<th>Concentration of Glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1 Before Invertase</td>
</tr>
<tr>
<td>Water</td>
<td>0%</td>
</tr>
<tr>
<td>Coca Cola</td>
<td>3.75%</td>
</tr>
<tr>
<td>Diet Coke</td>
<td>0.1%</td>
</tr>
<tr>
<td>Orange Juice</td>
<td>0.5%</td>
</tr>
<tr>
<td>Gatorade</td>
<td>0.5%</td>
</tr>
<tr>
<td>Milk</td>
<td>0%</td>
</tr>
</tbody>
</table>
Glucose in Drinks Tested vs Invertase Enzyme

Average Glucose Level/ Different Drink

Type of Drink

Glucose Concentration

Before Enzyme
After Enzyme

Water
Coca Cola
Diet Coke
Orange Juice
Gatorade
Milk
Notable Observations

- The glucose concentration increased after adding the invertase enzyme, yet it was not a dramatic change.
  - About 0.53% increase on average
- Coca Cola had the most glucose by a large margin.
- Orange Juice and Gatorade had an average amount of glucose, Diet Coke had slightly less, and Milk had close to none.
- The glucose strips were not fully accurate as they were originally made for urinalysis tests.
- Colors were often in between the given shades on the bottle.
Conclusion

- My hypothesis was supported:
  - Glucose levels will rise after adding the invertase enzyme
  - Coca Cola will have the most glucose
- Glucose levels rose because the invertase enzyme converts sucrose into glucose and fructose, thus creating more glucose
- Coca Cola is a soft drink with a lot of sugar, so the margin was much wider than a lot of the other drinks.
  - I believe that the calorie count is not an accurate estimate of how much glucose is in a drink, as there was not a direct correlation between the rest of the drinks
  - Not all glucose is used to provide energy, so the calorie unit is not the only factor to infer glucose amounts.
Further Investigation

Possible flaws in my experiment include:
- Inaccuracy in glucose testing strips
- Human error in calculating time
- Results are based on color
- Scale and beaker may not be exact

If I were to redo this experiment:
- Have more trials to ensure accuracy
- Another person to identify color and help with timer

How to elevate the experiment:
- Test more types of drinks or foods
- Test different types of the same drink
- Research other ways to measure glucose levels
- Research ways to test fructose levels (high-fructose corn syrup)
Applications

- There are many people with hyperglycemia or hypoglycemia who have to watch their sugar intake carefully.
- My experiment shows that there can be more sugar in certain drinks than portrayed in a food label, and people with these conditions should be mindful of the drinks they choose.
- These common drinks are a large part of our diet today, and learning about them is essential to stay healthy.


Kolonko. *Glucose Blood Level Sugar Test. Diabetes Insulin Hypoglycemia or Hyperglycemia Diagram Icon. Shutterstock*, 2020,


Acknowledgements

- I would like to thank my family for helping me with this experiment.
- I would also like to thank Dr. Dee, my sponsor, for all of her help.
Thank you all for listening! Are there any questions?