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The effects of honey on CO_2 emissions in fermentation of yeast

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Abstract

In this experiment, we are researching if the amount of honey effects the amount of carbon dioxide emissions in the fermentation process of yeast. The issue that this question addresses is if increasing amounts of honey will speed up the process of fermentation of yeast. Our experiment is unique because we used honey as our sugar in the yeast fermentation processes. We conducted nine trials comparing increased amounts of honey molarity to carbon dioxide emissions from the fermentation. We concluded that our evidence was not due to chance alone because p-value ($p < 0.03$) of our results compared to the alpha level (.05).

Introduction

In recent studies, experimenters L. Alba-Lois and C. Segal-Kishinevsky found that increased glucose concentration rapidly increased the fermentation process for beer and wine (2010). To test this, we conducted an experiment to see if the amount of sugar (honey) with yeast can speed up the process of fermentation. This was measured by the rate that carbon dioxide was emitted, because the chemical process of fermentation produces ethanol (C_2H_5OH) and carbon dioxide (CO_2) (D'Amore, 1992). As honey molarity increases, the rate of carbon emissions will also increase because the reactant of respiration will increase the product by le Chatelier's principle (Quilez-Pardo & Solaz-Portoles, 1995).

$$\text{Sugar} + \text{yeast} \rightarrow CO_2 + C_2H_5OH + \text{energy}$$

Bacteria require sugar to undergo fermentation for energy, therefore the more sugar (food) available to the yeast, the more energy (and therefore carbon dioxide) they are able to produce (Ashok, Muichandani & Luong, 1988). We will know if our hypothesis is supported if the rate of carbon dioxide emissions is significantly higher with honey molarity added or rejected if the rate of change in carbon dioxide emission does not change based on the molarity of honey in the yeast mixture.

Methods

We measured the amount of carbon dioxide given off by the fermentation of yeast by manipulating the concentration of honey in a water solution (0M (no honey/control), 0.15M, and 0.3M). We chose no honey as the control group, and since the honey mixture supplied was 0.3M we chose this as one of our experimental groups and 0.15M as the other group because it is a middle amount between 0M and 0.3M. First, we put 0.6g of yeast and 10mL of warm water in a 250 mL respiration bottle placed on a stir station with a carbon dioxide probe inserted into the top measuring the emissions in ppm for five minutes taking samples every thirty seconds, this was done three separate times for the control group sample. Second, we put 0.6g of yeast and 10 mL of warm water mixed with 0.15M honey in a 250mL respiration bottle placed on a stir station with a carbon dioxide probe inserted into the top for five minutes taking samples every thirty seconds, this was repeated for three separate trials for this sample group. Lastly, we put 0.6g of yeast and 10mL of warm water mixed with 0.3M of honey in a 250mL respiration bottle placed on a stir station with a carbon dioxide probe inserted into the top for five minutes taking samples every thirty seconds, this was repeated for three separate trials for this sample group. We made sure to rinse the respiration bottle thoroughly between every trial to ensure no cross contamination occurred.

We did not allow three minutes for yeast to "bloom" in warm water because we wanted to measure carbon dioxide emission as it was initially affected by honey molarity.

Carbon dioxide emissions were collected in parts per million (ppm) with a carbon dioxide probe through the LoggerPro computer program and transferred to Excel and Past3 for statistical analysis. We collected carbon dioxide because it is a product of fermentation, and by measuring this we can determine the rate at which yeast ferments.

For statistical analysis, we conducted a one-way ANOVA because the data is distributed normally, and we have one variable being measured. We will display our data in a box and whisker plot because we are comparing three different groups.

Results

As molarity increased (as seen in figure 1), so did carbon dioxide. For our control (no honey added), our average rate of carbon dioxide emissions in our three trials was 270.98 ppm/min; additionally, our average rate of change over three trials was 487.70 ppm/min for 0.15M, and 963.16 ppm/min for the three 0.30M trials.

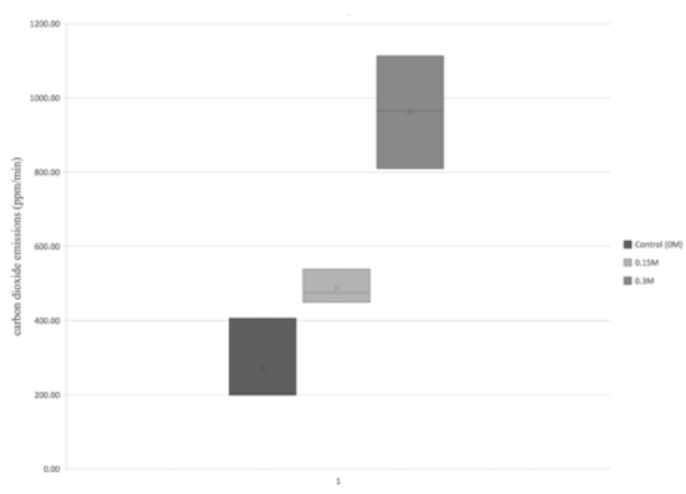

Fig 1. The average carbon dioxide rate of change in yeast fermentation with different moralities of honey/water mixture.

In the One-way ANOVA test it was found that our results are significant based on our p-value of $p < 0.03$ meaning that there is a significant difference in the carbon emissions released and the honey molarity.

Discussion

This data supports our hypothesis: the rate of carbon dioxide emissions did increase as we increased honey molarity. We then speculate that ethanol in beer and wine could also be produced faster (as carbon dioxide and ethanol are both products of fermentation), as our data shows that with increasing sugar concentrations, the rate at which yeast ferments also increases.

Carbon dioxide increased more quickly in trials with higher molarity of honey, because the yeast had more sugar to utilize for the process of fermentation. This allows more glucose to enter the system to undergo hydrolysis into pyruvate, which is then oxidized, producing carbon dioxide and ethanol as byproducts.

Potential confounding variables in this experiment are the possibility as the previously empty room, upon having 20+ people inside producing carbon dioxide (by breathing), could have increased the baseline carbon dioxide levels in the room.

Alternative interpretations of our results could be that the rapid fermentation of the yeast was not due to increasing honey molarity, but instead due other enzymes in the honey compared to pure glucose (White & Doner 1980).

Future studies can be done isolating honey enzymes and testing those to the rate of carbon dioxide production in yeast fermentation. However, this experiment can still be useful by showing a potential method of significantly increasing ethanol and carbon dioxide production in yeast fermentation. These results can impact how people make alcoholic beverages across the world.

References

Alba-Lois, L. & Kishinevsky, S. C. (2010). Yeast fermentation and the making of beer and wine. Nature Education. 3(9): 17

Ashok, R. D., Muichandani, H. T. J. & Luong, A. L. (1988). Oxygen requirement in pullulan fermentation. Applied Microbiology and Biotechnology. 28(4-5): 361-366

D'Amore, T. (1992) Cambridge prize lecture improving yeast fermentation performance. Journal of the Institute of Brewing. 98:375-382

Quilez-Pardo, J. & Solaz-Portoles, J. J. (1995). Students' and teachers' misapplication of le chatelier's principle: Implications for the teaching of chemical equilibrium. Journal of Research in Science Teaching. 32(9): 939-957

White, J. W. & Doner, L. W. (1980). Honey composition and properties. Beekeeping in the United States. 335: 82-91