Yeast's Reaction to Lactase in a Lactose Solution

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Abstract

We created this project to help demonstrate the function of the lactase enzyme in the digestion of lactose. We hypothesized that increasing the amount of lactase in the solution with a yeast population will increase the fermentation rate because lactase catalyzes the decomposition of lactose into glucose and galactose. This makes it digestible to the yeast. The data collected neither supports, nor refutes our hypothesis. Understanding how yeast cells use lactase to digest lactose can aid in understanding how humans use lactase. This data can help expand the diets of people with lactose intolerance to be less restrictive.

Introduction

Our research began with the question, 'How do varying masses of lactase effect the fermentation rate of yeast in a lactose solution?' We determined in our Fermentation Lab that yeast ferments fastest when given a 20% glucose solution (~0.71 mL CO2/min) and slowest when given a 20% lactose solution (~0.04 mL CO2/min). Lactose cannot be used for digestion because it is a disaccharide and too large to be diffused across the membrane for fermentation. It must be broken down into the monosaccharides that form it to be transported into the cell. Lactose binds to the active site of the lactase enzyme, where it undergoes hydrolysis, breaking it down into galactose and glucose (Forsgård, 2019). The glucose can then be transported into the cell to be used in fermentation. Yeast cannot produce lactase (Admin, 2017), therefore it requires an external source. Based off this data, we hypothesized that adding 0.5 grams of lactase in the form of crushed Lactaid would produce the highest fermentation rate in a 20% Lactose solution. This is because a larger concentration of the lactase enzyme means that the substrate (lactose) will bind more frequently with the enzyme (Waldron, 2023) which will produce more Glucose for the yeast cell to digest.

Methods

Materials & Location

To carry out this procedure, you will need 6-30 mL test tubes, 6-10 mL fermentation tubes, 2-10 mL pipettes, 1 pipettor, 6 stir sticks, 1-150 mL beaker, a mortar and pestle, 6 weigh boats (WB), an analytical balance, and an incubator at 37° C . You will also need 60 mL of 20% Lactose solution at 37° C, 100 mL of warm tap water, 2 packets of baker's yeast, and 1.5 grams of lactase.

Procedure

First, label weigh boats, test tubes, and fermentation tubes with numbers 1-6. Prepare yeast suspension; add 100 mL of warm water and 2 packets of baker's yeast. Grind lactase tablets into a fine powder using a mortar and pestle. Weigh the lactase using an analytical balance; to WB #1, add 0.0g, to WB #2, add 0.1g , to WB #3, add 0.2g, to WB #4, add 0.3g, to WB #5, add 0.4g, and to WB #6, add 0.5g. To each test tube, add 10 mL lactase solution and 10 mL yeast suspension with a pipettor. Add the contents of each WB to its corresponding test tube number. Mix each test tube and transfer to its corresponding fermentation tube. Tip each tube so that the solution fills the vertical column, place all tubes in the incubator and record the time. Remove tubes when one reaches 5 mL CO2. Record the volume of CO2 in each tube and record the time of measurement for each individual tube.

Fermentation Rate of Yeast in Lactose Solution When Given Lactase; Trial Data

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
0.0 g Lactase	0.0 mL CO2/min	0.0 mL CO2/min	0.0 mL CO2/min	0.0 mL CO2/min	0.0 mL CO2/min
0.1 g Lactase	0.95 mL CO2/min	1.42 mL CO2/min	0.20 mL CO2/min	0.40 mL CO2/min	0.20 mL CO2/min
0.2 g Lactase	1.13 mL CO2/min	0.98 mL CO2/min	0.43 mL CO2/min	0.44 mL CO2/min	0.13 mL CO2/min
0.3 g Lactase	1.38 mL CO2/min	1.14 mL CO2/min	0.68 mL CO2/min	0.41 mL CO2/min	0.64 mL CO2/min
0.4 g Lactase	1.33 mL CO2/min	0.71 mL CO2/min	0.65 mL CO2/min	0.45 mL CO2/min	0.38 mL CO2/min
0.5 g Lactase	1.07 mL CO2/min	0.88 mL CO2/min	0.73 mL CO2/min	0.45 mL CO2/min	0.48 mL CO2/min

Table 1. Shows the fermentation rate of the yeast within each trial. Fermentation rate is calculated by dividing the final volume of CO2 in the fermentation tube by the duration of fermentation recorded at the time of CO2 measurement.

Average Fermentation Rate of Yeast in Lactose Solution When Given Lactase

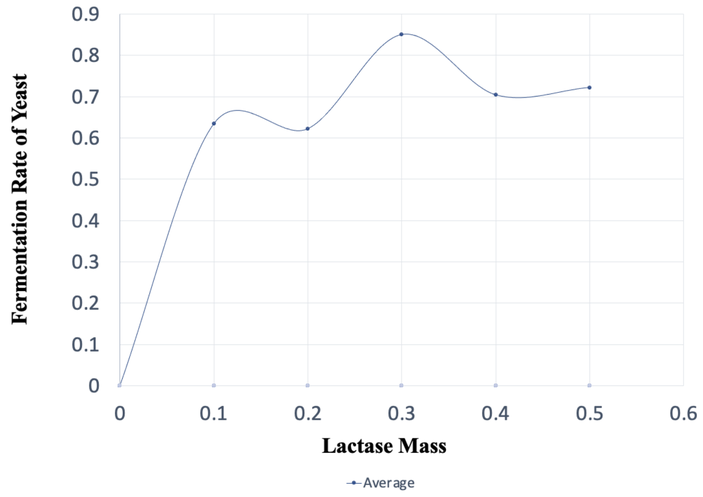

Figure 2. shows the average relationship between the mass of the lactase and the fermentation rate of the yeast across all trials.

Discussion

When comparing the fermentation rate of the yeast with no lactase to the fermentation rate of yeast with lactase, there was a clear increase in fermentation rate, but when only comparing fermentation when lactase is present, there is no logical pattern.

The difference in fermentation rate between the yeast with and without lactase can be explained by the known fact that lactase is an enzyme that breaks down lactose into glucose and galactose, which can be digested by the yeast. When there is only lactose in the environment, yeast are not able to digest it and therefore there would be no fermentation, but when there is lactase, they can carry out the fermentation process. When it comes to the relationship of all the masses, the deviation in the fermentation rate from the expected can be explained by a possible variation in yeast population in each tube. Because the yeast suspension is a heterogenous mixture, it is possible that a few of the test tubes received a higher yeast population than the others, which would affect the fermentation rate. With our present data, we can conclude that adding lactase to yeast in a lactose environment causes the yeast to ferment. The lactase mass associated with the highest fermentation rate was 0.3 grams of lactase for our set population of yeast.

For replication of this research, we suggest that in order to have a more consistent population of yeast in each test tube, the yeast suspension be stirred as the suspension is drawn as to evenly distribute the yeast in the solution. Though the hypothesis was not supported, this research still models the functionality of lactase in digesting lactose.

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