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# The Effect of Glucose and Saccharin on the Rate of Metabolic Activity of Baker's yeast (*Saccharomyces cerevisiae)*

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Carbon dioxide ($CO_2$) gas is a product of several metabolic processes in Saccharomyces cerevisiae, including aerobic fermentation. We investigated whether adding a natural sugar (glucose) or an artificial sweetener (saccharin) to a solution of yeast affected its rate of aerobic fermentation. We had two experimental groups for each sugar, and a negative control group using only de-ionized water. We measured the production of $CO_2$ gas over time to test whether the sugars added affect aerobic fermentation in yeast. We found that the yeast solution containing glucose produced $CO_2$ gas at a greater rate than the solution containing saccharin. Our findings contribute to the existing body of knowledge that monosaccharides such as glucose have a greater effect on the rate of fermentation in yeast than more complex sugars.

## Introduction

The rate of cellular metabolic activity of *Saccharomyces cerevisiae*, or Baker's yeast, can be measured by the production of carbon dioxide gas ($CO_2$). Aerobic fermentation, the process that creates $CO_2$ gas when a sugar is added to a solution containing yeast, occurs at higher rate when the rate of cellular respiration is lower (De Deken, 1966). Studies related to aerobic fermentation often examine what factors affect yeast fermentation performance. For example, D'Amore (1992) found that temperature, sugar concentration, and nutrient supplementation may impact the rate of fermentation in yeast. Other studies investigated whether different types of sugar and their chemical makeup affect its rate of fermentation (Cason et al., 1987; Anguista et al., 2014; Bauer et al., 2016). We were interested in comparing the effect of an artificial sweetener and a natural sugar on the metabolic rate of yeast, as measured by production of $CO_2$ gas over time. We hypothesize that the production of $CO_2$ gas over time will be greater when a natural sugar (glucose) is added to the yeast solution than when an artificial

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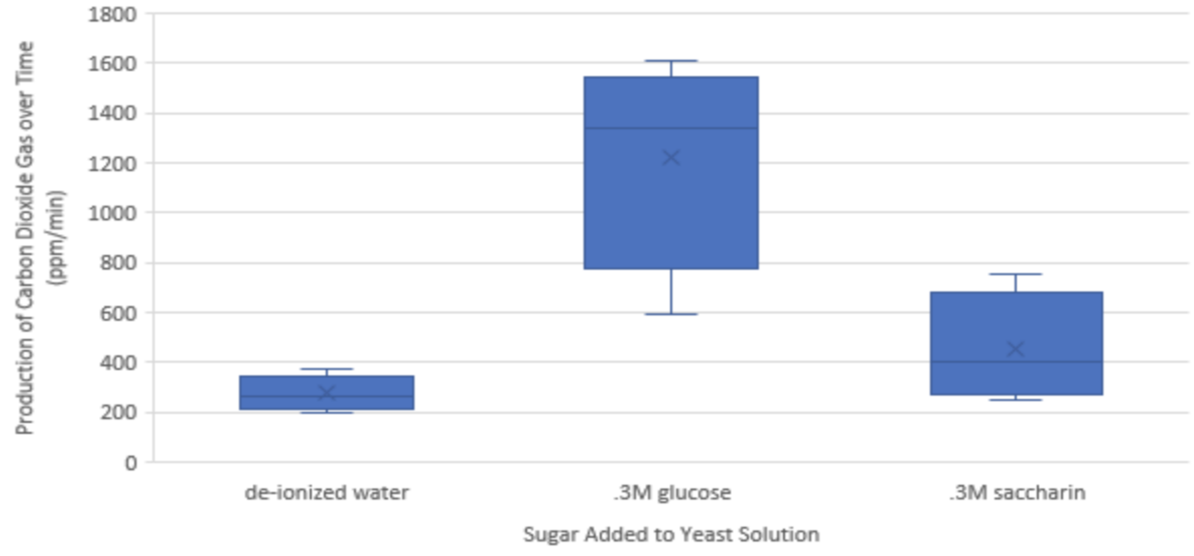


*Figure 1. Relationship between type of sugar added to yeast solution and the production of $CO_2$ gas over time. The addition of glucose to the yeast solution resulted in a greater rate of production of $CO_2$ gas than the addition of saccharin ($p = 0.01034$) or de-ionized water ($p = 0.00293$).*

sweetener (saccharin) is added because saccharin is a more complex monosaccharide than glucose. That is, the chemical composition of saccharin has nitrogen and sulfur in addition to carbon, hydrogen, and oxygen, whereas glucose is composed of only carbon, hydrogen, and oxygen. Therefore, we predict that the yeast solution containing saccharin will produce less $CO_2$ gas than the yeast solution containing glucose. Our hypothesis should be rejected if we do not find a significant difference between the two solutions.

