<u>EXAMPLE LAB REPORT:</u> Suzy Student

The Effect of Shaking on the Fermentation Rate of Sucrose by Yeast

Purpose

The purpose of this experiment was to determine the effects of shaking on sucrose fermentation by yeast. It was hypothesized that constant shaking of the fermentation mixture will increase the rate of fermentation of sucrose by yeast compared to only shaking the mixture every 30 seconds.

Background

Fermentation is a process in which the sugar from fruits or grains is converted to alcohol and carbon dioxide in the presence of water (Alverno College, 2011). Microorganisms, including yeast, have enzymes that can speed up this energy-producing process when they are put in an environment without oxygen (Chemical Heritage Foundation, n.d.). The balanced equation for fermentation of sucrose is:

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{yeast}} \underset{\text{ethyl alcohol}}{4\ C_2H_5OH} + \underset{\text{carbon dioxide}}{4\ CO_2} + \text{energy}$$

According to *Essentials of General, Organic, and Biochemistry*, when the number of collisions between reactants decreases, the chance that a reaction will occur decreases which generally decreases the rate of the reaction (Guinn, 2010, p. 297). Consequently, if the number of collisions between reactants increases, the rate of the reaction should increase. If the reaction mixture is shaken or swirled constantly during the 9 minutes of the reaction, the sugar and yeast should come into contact more often and this should result in a faster reaction which should increase the amount of CO_2 produced. According to Dues (2006), shaking a soda can releases some of the dissolved carbon dioxide gas and pressure builds up inside the can. When the soda is opened, the sudden release of pressure makes the liquid spew out. So when the fermentation reaction mixture is shaken, this should help release the CO_2 being formed from the reaction mixture. So, if the fermentation reaction mixture is shaken continually throughout the investigation instead of once every 30 seconds, more CO_2 should be produced from the reaction and the CO_2 that is produced should be more effectively released from the mixture. The increased rate should show a steeper slope on the graph and a larger final volume of CO_2 should be seen.

Experimental Procedure

Before this investigation began, the Alverno College (2011) *Chemistry of BioOrganic Molecules Laboratory* manual was read and understood. The procedures from that text were used and modified.

10mL of 6% sucrose were added to a small Erlenmeyer flask using a graduated pipet.

The water level in the measuring pipet of the Fermentation apparatus was adjusted to between 0.00mL and 1.00mL. 10mL of 6% yeast suspension (pH 5.5) was transferred to the small Erlenmeyer flask using a graduated pipet. The flask was quickly attached to the Fermentation apparatus and the water levels in the plastic funnel and glass measuring pipet were adjusted to be the same. The stopwatch was started and the initial water level in the glass measuring pipet recorded. The Erlenmeyer flask was swirled throughout the investigation every 30 seconds. At the end of each 1 minute interval, the water levels in the plastic funnel and glass measuring pipet were adjusted to be the same and the water level in the glass measuring pipet was recorded. This was continued for a total of 9 minutes.

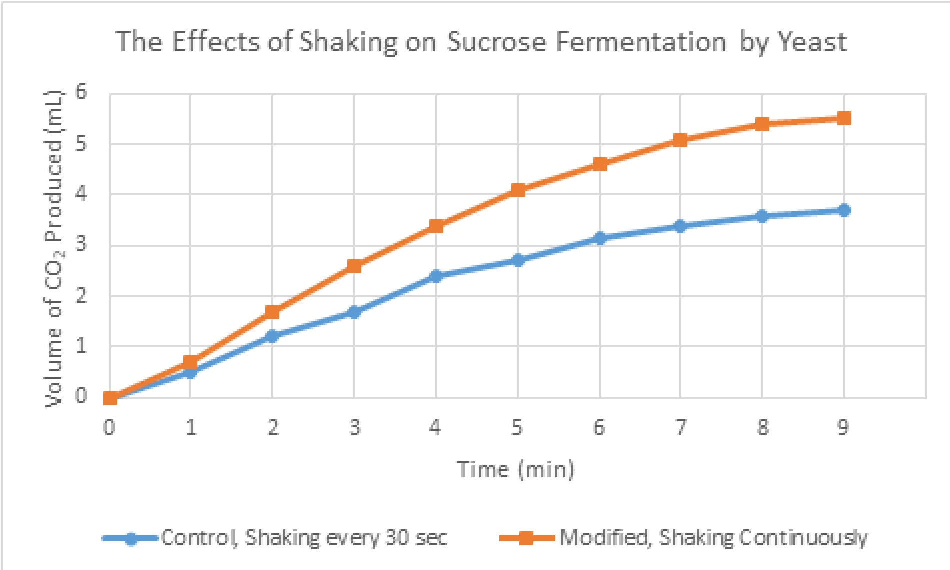
After the investigation was complete, all sugar and yeast solutions were discarded down the drain, all glassware was cleaned, dried and returned to the equipment counter. All pipets were thoroughly cleaned.

