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Monosaccharides Yield Higher Fermentation Rates than Disaccharides in *Saccharomyces cerevisiae*

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Abstract

In our experiment we compared the fermentation rates of monosaccharides and disaccharides through the use of two sugars: glucose and lactose. In order to compare the fermentation rates of each sugar, we first tested deionized water which served as a negative control and a baseline of comparison. We hypothesized that glucose would have a higher rate of fermentation because it is a monosaccharide which has a simpler structure and less bonds to break. This hypothesis was proven correct because our results showed that glucose had the highest rate of fermentation when compared to lactose and deionized water.

Introduction

Fermentation is an incredibly important process which is used in the production of many foods. The global population is growing extremely rapidly and the issue of food shortages is becoming more and more prevalent. Because of this food crisis many scientists are turning to the process of fermentation in order to produce alternate sources of food (Frias et al., 1996). The various rates of fermentation are used in order to achieve certain results in the desired product. For example in the production of drinks such as wine, scientists use various fermentation rates to break down glucose into CO_2 and alcohol which produces different kinds of wine (Loubser, 2017).

We are conducting this experiment in order to determine which type of sugar, monosaccharides or disaccharides, has the higher rate of fermentation. Aside from simply testing the fermentation rates of monosaccharides and disaccharides, we will also be using deionized water to serve as a negative control group to set a baseline for the two experimental groups. The complex disaccharide structure will cause a lower rate of fermentation and CO_2 production because the bond in its structure will take more energy to break. When comparing the

fermentation rates of the different sugars, the monosaccharide (glucose) will ultimately have the highest rate of fermentation/minute because its structure will be more easily broken down than the disaccharide (lactose). This is because glucose is a single molecule while lactose is composed of two molecules joined by a bond, which makes it more difficult to break down. Our hypothesis will be supported if the glucose is measured to have the greatest rate of fermentation. Conversely, our hypothesis will be rejected if the glucose has the smallest rate of fermentation when compared to the lactose and deionized water solutions.

Methods

The monosaccharide we are testing is glucose and the disaccharide is lactose. These sugars were chosen because of their similar chemical makeup. Both of these sugars will serve as experimental groups. In order to set a baseline that we can compare our experimental groups to, deionized water will serve as our control group.

Instructions to make the yeast solutions can be found in the lab manual (Shaw and French, 2018). After making the base solution, we added 10 mL of the solution we were testing, whether it was lactose, glucose, or deionized water. The relative amounts for each group can be seen in Table 1 in the appendix. Once the solution was added, we began to collect data points at a rate of 10 seconds/sample using the LoggerPro carbon dioxide sensor. We will be measuring the rate of fermentation through carbon dioxide production for all three groups. Each solution was tested three times, which resulted in a total of 9 trials.

For each trial, we will calculate the average slope [(Final Pressure-Initial Pressure)/(5 Minutes)]. With this data we will create a bar graph using Excel. This is the best type of graph to use for our data because it will clearly show which of the groups had the greatest rate of fermentation. For each solution we tested (glucose, lactose, and deionized water) we will also calculate the standard deviation in order to see the distribution among our three trials compared to their averages.

Results

After collecting our data, we found that glucose had the highest rate of fermentation, followed by lactose, and then deionized water had the lowest rate of fermentation, as displayed by Figure 1 in the appendix. The average rate of change of fermentation for glucose was 1181 ppm/minute, for lactose, 803 ppm/min, and for deionized water it was 627 ppm/min. Additionally, as seen in Figure 1, glucose

Table 1. Displays the amounts of volumes of each solution that are going into each trial.

Group		Yeast (0.6 g)	Lactose	Glucose	DI Water	Total
1	Lactose	10 mL	10 mL	-----	-----	20 mL
2	Glucose	10 mL	-----	10 mL	-----	20 mL
3	DI Water	10 mL	-----	-----	10 mL	20 mL

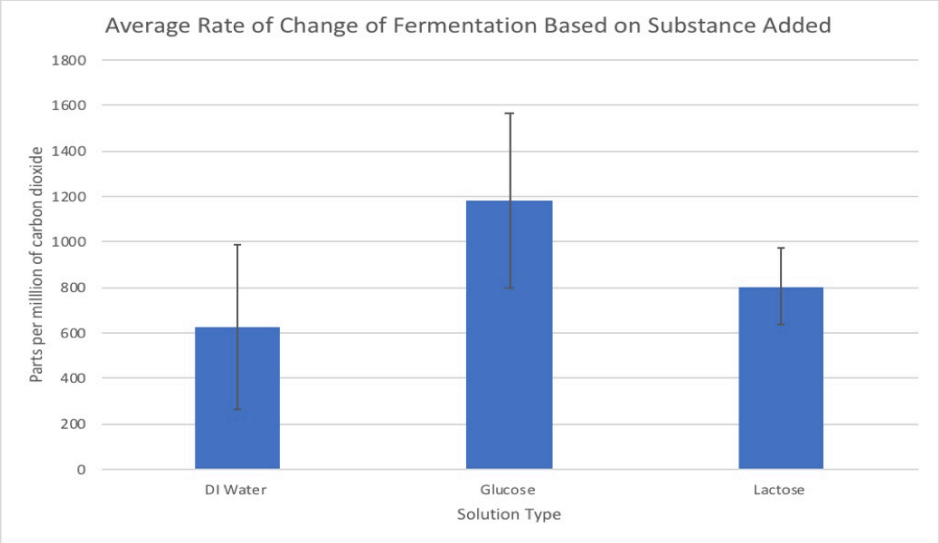

Figure 1. Displays average rates of change of fermentation for the three solutions that were tested with three different added substances.

and deionized water had higher rates of standard deviation than lactose, signifying that the average values we obtained for each trial for glucose and deionized water varied more when compared to each other. The deionized water, serving as a negative control group, had the lowest average rate of change of fermentation. Also, as displayed in Figure 1, lactose consistently fell between the average rate of change of glucose and the average rate of change of deionized water.

Discussion

Our initial question considered whether monosaccharides or disaccharides would allow for a higher rate of fermentation. Our hypothesis was proven correct because glucose had the highest level of fermentation when compared to lactose and deionized water. This was expected because glucose is a monosaccharide which has a simpler structure and allows for it to be more easily broken down. Disaccharides have a more complex structure composed of two molecules bonded together, as do water molecules, which contain two bonds. This can explain why their rates of fermentation were lower than that of glucose (Alm, 1982). An alternative explanation as to why glucose fermented at a higher rate than lactose is because enzymes in yeast have a more difficult time fermenting lactose as opposed to glucose (Pepin & Marzzacco, 2015).

One practical application of our results could be correlated with baking. For example, if you are trying to bake bread and do not have a lot of time for the bread to rise, you could use glucose, or more specifically any type of monosaccharide, as your sugar source. Once you combine the monosaccharide source with your yeast, the bread will rise at a high rate because monosaccharides are more easily broken down than disaccharides and therefore have a higher rate of fermentation.

Literature Cited

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