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Saccharomyces cerevisiae ferments monosaccharides faster than disaccharides

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Abstract

When looking at fermented foods and drinks, it is important to know which sugar type should be used to create the highest rate of fermentation. With so many different forms of sugar it can be difficult to know which is best when being used for fermentation. Depending on what is being made, the type of sugar used will impact the rate of fermentation. Rather than testing each and every sugar, this study focuses on one monosaccharide and one disaccharide to determine which produces the highest rate of fermentation. The results of our experiment will help future scientists as well as the food production industry by providing the knowledge that monosaccharides can be fermented in yeast faster than disaccharides can.

Introduction

Fermentation is the process in which yeast cells break down sugars and produces ethanol and CO_2 in an anaerobic environment (Arya, 2019). Fermentation remains both a historically and scientifically important process worldwide. With the wide variety of sugars available in the modern world, results of fermentation in food sciences can vary greatly. The simplest form of sugar, monosaccharides, are composed of a basic formula of CH_2O (Batema). The number of carbon atoms present in the basic monosaccharide structure determines the specific type of monosaccharide. When two monosaccharides form a glycosidic bond, they become a disaccharide. By definition, monosaccharides contain fewer bonds than disaccharides, therefore, enzymes in yeast can break monosaccharides down faster. In order to test the difference in rates of fermentation based on sugar type, we chose to use glucose, the most common natural monosaccharide, and lactose, a natural disaccharide.

Because of the simpler chemical structure of monosaccharides, we hypothesize that a monosaccharide will have a higher rate of fermentation than a disaccharide. If our hypothesis is supported,

glucose will have a higher rate of fermentation than lactose. If lactose has a higher rate of fermentation than glucose, or if their rates of fermentation are the same, we will know our hypothesis is not supported. Other experiments have been performed on this subject, however, we plan to measure the rate of fermentation rather than the amount of byproduct produced, making ours unique.

Methods

We started by determining which two sugars we would test for the rate of fermentation. We chose glucose and lactose because studies show that they have differing rates of fermentation, whereas glucose and sucrose, which is another disaccharide, have similar results (Verstrepen, 2004). Our experimental group, glucose, is used to represent monosaccharides, and our other experimental group, lactose, is used to represent disaccharides. We will also use deionized water as a negative control group. Each group will be tested in three different trials. A sample of carbon dioxide will be taken from each trial every twenty seconds for five minutes using a CO_2 probe. We will determine the rate of fermentation by using LoggerPro to calculate the slopes of each line of all the data points collected in each trial.

We acquired the following materials: balance, weigh boat, yeast powder, magnetic stir bar, respiration bottle, graduated cylinder, and a timer. Before each trial, we prepared our yeast solution by adding 10 mL of warm water and 0.6 g yeast powder to the respiration bottle and letting it stir for 3 minutes (Shaw and French, 2018). We began each trial by placing our 250mL respiration bottle onto the stir station and adding our solutions which are represented in Table 1. Our data will be recorded in LoggerPro in the unit ppm. Once we have collected all of our data, we will analyze it and create a box and whisker plot to display the information. We will also use PAST3 to conduct a one-way ANOVA test to determine statistical significance.

Results

Our results showed that glucose had the highest average rate of fermentation at 1,417 ppm/min (see figure 1). It also shows that lactose hinders the rate of fermentation because its average rate of fermentation was 759 ppm/min while our control group using deionized water had an average rate of fermentation of 1,131 ppm/min.

Table 1: Materials used for each solution.

Trial	Yeast Solution	Lactose	Glucose	D.I Water	Total
Monosaccharides	10 mL Water/.06 Yeast	/	10 mL	/	20 mL
Disaccharides	10 mL Water/.06 Yeast	10 mL	/	/	20mL
Negative Control	10 mL Water/.06 Yeast	/	/	10 mL	20mL

