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Magical Inflating Balloons

Purpose: The purpose of this experiment is to blow up a party balloon via fermentation using yeast, sugar, and warm water!

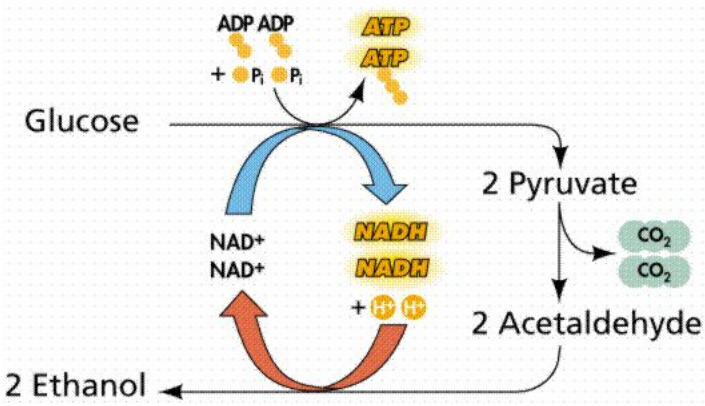
Introduction: In our experiment, one of our main ingredients is yeast. This unicellular organism has been used for many years to help bread bake and rise. Moreover, in today's experiment we will be testing the ability of yeast to ferment different amounts of sugar provided. We will be performing this experiment anaerobically since we want to keep out the air that would otherwise convert the ethanol into acetic acid, and give us some other unwanted by-products.

The difference between aerobic respiration and fermentation is that aerobic respiration uses oxygen (electron acceptor) to break down organic compounds whereas fermentation does not use oxygen. In aerobic respiration, we begin with a step called glycolysis where an organic compound (such as glucose, sucrose etc.) is broken down to form a molecule called pyruvate. Moreover, if enough oxygen and or other electron acceptors are still present, then the pyruvate transfers to the next step of aerobic respiration. Ultimately, glycolysis is making a net gain of 2 ATP. Correspondingly, fermentation is nearly a similar process where the organic compound is also broken down, however instead of making pyruvate (like in aerobic respiration), the product is a different molecule depending on the type of fermentation (Scoville, 2020). For instance, alcoholic fermentation is the breaking down of organic compounds to produce ethyl alcohol and carbon dioxide (Scoville, 2020). Moreover, in humans if not enough oxygen is present we will undergo lactic acid fermentation. Ultimately, fermentation occurs when there is a lack of enough oxygen to continue the process of aerobic respiration.

Yeast feeds on sugars and starches, and when the yeast in our bottle consumes the sugar, it breaks it down to be used as energy. However, just like all living beings, metabolizing the food results in waste products being produced. Thus, when the yeast metabolizes the sugar, the waste products produced are carbon dioxide (gas) and ethanol. This is due to the experiment being performed anaerobically (without oxygen). Furthermore, the increase of carbon dioxide waste products will cause the pressure inside the bottle to increase, causing the balloon to inflate!

Below is the chemical reaction for the fermentation of the yeast and sugar.

(Under anaerobic conditions, the yeast will convert the glucose to pyruvic acid via the glycolysis pathways, and will then go one step further to convert the pyruvic acid into ethanol)



$$C_{12}H_{22}O_{12} + H_2O \rightarrow 4CH_3CH_2OH + 4CO_2\,(g)$$

(sucrose) (ethanol) (carbon dioxide)

Materials

1. Dried Yeast (available at your local supermarket)
2. 4 clean bottles (glass or plastic is fine. 16 oz. or smaller is preferred. Just ensure they are properly cleaned before we begin the experiment since we want to avoid any cross contamination!)
3. Table Sugar
4. Warm Water (105° - 115°F)

5. Measuring Utensils (fabric measuring tape to measure circumference of balloons, a thermometer to measure the water, a teaspoon to measure the appropriate amount of sugar and yeast, and a glass measuring cup to measure the appropriate amount of water.)
6. Oven mitt (to remove the warm water from the microwave)
7. Funnel (to easily transfer our water)
8. 4 Party balloons (12 in. or greater is preferred)
9. Eye protection, long sleeved pants/shirts, and gloves (if these are available around the house, we are not working with anything dangerous, however safety is always the #1 priority.)

Procedure

1. Label your 4 clean bottles #'s 1-4 to ensure we know which bottles have the corresponding sugars added.
2. Remove 4 balloons from your bag, and begin blowing on them to loosen them up.
3. To all of your 4 clean bottles, add 2 ¼ teaspoons of yeast.
4. Add no sugar to bottle #1, add 1 teaspoon of sugar to bottle #2, add 2 teaspoons of sugar to bottle #3, and add 3 teaspoons of sugar to bottle #4.
5. Next, run the tap water under the hottest setting for at least 10 seconds to ensure proper warm conditions have been met. Then, using an oven mitt, place your measuring cup under the faucet with the hottest setting on until 1 cup has been reached. Then, turn off the faucet immediately.
6. Next, take your thermometer and measure the temperature of the water. We need the temperature to be really warm, however a specific number does not have to be met. However, just insure to keep all the warm water constant! Thus, if 90 °F was the warmest your faucet could go, then insure all water added to the bottles is at 90 °F. Correspondingly, it must be noted that anything over 130 °F will kill the yeast, so do not go over this limit! Repeat this process 3 more times to get 4 cups of your warm, yet same temperature water.

