Bread Lab

Question: What effect will the mass of glucose added to yeast have on the rate of reaction of cellular respiration of yeast measured by the growth of bread (CO_2 production).

Hypothesis: I hypothesize that as the sugar mass increases the rate of cellular respiration will also increase. This is because yeast (saccharomyces) has the ability to perform anaerobic respiration therefore oxygen isn't a limiting factor in the rate of respiration. The only other factor that can be changed is the mass of sugar. This will allow for more glucose to be changed in pyruvate and the process of respiration will continue. This trend will exist as long as the glucose remains the limiting factor in the reaction. Once the yeast has been saturated with sugar the rate of reaction will remain constant because enzymes in the yeast will be limiting opposed to the glucose. Therefore 3 grams of glucose will have the greatest rate of respiration while 1 gram will have the slowest.

Independent Variable:

The independent variable in this experiment the mass of glucose that is mixed with the yeast in order to "activate" it and cause it to undergo anaerobic respiration.

Dependent Variable:

The dependent variable in this experiment is the rate of photosynthesis, which will be measured using the increase in volume of bread due to CO_2 production from the respiration of the yeast/ saccharomyces.

Controlled Variables:

- Source and amount of water
- Source and amount of yeast
- Source and type of glucose
- Electronic balance used
- Amount and source of flour
- Temperature at which the yeast and glucose are heated
- Amount of time the bread is allowed to rise
- Thermometer used
- The initial volume of the dough in the beaker therefore controlling the density of each trial

Procedure:

1) Measure and weigh, using weigh boat and electronic balance, 1 gram of glucose.
2) Mix the glucose, yeast and water in a 250 mL beaker. The amount of water is written on the package which the yeast came in.
3) In order to speed up the dissolving process, put the beaker on a hot plate and heat to a temperature of 30^0C indicated by a thermometer.
4) Once the sugar has been completely dissolved remove the beaker from the hot plate and allow it to cool back down to room temperature.
5) Using a weigh boat, measure 2 imperial cups of flour. The same bag and same cup should be used in all trials for consistency.
6) Pour the flour into a 500 mL beaker.
7) Using a 500 mL graduated cylinder measure 250 mL of distilled water.
8) Pour the flour onto the table and create a well in the middle of the flour.
9) Pour the yeast- glucose solution into this well and begin to mix the flour and the solution together to form the dough
10) From the 250 mL of distilled water add 50 mL to the yeast-glucose solution and flour.
11) Continue to mix the dough for 5 minutes and then form a small ball from the dough.
12) Place the dough ball into a 500 mL and compress to the bottom of the beaker so that there is no empty space at the bottom of the beaker.
13) Arrange the dough so that it is compressed enough so that the top of the dough is at 50 mL.
14) Place a damp cloth at the opening of the beaker.
15) Place the beaker in a 38^0C incubator and allow for it to rise for 30 minutes measured by a stop watch.
16) After 30 minutes remove the beaker and record the final volume of the dough.
17) Repeat steps 1-16 three times for each different mass of sugar (1.5, 2.0, 2.5, 3.0 grams).

Data:

Table 1: Shows the raw data that was collected from the experiment described in the procedure.

Mass of Glucose g (±0.05 g)	Trial Number	Initial Volume mL (± 0.5 mL)	Final Volume mL (±0.05 mL)
1.0	1	50.0	150.0
	2	50.0	158.0
	3	50.0	148.0
1.5	1	50.0	190.0
	2	50.0	177.0
	3	50.0	185.0
2.0	1	50.0	197.0
	2	50.0	200.0
	3	50.0	204.0
2.5	1	50.0	210.0
	2	50.0	220.0
	3	50.0	218.0
3.0	1	50.0	350
	2	50.0	335
	3	50.0	365

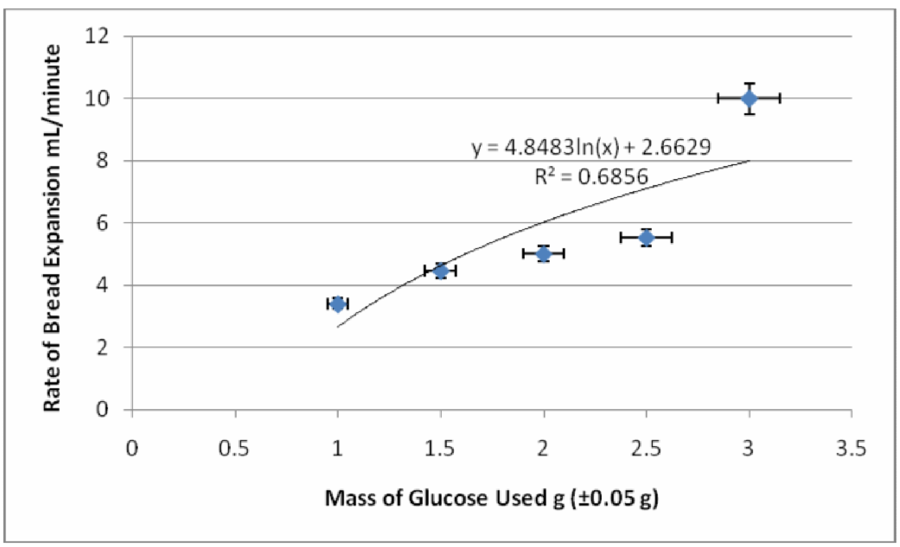
Table 2: Shows the increase in volume of each of the different bread samples and their respective averages created using different masses of glucose.

