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Diet wine for the skinny moms: The use of glucose substitutes in yeast fermentation to reduce the caloric load of wine

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Abstract

Yeast is used around the world in various products, including wine. Wine often is an obstacle in weight loss programs, as many people prefer to have a glass or three of wine with dinner. Wine is a very calorie dense beverage, if the density of calories can be reduced, it may help people lose weight while still enjoying their wine with dinner. Through the testing of fermentation rates with glucose sources that are lower in calories than traditional glucose, an opportunity has arisen in the wine market for "diet" wine. The application of lower calorie fermentation in alcohol applications would enable an opening in the market for people who are counting calories but still want to indulge in their daily glass. Using glucose as a control, other types of monosaccharides were used to substitute the glucose in yeast fermentation and measured for the rate of ethanol production in the reaction. Our hypothesis was rejected; we predicted that the control would produce more ethanol because it would not have to go through additional steps to enter fermentation. This shows that glucose substitutes that are lower in calories can replace glucose as an aid in fermentation, which can then be used in the fermentation of grapes to produce diet wine.

Introduction

In today's consumer market, people are always looking for ways to cut back on calories as well as costs. Something not seen often on the market is a low-calorie wine that comes with an affordable price tag. Developing a wine that is low calorie while maintaining a good taste would be crucial for making money in a cornered market. We plan to bring this unseen product to the consumer by experimenting with low calorie glucose substitutes in exchange for regular glucose which has 387 calories per 100 grams ("Calorie King", 2019). Honey holds 304 calories per 100 grams (USDA Food Composition Databases, 2018). Saccharine holds 360 calories per 100 grams (Vanovschi, 2019). High fructose corn syrup holds 281 calories ("Calorie King", 2019) .

Glucose is the most common carbohydrate used by species of yeast, but the fermentation process can be carried out by other carbohydrate sources (Verstrepen *et al.,* 2004). It has been shown that alternate carbohydrate sources that are used in fermentation provide results that are less efficient than glucose (Wang *et al.,* 2004). Ethanol is a by-product of the fermentation of yeast and so the more ethanol that is produced, the higher the rate of the fermentation. By comparing the ethanol production of yeast solutions using sugar substitutes to a traditional glucose fueled yeast fermentation, we will be able to determine if these substitutes are worth their lack of calories. Ethanol production will be higher in the glucose fueled yeast reaction compared to the experimental groups in order for our hypothesis to be accepted. Due to glucose being the primary molecule used in fermentation, we hypothesize that derivatives of this saccharide will create a decrease in the fermentation rate of the yeast because the cell will have to go through extra processes to separate the glucose for fermentation. If the ethanol production in the sugar substitute fueled fermentation is higher, then our hypothesis will be rejected.

Methods

In order to test if glucose will have a higher rate of fermentation, we will test each sugar in a yeast fermentation reaction, measure the ethanol produced in each reaction, and compare the rates. The protocol created by Shaw and French for yeast reactions was followed as a base for all of the tested reactions (2018). A fermentation reaction using glucose (monosaccharide) and the yeast solution will serve as a comparison to the other experimental groups. Three milliliters of honey (50/50 mix of monosaccharides glucose and fructose), high fructose corn syrup (45/55 mix of glucose and fructose), and a sugar substitute (saccharine, a monosaccharide), all with a 0.3 M concentration, will serve as replacements for the glucose used in the fermentation reactions. An ethanol sensor is used to measure the rate of fermentation in each reaction. Each trial will last for seven minutes each, with the sensor taking a 10 measurements every minute. This data will then be analyzed through a statistical normality test and a box and whisker plot.

Results

The experiment showed that the glucose substitute with the highest rate was honey with a mean ethanol production of 54.05 ppm/min. Following that was high fructose corn syrup with a mean of 50.76 ppm/min and glucose with 46.24 ppm/min. The substitute with the least amount of fermentation was saccharine with a mean of