7. Next, take your funnel and begin adding 1 cup of warm water to each bottle.
8. Cover all 4 bottles with your hand or a lid, and begin mixing/shaking gently.
9. Remove the cap from the bottles, and begin placing pre-stretched balloons to each lid.
10. Once all the balloons have been placed on each lid, let the bottles rest somewhere warm for the next hour. This is where the magic will happen!

Results: From your observations, record which bottle with their corresponding sugar added yielded the largest balloon. To measure the balloon, use a fabric measuring tape to measure the circumference of the balloon. To do this, wrap the measuring tape around the widest part of the balloon (most likely center part) and make sure the tape measure is perfectly horizontal/straight all the way around. Then, just simply record the number!

Variables:	**Bottle #1**	**Bottle #2**	**Bottle #3**	**Bottle #4**
How much sugar was added? (tsps.)				
Did the balloon inflate?				
Rank the following bottles from 1 being the largest balloon and 4 being the smallest.				
What is the circumference of each balloon? (in inches)				

Data Analysis/Discussion: All materials used in this procedure are readily available at your local grocery store, meaning that this experiment can be manipulated and replicated many times. Furthermore, all factors remained constant except for the amount of sugar added to

each bottle. Hence, the controlled variables were the bottles size, amount of yeast, and amount of warm water added. Moreover, our balloon is the dependent variable in our experiment since it is the only element we are measuring. Additionally, the control was bottle #1 with no sugar added, and other 3 bottles were given a dose of various teaspoons of sugar.

Today, the independent variable was the amount of sugar added, however we can tweak this experiment to view other instances. For example, we can keep all things constant except for the temperature of water, and observe which conditions the yeast enjoy or thrive more on. Does it perform better in warmer conditions or cooler conditions? Maybe it does better in an intermediate temperature? Regardless, varying these components of the experiment makes them independent variables, which can all be utilized to expand the nature of this experiment.

Procedure for Water Temperature effects:

1. Label your 3 clean bottles #'s 1-3 to ensure we know which bottles have the corresponding water temperature added.
2. Remove 3 balloons from your bag, and begin blowing on them to loosen them up.
3. To all of your 3 clean bottles, add 2 ¼ teaspoons of yeast and 3 teaspoons of sugar.
4. Next, we will begin preparing the 3 different temperatures of water. We will have a cool temperature, an intermediate, and a hot temperature.
5. To begin, position the tap water under the coldest setting for at least 10 seconds to ensure proper cooler water conditions have been met. Then, place your measuring cup under the faucet until 1 cup has been reached. Now turn off the faucet immediately. You can use a thermometer to see if the temperature is cool enough. Anything <50°F should be fine.
6. Now, we will prepare our intermediate or warm water temperature. For this step, position the tap water in between the coolest and warmest setting, and let the water run for 10 seconds to ensure proper temperature has been reached. Then, place your measuring cup under the faucet until 1 cup has been filled. Now, take your thermometer to check the temperature of the water. Our desired temperature should be around 68-72°F.

7. Now, we will prepare our hot water temperature. Begin by running the tap water under the hottest setting for at least 10 seconds to ensure proper warm conditions have been met. Then, using an oven mitt, place your measuring cup under the faucet with the hottest setting on until 1 cup has been reached. Then, turn off the faucet immediately. Now, take your thermometer and check the temperature of the water. It should be 15 degrees larger than our warm water, thus anything >80°F should be fine. Remember, anything over 130°F will kill our yeast!
8. Next, take your funnel and begin adding 1 cup of each designated water to each bottle. Add the cooler water to bottle #1, warm water to bottle #2, and hot water to bottle #3
9. Cover all 3 bottles with your hand or a lid, and begin mixing/shaking gently.
10. Remove the cap from the bottles, and begin placing pre-stretched balloons to each lid.
11. Once all the balloons have been placed on each lid, let the bottles rest somewhere warm for the next hour. This is where the magic will happen!

Results for Water Temperature effects: From your observations, record which bottle with their corresponding water temperature added yielded the largest balloon. To measure the balloon, use a fabric measuring tape to measure the circumference of the balloon. To do this, wrap the measuring tape around the widest part of the balloon (most likely center part) and make sure the tape measure is perfectly horizontal/straight all the way around. Then, just simply record the number!

Variables:	**Bottle #1**	**Bottle #2**	**Bottle #3**
What was the water Temperature added? (°F)			
Did the balloon inflate?			
Rank the following bottles from 1 being the largest balloon and 3 being the smallest.			

What is the circumference of each balloon? (in inches)			

<u>Data Analysis/Discussion</u>: For this experiment, the controlled variables were the bottles size, amount of yeast, and amount of sugar added. Moreover, our balloon is the dependent variable in our experiment since it is the only element we are measuring. Additionally, the independent variable was the temperature of the water. Bottle #1 had cold water, bottle #2 had warm water, and bottle #3 had hot water.

<u>Conclusion</u>: What can we conclude when more sugar is added? Why does this occur, and what is the ultimate result? Make sure to analyze your data to answer to determine this. Furthermore, what can we conclude when the yeast grows in warmer water conditions compared to cooler temperatures? Does it perform better in warmer conditions or cooler conditions? Again, analyzing the data will be helpful in coming up with a valid conclusion.

<u>Questions</u>:

1. What was the Independent Variable for experiment #1? What about experiment #2?

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2. What is the overall chemical reaction between the yeast and sugar?

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3. What specifically caused the balloons to inflate?

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4. Did you have fun today, and what did you learn?

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Works Cited

1. Scoville, Heather. "The Difference Between Fermentation and Anaerobic Respiration."ThoughtCo, Aug. 28, 2020, thoughtco.com/difference-between-fermentation-and-anaerobic-respiration-1224609.