Mass of Glucose g (±0.05 g)	**Trial Number**	**Change in Volume mL (± 1.0 mL)**	**Average Change in Volume mL (±1.0 mL)**
1.0	1	100.0	102.0
	2	108.0	
	3	98.0	
1.5	1	140.0	134.0
	2	127.0	
	3	135.0	
2.0	1	147.0	150.3
	2	150.0	
	3	154.0	
2.5	1	160.0	166.0
	2	170.0	
	3	168.0	
3.0	1	300.0	300.0
	2	285.0	
	3	315.0	

Table 3: Displays the rate of bread expansion for each mass of glucose used.

Mass of Glucose g (±0.05 g)	Average Change in Volume mL (±1.0 mL)	Time minutes (±0.005 minutes)	Rate of Bread Expansion mL/minute
1.0	102.0	30.00	3.400 ±0.98%
1.5	134.0	30.00	4.467 ±0.74%
2.0	150.3	30.00	5.010 ±0.66%
2.5	166.0	30.00	5.533 ±0.60%
3.0	300.0	30.00	10 .00±0.33%

Graph 1: Shows the correlation between the rate of bread expansion and the mass of glucose that was mixed with the yeast.



Conclusion/ Evaluation

Based on this experiment the hypothesis was supported. In this experiment the rate of respiration was measured through the change in volume of bread. This is an accurate method for representing the rate of respiration because the increase in bread volume is a result of the increase in carbon dioxcide. Along with ethanol, CO_2 is a final product of anaerobic respiration from sacchromyces therefore as respiration increase the concentration of CO_2 will increase which in turn will increase the volume of the bread. Based on this the greatest volume and the greatest rate of bread expansion will equate to the fastest and greatest rate of respiration.

The greatest mass of glucose resulted in the greatest rate of anearobic respiration because, as aforementioned, glucose is a reactent in the reaction to produce CO_2: Glucose ($C_6H_{12}O_6$)→Pyruvate→CO_2+ C_2H_5OH+ATP. As can be seen in the reaction if there is a defficiency in glucose the reaction will not react at its full capacity. It will reach its maximum rate when the yeast/ sacchromyces becomes saturated with glucose resulting in the limiting factor being in the cells and not a variable being changed. The mass of glucose which woul yield the greatest rate of reaction can be calculated using the line of best fit which was chosen.

In **Graph 1**, a logarithmic line of best fit was chosen because of the expected behaviour of the reaction. Once the yeast becomes saturated the rate of respiration levels out and stops increases; this creates a plateu in the graph. This plateu is a charactersitic of a logarithmic graph therefore the maximum rate of respiration and the amount of glucose can both be calculated. From an expansion of the line of best fit the line appears to level out at around y=30 indicating that this would be the greatest and most efficient rate of respiration. This has a glucose mass of about 40 grams. At this point the yeast begins to be saturated. While this is the trend using the trendline, there is not a very strong correlation between the data as indicated by the R^2 value. In this experiment the R^2 value is 0.6856 which isn't a strong correlation, where 1.0 is the strongest correlation and 0 being no correlation. One factor in this error is from the uncertainties with the measurement devices. These do not contribute to a significant aspect of the error with an error of ±0.05 grams associated with the mass of glucose and a maximum of 0.98% associated with the average rate of bread expansion. In this graph, it can be seen that the data is significantly different because of the error bars. None of the error bars on the graph overlap indicating that the data is valid. This is also true because the respective uncertainties of the two variables are relatively insignificant. Because of the small error associated with the uncertainty there were other errors in the experiment.

The first possible error associated with the experiment is from the possibility that the final piece of bread was more compact and denser than another piece. This would have occurred when the bread was being heated and expanding it was assumed that the only direction that would expand would be upwards because of the beaker which is was held in; however, if the bread expanded and it expanded towards the side it would become more dense as more pressure built up while expanding towards that side. This therefore, would have changed the density of the bread making it appear the less CO_2 was released because its upward growth was less. This could not be controlled but was reduced by conducting three trials. Another similar error that was eliminated was that when the dough was first placed in the beaker and compressed the densities would have also been inconsistent but because it was regulated to a volume that it had to be compressed to the density would be the same because each piece of dough was formed using the same size pack of yeast.

A second possible error that could have occurred is the time lag between the activation of yeast and its mixture and placement into the beaker. If the yeast was activated and there was a lot of time to the time when it was placed in the beaker, the yeast would have already used up some of the sugar that it was mixed with. The longer it would sit the less the dough would expand because less CO_2 produced from respiration would be trapped by the dough. Similar to the previous error this too was reduced by conducting three trials. Another possible solution to this would have been to designate a certain amount of time that the yeast would be left for before mixing with the flour and water. The amount of time would have to long enough to ensure that the experiment could be set up within the time limit.

A third possible error could have been that some CO_2 gas escaped from the beaker while the experiment was being conducted. This would have caused the volume of the bread to be less even though more CO_2 could have been produced. A possible solution to this could be to put a solid lid on top of the beaker in order to prevent the CO_2 from escaping. This solution might also cause some errors because if the pressure is too high in the beaker the lid might come off and the problem would still exist however, this would not solve the underlying problem that the dough would not trap the CO_2 and expand. This isn't too significant of an error because it was consistent throughout all of the trials and the trials are being compared to each other opposed to a known value. The other affects the accuracy not the precision, which is the important thing in this experiment.

A fourth error that could have occurred is that when the bread rises it will not create a perfectly flat surface in order to measure the change in volume. In order to reduce this error the highest point of the dough was taken as the volume change. Similarly, the measurement of the initial volume had the same error and the same solution was used to reduce the error.

Another possible error which wasn't controlled was the temperature and any of the conditions in which the experiment was conducted. It is unlikely that this would have contributed to any errors because all of the trials were conducted on the same day and in the same area of the classroom meaning that the temperature and light intensity were all relatively the same amongst the trials.