Data and Calculations

The Effects of Shaking on the CO_2 produced from the Fermentation of Sucrose by Yeast

Time (min)	Control Water level (mL) at time t	Control Vol of CO_2 (mL) at time t	Control Incremental Vol of CO_2 for each 1 min interval (mL)	Control Incremental Rate of Fermentation for each 1 min interval (mL/min)	Continuous Shaking Water level (mL) at time t	Continuous Shaking Vol of CO_2 (mL) at time t	Continuous Shaking Incremental Vol of CO_2 for each 1 min interval (mL)	Continuous Shaking Incremental Rate of Fermentation for each 1 min interval (mL/min)
0	0.70	0.00	0.00	n/a	1.10	0.00	0.00	n/a
1	1.20	0.50	0.50	0.50	1.80	0.70	0.70	0.70
2	1.90	1.20	0.70	0.70	2.80	1.70	1.00	1.00
3	2.40	1.70	0.50	0.50	3.70	2.60	0.90	0.90
4	3.10	2.40	0.70	0.70	4.50	3.40	0.80	0.80
5	3.40	2.70	0.30	0.30	5.20	4.10	0.70	0.70
6	3.85	3.15	0.45	0.45	5.70	4.60	0.50	0.50
7	4.10	3.40	0.25	0.25	6.20	5.10	0.50	0.50
8	4.30	3.60	0.20	0.20	6.50	5.40	0.30	0.30
9	4.40	3.70	0.10	0.10	6.60	5.50	0.20	0.20

Control



- Overall Rate of Fermentation = 3.70 mL ÷ 9 min = 0.41 mL/min
- Maximum Incremental Rate of Fermentation = 0.70 mL/min (from 1 to 2 min)
- Minimum Incremental Rate of Fermentation = 0.10 mL/min (from 8 to 9 min)

Continuous Shaking

- Overall Rate of Fermentation = 5.50 mL ÷ 9 min = 0.61 mL/min
- Maximum Incremental Rate of Fermentation = 1.00 mL/min (from 1 to 2 min)
- Minimum Incremental Rate of Fermentation = 0.20 mL/min (from 8 to 9 min)

Formulas Used:

Total Volume of CO_2 produced at time t (mL) = Water level CO_2 (mL) time t - Water level of CO_2 (mL) time 0

Incremental Change in Volume of CO_2 for each 1 minute interval (mL/1 min) = Water level CO_2 (mL) at t_2 min – Water level CO_2 (mL) at t_1 min

Incremental Rate of Fermentation (mL/min) = Incremental Vol CO_2 (mL) ÷ Time Interval (1 min)

Overall Rate of Fermentation (mL/min) = Total Vol CO_2 (mL) Produced ÷ Total Time (min)

Discussion

The hypothesis that constant shaking of the fermentation mixture would increase the rate of fermentation of sucrose by yeast was supported by the investigation. The overall average fermentation rate for the continuous shaking condition was 0.76 mL/min, while the intermittent shaking had an average rate of 0.52 mL/min. When looking at the graph, it can be seen that the experiment where the fermentation mixture was continuously shaken rises faster than the control that was shaken only once every 30 seconds. The steeper slope indicates that the rate of the mixture that was shaken continuously was faster than that of the control.

Fermentation rates were fastest in the first six minutes in both trials, with the average rate of CO_2 production for the control (shaking every 30 seconds) at 0.56 mL/min, compared to the average rate for the continuous shaking of 0.81 mL/min. In the last 3 minutes the rate in each experiment slowed, but the continuous shaking was still at a higher rate than the intermittent shaking (0.45 mL/min vs 0.67 mL/min, respectively). A larger total volume overall was also seen for the continuously shaken mixture (5.50 mL) compared to that of the control (3.70 mL).

The consistently faster rate of production of CO_2 as well as the overall larger volume by the constant shaking of the fermentation mixture supports the hypothesis, and is consistent with both sources (Guinn and Dues) used to support the hypothesis.

It does not appear that there were any experimental errors in carrying out the investigation. It is possible that the apparatus could have had an undetected leak but there was nothing in the results that would point to that being the case. Each volume measurement could have been off since there is some subjectivity in adjusting the water levels just prior to reading the volumes. It was difficult to control the intensity of the shaking since it was done by hand. Repeating the investigation using a mechanical stir bar or some type of mechanical agitation would eliminate this as a possible factor.

Conclusion

The hypothesis was supported by this investigation. When the fermentation mixture containing sucrose and yeast was constantly shook, the rate of CO_2 production and the total volume of CO_2 produced in the experiment were both higher than when the fermentation mixture was shaken every 30 seconds. It would be interesting to perform the investigation with no stirring at all to see what effect this would have on the release of CO_2 from the mixture.

References

Alverno College (2011). Fermentation of sugars (a yeast-catalyzed reaction). *Chemistry of BioOrganic Molecules Laboratory* (Spring 2011 ed.). Milwaukee, WI: Alverno College.

Dues, J. (2006). Soda can mythbusting. *Technology Interface*. Retrieved from http://technologyinterface.nmsu.edu/Spring06/12_Dues-Accepted/index.pdfhttp://technologyinterface.nmsu.edu/Spring06/12_Dues-Accepted/index.pdf

Guinn, D. & Brewer, R. (2010). *Essentials of general, organic, and biochemistry.* New York, NY: W.H. Freeman.

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