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Larger Glycemic Index Results in Higher Rate of CO_2 Production in Yeast

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Abstract

Yeast uses fermentation as its main source of energy using carbohydrates to produce heat and create CO_2, ethanol, and ATP. In this experiment, we tested the difference in the rate of CO_2 production between glucose and honey to find if there was a correlation between glycemic index and the amount of CO_2 produced, which we measured in ppm. This is due to the fact that there is a higher concentration of usable carbohydrates in higher glycemic indexes compared to carbohydrates with lower glycemic indexes. The results of our experiment supported this as the higher glycemic index produced a significantly higher amount of CO_2 proportional to the change in glycemic index. This occurred because honey only has half the optimal composition for optimal carbohydrate usage due to the fact that it is only half the glycemic index of glucose, since it is composed of half glucose and half fructose.

Introduction

Yeast is a eukaryotic organism, one that uses anaerobic cellular respiration via fermentation as a source of its energy. Fermentation is the process in which a substance chemically breaks down due to outside factors and results in the release of heat, in this case specifically, glucose and fructose are broken down prior to sugar being transported through the mitochondria (D'Amore, Russell, Stewart, 1988). To accomplish this, yeast utilizes glucose to produce CO_2, ethanol, and ATP. All products of this anaerobic cellular respiration are created in equal amounts (Bauer, Burton, Christopher, Bauer, Ritchie, 2016). Various factors can affect the rate of fermentation in yeast. Such factors include the type of carbohydrates used, the amount of carbohydrates used, and the glycemic index of said carbohydrates (D'Amore). The glycemic index is a ranking of carbohydrates based on their ability to convert glucose in the human body. This scale ranges from 1-100. (SELFNutritionData). In this experiment, our focus was the correlation between levels of glycemic index and rate of fermentation, measured by CO_2 production. This experiment was unique because instead of looking at concentrations of sugar, we observed the effects of glycemic index by using honey (50/50 glucose & fructose) compared to glucose. We hypothesized that carbohydrates with a higher glycemic index will produce more CO_2 than carbohydrates with a lower glycemic index because there is a higher useable concentration of carbohydrates to be broken down during glycolysis. This will be supported if the yeast mixture with the glucose (glycemic index: 100) will produce more CO_2 than the yeast mixture with the honey (glycemic index: 55). Should the hypothesis not be supported, then the yeast mixture with honey shall produce more if not the same amount of CO_2 as the mixture with glucose. We conducted this experiment for the purpose of discovering what substances would help fermentation processes be more effective.

Methods

Using a 250 mL glass jar, we added 0.6 g of yeast alongside 10 mL of H_2O, and 10 mL of a sugar solution with either 0.3 M glucose (GI: 100) or 0.3 M honey (GI:55). We placed the jar on top of a stir station and added the stir stick inside the jar before pouring in the solutions of glucose/honey, H_2O, and yeast. Before each trial, we allowed each mixture to be stirred for five minutes before collecting data using the CO_2 probe, collecting data in ppm every 30 seconds for five minutes. We allowed the mixture to bloom for these five minutes before taking CO_2 measurements to avoid the delay in the start of fermentation. So, by the time we inserted the CO_2 probe fermentation was already occurring. While the mixture was stirring, we let the CO_2 probe heat up for at least 90 seconds prior to use. This was because the probe measures the amount of radiation, which is proportional to the amount of CO_2. The sensor needed to heat up to reach a threshold voltage to accomplish this (Shaw and French. 2018). Levels of glycemic index, based on glucose or honey, were changed throughout the experiment to see how it would affect the release of CO_2 measured in ppm. This was conducted while keeping temperature, amount of water, and a consistent level of the CO_2 in the air. Three replicates of each solution were run, leaving three trials for honey and three trials for glucose. We ran two sets of three trials between these substances because they are commonly used in fermentation, and it allows us to test them as comparison groups, eliminating the need for a control group. We organized our data into a box and whisker plot graph, allowing for easy comparison between the rate of CO_2 production in each trial, which alludes to the rate of fermentation of yeast. A box and whisker plot showed the total amount of CO_2 produced in each trial while also accounting for discrepancies in the data. We also performed a statistical analysis via an unpaired T-test because our data was both nominal and mathematically measurable, and both variables were normally distributed.

