Enhancing the Efficacy of Ingested Lactase by Altering Gastric pH

Introduction

Lactose Intolerance

- Inability to digest lactose sugars in dairy products
- Around **68%** of the world's population has lactose intolerance
- **Cause:** Insufficient lactase production in the duodenum
- **Symptoms:** Abdominal pain, bloating, and diarrhea
- **Risk Factors:** Age, ethnicity, premature birth, small intestinal diseases, and cancer treatments
- Avoiding dairy products can lead to lower calcium intake and increase the risk for diseases, such as osteoporosis
- People take lactase medications before eating dairy products to help break down lactose

$$\text{lactose} \xrightarrow{\text{lactase}} \text{glucose} + \text{galactose}$$
$$C_{12}H_{22}O_{11} \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

Background

Lactase

- Produced and acts in the duodenum
- Works best between pH 5-7
- Oral lactase taken by lactose intolerant people
  - Has to pass through stomach (pH 1.5-2)

Calcium Carbonate ($CaCO_3$)

- Increases stomach pH
- Used to treat acid reflux
- There are no prior studies examining direct effect of $CaCO_3$ on lactase efficacy

Where Milk Meets Lactase

Lactose Tolerant People

- Milk first encounters lactase produced in duodenum (pH 6-7.4)

Lactose Intolerant People

- Milk does not encounter lactase unless it is ingested
- Milk then meets lactase in the stomach, which has pH 1.5-2

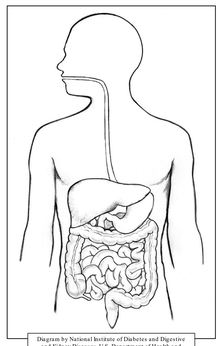

Diagram by National Institute of Diabetes and Digestive and Kidney Diseases, U.S. Department of Health and Human Services

Hypothesis

IF lactase is more effective at a higher pH,

THEN the addition of calcium carbonate will increase the effectiveness of ingested lactase,

BECAUSE calcium carbonate raises the pH of the stomach.

Methodology

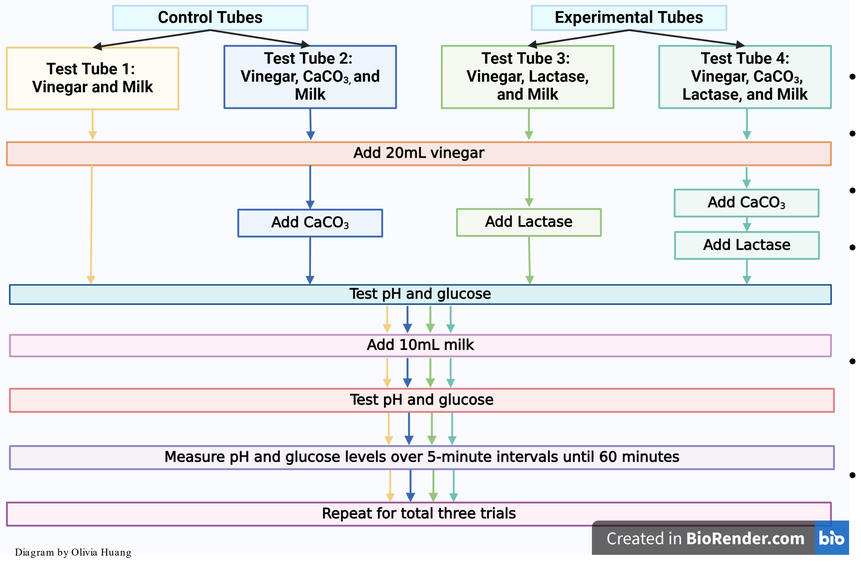

Diagram by Olivia Huang

- Vinegar (simulated stomach acid) - Distilled White Vinegar 5% Acidity
- Milk - Whole milk
- $CaCO_3$ - 750 mg TUMS tablets
- Lactase - 9000 FCC tablet
- pH tested with Drenoyic Premium Wide Range Strips Test Strips
- Glucose measured using glucometer (CareSens N Blood Glucose Monitoring System)
- If glucose level too low to be detected by glucometer, test strips (URS-10T Reagent Strips) were used instead

