JUBLI
Journal of Undergraduate Biology Laboratory Investigations

The effect of differing glycemic indexes in raw sucrose and glucose results in similar production rates of CO_2

Carter Breedlove[1], Sean Boyles[1], Alison Barnett[1], Courtney Adler[1], Rodet Silva*
[1]University of Oklahoma, Department of Biology, 730 Van Vleet Oval, Room 314 Norman, OK 73019

Abstract

The process of yeast fermentation is prevalent in the food industry, and in recent times farmers have been interested in what effects different sugars with differing glycemic indexes within their foods would have on how fermented the food and drink would be. Several farmers attempt to use different types of sugars with different glycemic indexes to manipulate a desired amount of alcohol and salt concentration within the food and drinks. We proposed that the use of monosaccharides and disaccharides, which have different glycemic indexes, will produce differing amounts of carbon dioxide when reacted with yeast in a fermentation process. We conducted four, five-minute trials comparing the glycemic index of the sugar used with yeast and the amount of carbon dioxide produced when fermented. We expect this information to be of interest to farmers and workers within the food industry who are wishing to produce saltier and more alcohol concentrated food and drinks that have been fermented more.

Introduction

Fermentation is the chemical breakdown of different substances via the presence of yeast. The process of fermentation releases energy whenever carbohydrates, sugars, and other organic compounds are oxidized. When these organic compounds are oxidized, they are converted into alcohol or acid which releases energy. Yeast is a microorganism that undergoes the fermentation process in the absence of oxygen, and this process converts different sugars to carbon dioxide and ethanol as waste products. The yeast *Saccharomyces cerevisiae* takes part in this specific process of respiration, the process of anerobic respiration, a process that releases ATP energy per molecule of sugar in the absence of oxygen (Burnison et al., 2018). The yeast *Saccharomyces cerevisiae* is often used in food production (Bauer et al., 2016). The amount of carbon dioxide that is produced during the fermentation process can be altered by using sugars that have different glycemic indexes that are combined with the yeast.

Two main types of sugar structures are monosaccharides and disaccharides. Disaccharides comprise, at the basic level, two monosaccharide molecules bonded together. Disaccharide sugars have higher glycemic indexes than monosaccharides, meaning that when consumed, disaccharides more quickly increase blood sugar concentrations and in a shorter period (Westberg et al., 2003). The glycemic index of the sugar that is being fermented also effects how much fermentation the sugar goes through. Therefore, sugars that have higher glycemic indexes will go through more fermentation and produce more waste products of fermentation than a sugar with a low glycemic index. If more products of this process are desired, then higher glycemic index sugars need to be reacted. We aimed to find the difference in carbon dioxide produced from monosaccharide sugars with low glycemic indexes and disaccharide sugars with high glycemic indexes combined with yeast to determine the difference in the rate of fermentation for each. This is a good measure of how much a specific sugar went through fermentation because carbon dioxide is a product of this biological process. The disaccharide sugar combined with the yeast will produce the most carbon dioxide because it has the higher glycemic index. If the disaccharide produces more carbon dioxide than the monosaccharide, then the higher glycemic index does have an influence on increased fermentation. However, if the monosaccharides produce more carbon dioxide or if there is no significant difference between the two, then the glycemic index does not influence the amount of fermentation that the sugar goes through.

Methods

We imitated the process outlined in Shaw and French (2018) to set up a yeast solution and prime it to be then tested with differing sugars. We added either 10 mL of monosaccharide glucose in one test or 10 mL of disaccharide raw sucrose in a separate test to the respiration chamber with the yeast solution. In the respiration chamber, the carbon dioxide detector was placed inside the top of the bottle once the solutions were in the bottle and the magnetic stir bar was activated. The carbon dioxide indicator measured the amount of carbon dioxide produced inside the respiration chamber in order to be able to see the differences in carbon dioxide production between disaccharides with high glycemic indexes and monosaccharides with low glycemic indexes. Carbon dioxide is a product of the process of fermentation, so its presence indicates how much fermentation the solution went through. A water and yeast solution were tested in order to compare the values of carbon dioxide production between

Table 1:

