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Sugar Rush: Effects of Sugar Concentration on Cellular Respiration in Baker`s Yeast

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Yeast (*Saccharomyces cerevisiae*), is a single-celled organism that needs to perform cellular respiration to survive. We asked ourselves whether or not a higher sugar concentration would affect, particularly increase, CO2 output. To test this, we set up an experiment with four groups that had different sucrose concentrations with constant measurements of water, yeast, and sodium phosphate, and took six samples of CO2 production over a fifteen-minute period. Our results supported out hypothesis and showed that indeed, a higher sugar concentration will increase CO2 production. Ultimately increasing ATP production and growth rates.

Introduction

We are with the Acme Brewing & Baking Company and we're looking at yeast and a way to maximize its growth. Baking and Cooking can be described as molecular-level chemical reactions (Claire 2014). In identifying key ingredients, it is possible to manipulate recipes and create a better overall final product (Claire 2014). Baker`s yeast has been used for many years; it has been used to make bread, other baked goods, alcoholic beverages, industrial ethanol, and biofuels (French 2017). Yeast is a living organism that is classified as a fungus, and like any other organism, it needs to perform cellular respiration. Therefore, the presence of glucose and water influence the cell to produce ATP (Hart 2015). A food chemist, Louis Pasteur, discovered how yeast behaved in 1859 (Frenchbean 2007). He stated yeast was a living organism and went through the fermentation process within cellular respiration (Frenchbean 2007). He described this process as the breakdown of starches in flour, which produces Carbon Dioxide, and expands gluten proteins within the yeast causing it to expand (Frenchbean 2007). Some factors that influence cellular respiration rate include temperature, acidity, concentration of sugar, and ions available (Jacobs 2003). With so many factors affecting cellular respiration, it led us to question whether or not sugar, specifically sucrose, effected the cellular respiration rates in Baker`s yeast. We chose the sugar sucrose because when yeast is exposed to high glucose concentrations they switch from aerobic to anaerobic respiration, which makes less energy (Bolen et al. 2015). Sugar contains energy which helps start the process of cellular respiration. Similar to what was said above, the process of fermentation breaks down sugars to produce CO2. We hypothesize that the CO2 levels in Baker`s Yeast will increase when exposed to more sucrose due to the influence that sugars have on ATP production.

Methods

To test our hypothesis, we measured the CO2 output based on the different levels of sugar, specifically sucrose, which we exposed to the yeast. First, we mixed a solution 39 mL of water, 1 mL of baker`s yeast, 80 microliters of sodium phosphate, and 0.8 grams, or 2% sucrose. This served as our control group. After measuring out the different ingredients, we placed the solution on a spin station

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and used a magnetic stir stick to ensure it mixed correctly. After we mixed the solution, we continued to let the solution spin and monitored the CO2 levels with a CO2 probe for 15 minutes. Within the 15 minute intervals we collected six samples. We then repeated the step above two more times, but added in our independent variable, the different amounts of sugar. In the second group, we increased the sucrose level to 1.5 grams, or 2.5% but kept the other measurements the same as the control group. In the third group, we increased it to 2 grams, or 5%, while keeping everything else the same. Again, we measured the CO2 levels for 15 minute intervals and recorded the data. We did three trials for every group.

To calculate the generations per minute, we first copied over our six samples into Microsoft Excel, then we created a scatter plot from the data that was connected with a smooth line. Next, we found the log phase of the growth curve by examining the graph. Specifically, we were looking for a steady increasing line on the plot. Fourth, we plotted a new scatter plot only using the points we received in the log phase. We then added a trend line to the points in the log phase. Finally, we calculated the mean growth rate, or generations per minute, using the slope from the trend line. We used the following equation: K= slope/0.301 (French 2017). We repeated this step for every trial we performed.

Results

Throughout the experiment, we witnessed the increase of CO2 when yeast was introduced to more sucrose. In our control group, a 2% concentration of sucrose was mixed into the solution and the average CO2 production was 1541.33 ppm and the average gen/minute was .572. In our second group with a 2.5% sucrose concentration the average CO2 production was 2200.23 ppm and the average gen/minute was .546. Finally, in our group with a 5% concentration the average CO2 production was 1805.96 ppm and the average gen/minute was.560.

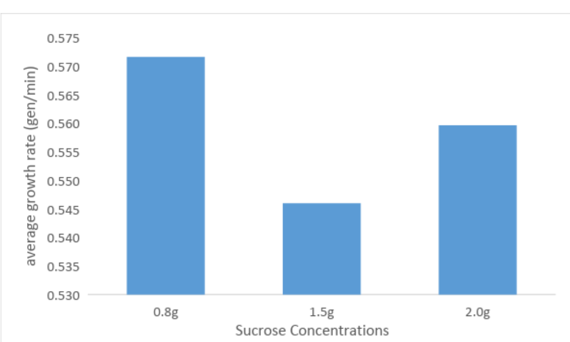

Figure 1.1: The average growth rate of all trials based on the sucrose concentration.

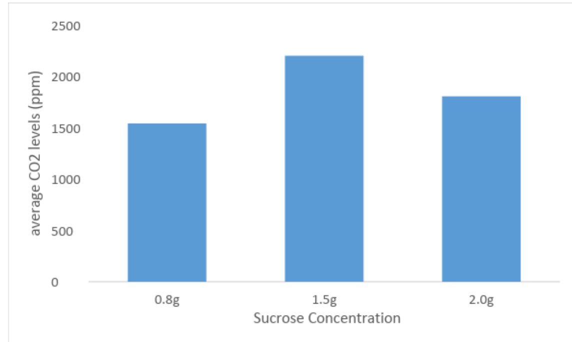

Figure 1.2: The average CO2 levels in all trials based on the sucrose concentration.

Discussion

These results support our hypothesis, we predicted that the more sucrose that was exposed to yeast, the higher the CO2 levels are. Therefore, more energy was produced through cellular respiration. The results gathered indicate that a sugar concentrated yeast solution will have a substantially higher respiration rate than a solution with the minimum amount of sugar recommended. The more we increased the sugar concentration in the yeast solution, the higher the CO2 levels were for every sample we collected. In many of the studies found, it was shown that groups exposed to more sugar were faster growing and showed increased CO2 output than the corresponding groups exposed to less sugar, or that were free cells, or cells not exposed to any sugar concentration (Holeberg and Margalith 1981). In the future, running a t-test would be sufficient in making sure our results between our trials do not majorly vary (Bradfield et al. 2017; McCoy et al. 2017). Or perhaps using a different sugar concentration rather than sucrose. It has been found that sucrose only utilizes a certain amount to be able to ferment (Begley et al. 2016). Overall, Acme Brewing Company could maximize yeast growth by introducing it to more sugar. The more sugar that is exposed, the higher the CO2 rate, so therefore the more ATP is produced through cellular respiration, and so growth rate is increased.

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