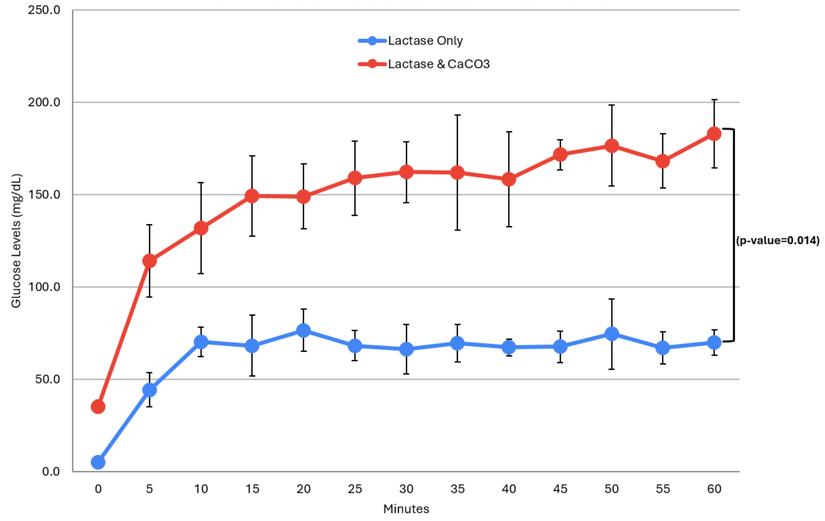

Chart by Olivia Huang

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CareSens N Blood Glucose Monitoring System

Drenoyic Premium Wide Range pH Test Strips

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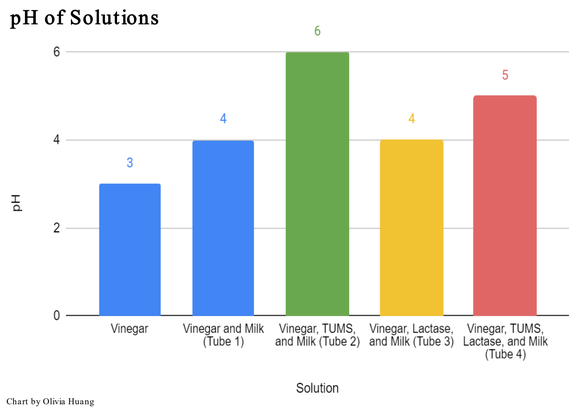

Chart by Olivia Huang

Results

Control Tubes

- **Tube #1 – Vinegar + Milk**
  - No glucose detected
  - pH 4
- **Tube #2 – Vinegar + $CaCO_3$ + Milk**
  - No glucose detected
  - pH 6

Experimental Tubes

- **Tube #3 – Vinegar + Lactase + Milk**
  - Average glucose level
    - 5 mg/dL at 0 min
    - 70 mg/dL at 60 min
  - pH 4
- **Tube #4 – Vinegar + $CaCO_3$ + Lactase + Milk**
  - Average glucose level
    - 35 mg/dL at 0 min (+600% difference vs Tube #3)
    - 183 mg/dL at 60 min
  - pH 5

Conclusions

- Calcium carbonate significantly enhances the ability of ingested lactase to break down lactose
- It amplifies the immediate and prolonged effect on ingested lactase for up to 60 minutes
- This effect is likely due to calcium carbonate increasing the pH and allowing lactase to work within its optimal pH range
- This novel combination is a cost-effective way to durably treat the very common problem of lactose intolerance

Next Steps

- Test for an even longer duration and add more milk as time progresses
- Findings can serve as the basis for studies in humans
- Create a combination lactase and calcium carbonate pill to enhance efficacy of lactose breakdown (patent pending)