Type of Solution	Yeast (grams)	Water (mL)	Variable (mL)	Molarity (M)
Raw Sucrose-yeast	.6	10	10	.15
Glucose-yeast	.6	10	10	.3
Water-yeast	.6	10	10	N/A

sucrose and glucose. Water has a glycemic index of 0, so there are no sugar molecules within the water. For each water, sucrose, and glucose solution with yeast we conducted four, five-minute long trials each. We collected data on the amount of carbon dioxide in parts per million (ppm) that was released in the bottle over time for five minutes, taking measurements of 75 readings over 5 minutes. This reflects how much fermentation is occurring because carbon dioxide is a product of this process. We performed a One-way ANOVA statistical analysis to determine if there was a statistically significant difference between the rate of carbon dioxide produced by the yeast glucose monosaccharide solution and the yeast raw sucrose disaccharide solution. The statistical analysis concluded that our results there was a difference, so we used the Tukey's Pairwise post-hoc follow up test to detect what the specific differences were.

Results

The median rate of carbon dioxide production for the raw sucrose-yeast solution was greater than that of the glucose-yeast solution (see Figure 1). However, there was a greater IQR in the rate of carbon dioxide production for the raw sucrose-yeast solution than for the glucose-yeast solution. A One-Way ANOVA was conducted to compare the effect of the type of yeast solution on the rate of carbon dioxide production in raw sucrose, glucose, and water conditions. There was a significant effect of type of yeast solution on the rate of carbon dioxide production between the three conditions; [F (2,9) = 17.97; p=0.0007203]. A Tukey's pairwise test revealed that the rate of carbon dioxide production was not statistically different in the raw sucrose condition than the glucose condition (raw sucrose and glucose, [0.9794]), but both were statistically

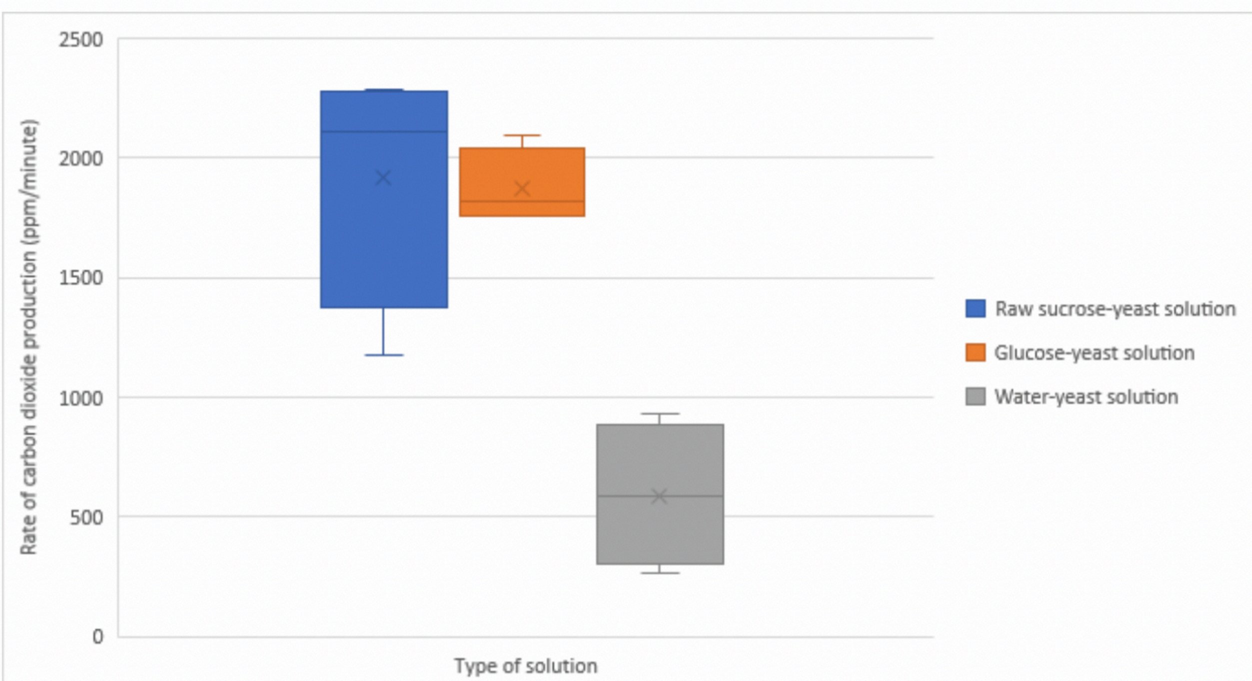

Figure 1. The rate of carbon dioxide production by the various yeast solutions.