## Methods

In our experiment, we tested whether the production of $CO_2$ gas will be less when a sugar substitute (saccharin) is added to the yeast solution than when a natural sugar (glucose) is added. First, we weighed out 0.6 g of yeast and 10 mL of de-ionized water in a graduated cylinder. The yeast and de-ionized water were added to a 250 mL bottle containing a magnetic stirrer and placed on a stir station. We stirred the yeast solution for 5 minutes (Shaw and French, 2018). For the first trial, we added and stirred an additional 10 mL of de-ionized water (the negative control group) and measured the production of $CO_2$ gas in ppm over a period of 7 minutes using the Vernier Carbon Dioxide Gas Sensor and the Logger Pro software (LoggerPro3). For the second trial, we added and stirred 10 mL of a .3 M solution of glucose to a new yeast solution and measured the production of $CO_2$ gas in ppm over a period of 7 minutes. For the third trial, we added and stirred a 10 mL of a .3 M solution of saccharin to a new yeast solution and measured the production of $CO_2$ gas in ppm over a period of 7 minutes. We repeated each trial four times. We used a One-Way ANOVA test to determine whether the relationship between the type of sugar added to the yeast solution and the rate of production of $CO_2$ gas in ppm/min was statistically significant. A Tukey's pairwise test was used to determine whether there was a statistically significant difference in the rate of production of $CO_2$ gas between each group (PAST3).

## Results

We found in our experiment that the average rate of production of $CO_2$ gas was greater when glucose (1221 ppm/min) was added to the yeast solution than when saccharin (451 ppm/min) was added (see Figure 1). However, in the trials for both glucose and saccharin, the rate of production of $CO_2$ gas of the yeast solution varied greatly from the mean (between 593 and 1607 ppm/min for glucose, and between 248 and 752 ppm/min for saccharin) whereas the trials in which only de-ionized water was added varied less (between 198 and 373 ppm/min). A One-Way ANOVA test revealed that there was a significant effect of the type of sugar added to the yeast solution on the rate of production of $CO_2$ gas in each of the groups; [$F(2, 9) = 12.43$; $p = 0.002572$]. A Tukey's pairwise test showed that the rate of production of $CO_2$ gas was statistically higher in the yeast solution containing glucose than in the yeast solution containing de-ionized water ($p = 0.00293$) and the yeast solution containing saccharin ($p = 0.01034$).

## Discussion

Our data shows that the yeast solution containing glucose produced $CO_2$ gas at a greater rate than the yeast solutions containing saccharin or de-ionized water, supporting our hypothesis. This finding suggests that aerobic fermentation in yeast occurs at a higher rate with the addition of simpler monosaccharides than complex ones, which is consistent with several studies that found that glucose and fructose result in greater rates of aerobic fermentation than other sugars (Cason et al., 1987; Anguista et al., 2014). Another study found that the rate of aerobic fermentation was lower with the addition of a sugar substitute than with the addition of natural sugars (Bauer et al., 2016). As we addressed in our results, the rate of production of $CO_2$ gas for the yeast solution containing glucose or saccharin varied greatly from its mean, which may affect the validity of our findings. We have three suggestions for future research: (1) increase the number of times each trial is repeated to ensure accurate results, (2) use a greater variety of monosaccharides to determine which specific elements (e.g., nitrogen and sulfur in saccharin) affect the rate of fermentation in yeast, and (3) experiment with the concentration of sugar in each solution to determine the optimal fermentation performance for yeast (Verstrepen et al., 2004). Using these suggestions, future studies can determine which specific elements in natural sugars and artificial sweeteners result in the optimal rate of fermentation in yeast for commercial products such as soy sauce and champagne (Shaw and French, 2018).

## Literature Cited

Anguista, J., Chan, M., Dinneen, D., Hortamani, S., & Mutabaruka, D. (2014). The effect of different sugars in the medium on carbon dioxide production in Saccharomyces cerevisiae. The Expedition, 7(1): 1-16.

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.

Cason, D. T., Reid, G. C., & Gatner, E. M. S. (1987). On the differing rates of fructose and glucose utilization in Saccharomyces cerevisiae. Journal of the Institute of Brewing, 93(1): 23-25.

D'Amore, T. (1992) Improving yeast fermentation performance. Journal of the Institute of Brewing, 98(5): 375-382.

De Deken, R.H. (1966). The Crabtree effect: a regulatory system in yeast. Journal of General Microbiology. 44(2): 149-156.

Harper & Harper. (2013). PAST3 (3.2) [Computer Software]. Oslo, Norway: https://folk.uio.no/ohammer/past/.

LoggerPro3 (Version 3) [Computer Software]. Oslo, Norway: https://folk.uio.no/ohammer/past/.

Polakowski, T. M. (2008). The effect of different sugars on the rate of fermentation in yeast. Ohio Journal of Science, 108(1):

Shaw, T. & French, D. (2018). Authentic Research in Introductory Biology, 2018 Ed. Fountainhead, Fort Worth.

Verstrepen, K. J., Iserentant, D., Malcorps, P., Derdelinckx, G., Van Dijck, P., Winderickx, J., & Delvaux, F. R. (2004). Glucose and sucrose: Hazardous fast-food for industrial yeast? Trends in Biotechnology, 22(10): 531-537.