Results

The honey (glycemic index of 55) mixed with yeast produced 3750.228 ppm of CO_2 after five minutes on the stir station, while the glucose (glycemic index of 100) mixed with yeast produced 6736.374 ppm of CO_2 after five minutes on the stir station. Based on our experiment and results, the data shows that the trials ran with lower glycemic indexes had a lower production of CO_2 compared to the trials ran with a higher glycemic index. An Unpaired t-Test was conducted to compare the effect of different carbohydrates on CO_2 produced when mixed with yeast. There was a significant difference between the two conditions; t (df)= 2.5295, $p = 0.0199$.

Discussion

Carbohydrates with a higher glycemic index produced more CO_2 than carbohydrates with a lower glycemic index. This positive correlation shows that a higher glycemic index would be more effective when fermenting yeast as a higher CO_2 production with the same amount of carbohydrate. This is due to the fact that a higher concentration of carbohydrates causes more CO_2 to be

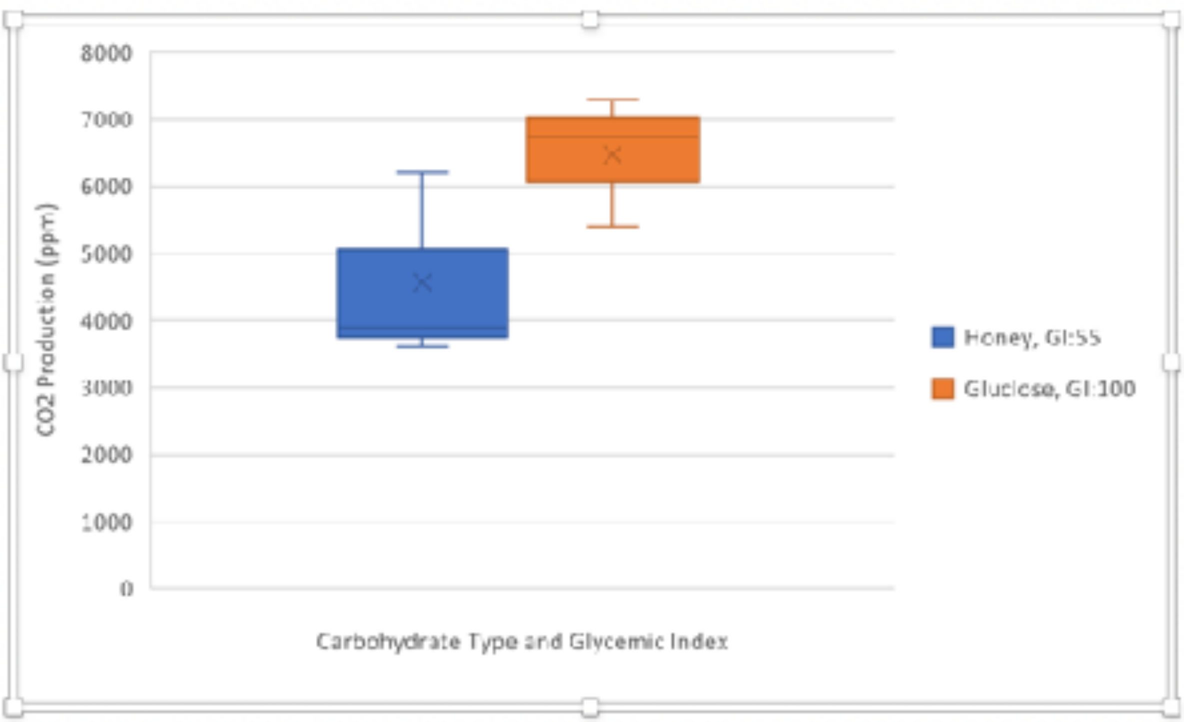

Figure 1: CO2 produced between different carbohydrate types and glycemic indexes

as honey during their fermentation periods, with honey having a glycemic index of 55. As glycemic index increases, the amount of CO_2 produced increases proportionally. Fructose has a structure which is more complex than others, and makes up 50 percent of honey, while glucose makes up the other 50 percent. Only half of the composition of honey has the optimal concentration of usable carbohydrates, which explains why it has a glycemic index half that of glucose.

Honey is not as pure as glucose, as it contains other things like enzymes. Also, due to it not being processed or being as pure as glucose, it has a lower glycemic index because it is not as effective in breaking down those carbohydrates. Another variable that may have affected the results of the experiment was the exposure or lack thereof of yeast to sugar prior to the experiment. Avoiding glucose before fermentation creates a storage of carbohydrates and can increase the initial rate of fermentation (Verstrepen et. al, 2004).

Future variations of this experiment may benefit from changes such as adding the sugar after the five minutes of stirring purely the yeast, due to the fact that it would allow for data collection at the beginning of fermentation rather than five minutes into the process.

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