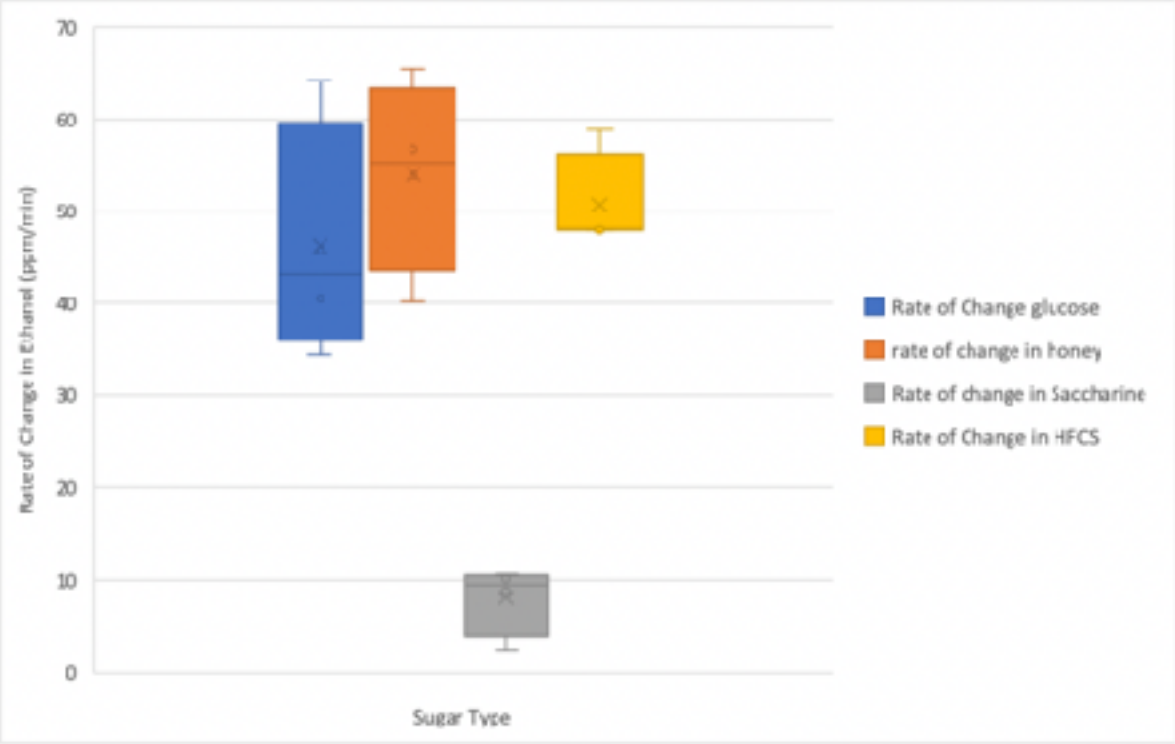

Figure 1: The rate of change in ethanol production in ppm per minute compared to glucose types honey, saccharine and high fructose corn syrup (HFCS). Honey had the highest mean of all types of change in ethanol production with a mean of 54.05 ppm. High fructose corn syrup followed honey, but was superior to glucose. Saccharine came in last with a mean value of 7.98.

7.98 (Figure 1). Through the use of yeast fermentation using multiple types of glucose substitutes, it can be concluded that some types of glucose substitutes actually increase the rate of fermentation. Our hypothesis is therefore, rejected. All but Saccharine were shown to be abnormal through statistical normality tests. A Mann-Whitney U test was used to compare the effect of sugar derivative on the rate of ethanol produced in fermentation reactions with yeast, with the sugar derivatives being honey, High Fructose Corn Syrup, and Saccharine. The Mann-Whitney U Test gave p values of 0.471, 0.312, and 0.0303 for Honey, HFCS, and Saccharine; the test also provided Mann-Whitney U values of 5, 4, and 0 respectively. The test revealed that the only statistically significant data group was the Saccharine against the control of glucose. More trials would be needed to derive a normal distribution for the honey and HFCS groups.

Discussion

Our data demonstrated that glucose substitutes worked better in yeast fermentation reactions. The glucose, our control, was the second to last producer of ethanol in the fermentation reaction. The honey was the best producer of ethanol in the yeast fermentation. To further these results and interpretations, the different threads of

honey, for example, could be tested for their variation in ethanol production. Honey, much like yeast, is a living colony of different bacteria and can change the rate of fermentation.

The data collected did have a tendency to fluctuate in fairly large amounts. This can be attributed to a variety of sources such as the yeast colonies used in each trial. For each trial, a new yeast solution had to be made. However, because yeast is a bacteria, with each new sample of yeast used, there is a possibility that the number of living yeast was different for each trial. It is also possible that the population of *Saccharomyces cerevisiae* can be infected with a prion that could change the phenotype, which can change the efficiency of rate of fermentation (True, 2000). These variations would create a change in the rate of fermentation. Additionally, the temperature within the lab fluctuated and caused the lab to drop in temperature. This experiment was extremely temperature sensitive, so the flux in temperature would have affected the rates dramatically. These errors were environmental related and could not be avoided.

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