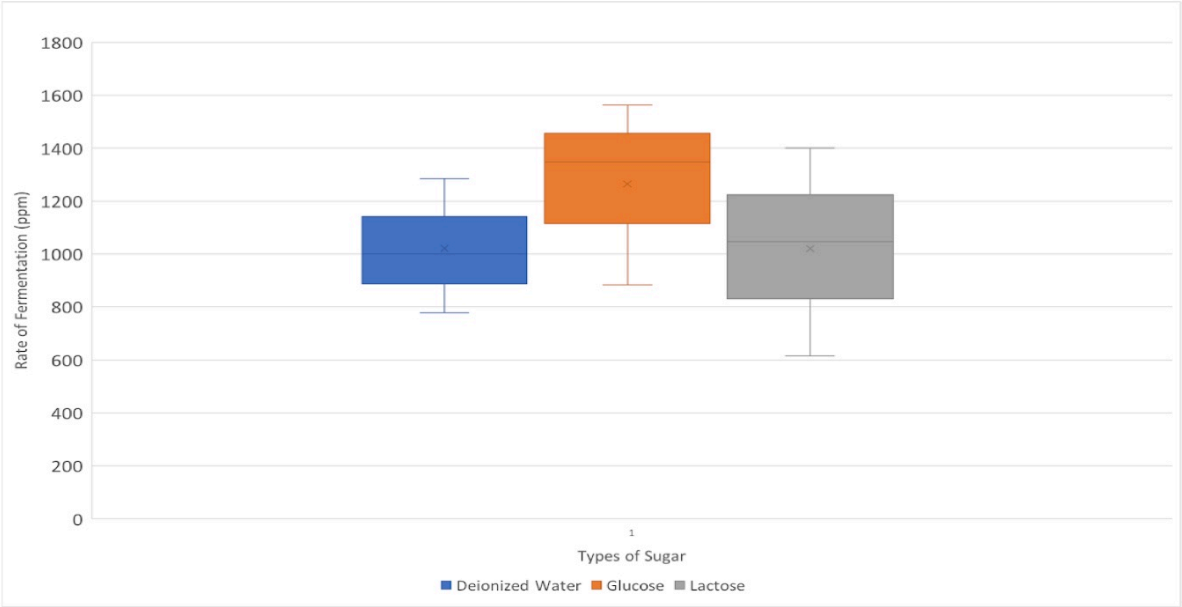

Figure 1: Glucose has a higher average rate of fermentation than lactose and deionized water. These results are significant.

A one-way ANOVA test was conducted to compare the effect of different types of sugars on rates of fermentation. We calculated a P value of 6.17×10^{-3}. This shows that there was a significant effect of type of sugar on rate of fermentation between glucose, lactose, and deionized water.

Discussion

Our data supports our hypothesis because glucose had a faster average rate of fermentation than lactose. The one-way ANOVA test proves that our data is statistically significant, meaning that our independent variable caused the change in rate of fermentation. The monosaccharide (glucose) had higher rates of fermentation than our other groups, which were lactose (disaccharide) and our control (deionized water). In the beginning of our experiment we asked the question "do monosaccharides have higher rates of fermentation then disaccharides?" We based our experiment off this question and proved it to be true. Our data showed a trend in increased rate of fermentation and production of CO_2 in monosaccharides compared to disaccharides. The monosaccharide (glucose) acted as an aid when it came to the rate of fermentation, while lactose (disaccharide) hindered the rate of fermentation. This happens because glucose is a simple carbohydrate with less bonds than a more complex carbohydrate, such as lactose, that has a higher amount of bonds. We believe that because it has fewer bonds it has a higher rate of fermentation because it can be broken down faster.

An alternative interpretation for our data could be that, because the molecule was so small, it was more easily metabolized, leading to higher rates of CO_2 production. Due to the fact that glucose is such a small

molecule, it is more easily metabolized, and therefore produces higher amounts of CO_2. In the sense of this experiment the yeast was able to break down the glucose with more ease making it faster than the lactose.

The results of our data could help scientists as well as people in the alcohol business in the future determine which sugar is best for their project or experiments. Our results reflect that of R.H. De Deken in the experiment regarding rates of fermentation of specific sugars. In that experiment, it was shown that glucose has a higher rate of fermentation than lactose (De Deken, 1965). Our results were, again, supported by a similar experiment at the University of Oklahoma. Their results also showed that monosaccharides have a higher rate of fermentation than disaccharides (Burnison et al., 2018).

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