different from the water condition (raw sucrose and water, [0.001308]) (glucose and water, [0.001691]).

Discussion

Our data from the experiment ("see Figure 1") and statistical analysis concluded inconsistent with our hypothesis. From our results we can conclude that the glycemic index does not influence the rate of fermentation. The results of our data show that the rate of carbon dioxide between the high glycemic index of the raw sucrose and the low glycemic index of the glucose was similar. The results had too much variability within the raw sucrose data for us to be able to state that high glycemic indexes within the raw sucrose disaccharide influenced a higher rate of carbon dioxide production. In other words, glycemic index does not affect the fermentation process within different sugars. However, we speculate that if we conducted more trials, our results may have been more consistent with our hypothesis that the high glycemic index sugar leads to a higher rate of fermentation. A reason for slow respiration may be a cause of inhibition of activity or synthesis of the respiratory enzymes (De Deken, 1966).

Sucrose and glucose are both glycemic carbohydrates, which means that they both affect the blood glucose level after eating (Ostman, 2003). Both sugars have in common that they are absorbed directly when eaten. One reason why our results show that raw sucrose and glucose have similar production rates of carbon dioxide, may be because they are both a bioavailable form of a carbohydrate. Before disaccharides are absorbed into a stomach, they are broken down into their component parts of monosaccharides. This may have an effect on the fermentation because the raw sucrose disaccharide sugar breaks down into the monosaccharide molecules glucose and fructose before it partakes in fermentation (D'Amore et al., 1988). This could be a reason as to why the rates of carbon dioxide were similar between the monosaccharide and disaccharide sugar.

Another reason the results for the glucose-yeast solution and raw sucrose-yeast solution were similar is possibly the fact that when raw sucrose is hydrolyzed by the enzyme invertase, glucose and fructose are produced to act as the reactants for fermentation.

The work that studies fermentation process is important for a multitude of reasons. Most commonly, knowing how to manipulate a solution into fermenting more, which produces more acid and alcohol, is of special interest to people within the food industry. Many farmers and producers urge to find an easy way to have a higher alcohol concentration within their drinks and a higher salt concentration. Researching how the fermentation process can be influenced by different factors will provide an easy way to change these foods and drinks desires. In future experiments, testing different acids and bases may result in finding different ways to manipulate rates of fermentation. Acids and bases have opposite pH values, so seeing how a very low pH a

Literature Cited

Bauer, J., Burton, J., Christopher, K., Bauer, B., Ritchie, R. (2016). Ethanol Production in Yeast According to Sugar Type. *Journal of Introductory Biology Investigations.* 5(2): 1-4.

Burnison, H.,Granato, T.,King, M.,Peoples, H., Hallidaschult, T. (2018). The Effect of Monosaccharides versus Disaccharides on the Rate of CO_2 Production. Journal of Undergraduate Biology Laboratory Investigations. 1(1).

D'Amore, T., Russell, I., Stewart, G. (1988). Sugar utilization by yeast during fermentation. Journal of Industrial Microbiology. 4: 315-324.

De Deken, R. H. (1966). The Crabtree Effect: A Regulatory System in Yeast. *Microbiology* 44-2: 149-156 (155)

Ostman, E. (2003). Fermentation as a Means of Optimizing the Glycaemic Index. Applied Nutrition and Food Chemistry at Lund University. 1(1).

Westberg, K.,Litchfield, R., Nelson, D. (2003). Using the Glycemic Index to Compare Carbohydrates. https://www.iahsaa.org/wp-content/uploads/2013/08/Glycemic_Index.pdf. (accessed 2/27/19).