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Investigating the effect of concentration of sugar on the respiration rate of yeast

We did an investigation to find how different concentrations of sugar effect the respiration rate of yeast and which type of concentration works best.

Respiration is not breathing in and out; it is the breakdown of glucose to make energy using oxygen. Every living cell in every living organism uses respiration to make energy all the time. Plants respire (as well as photosynthesise) to release energy for growth, active uptake, etc…. They can also respire anaerobically (without oxygen) to produce ethanol and carbon dioxide as by-products. This reaction is shown in the equation:

Glucose	Ethanol + Carbon Dioxide + Energy
$C_6H_{12}O_6$	$2C_2H_5OH + 2CO_2$

Anaerobic respiration by yeast is generally called fermentation. Yeast is a living organism that produces enzymes. These enzymes break down glucose (by colliding with each other) to be able to respire anaerobically.

I predict that the rate of fermentation will increase proportionally as the concentration of sugar increases but only up to a certain point were it will begin to decrease and eventually stop.

I believe this because the more sugar added to the yeast the more glucose broken down producing ethanol and carbon dioxide. The rate of carbon dioxide produced in a minute will also increase because the higher the concentration of sugar the more heat energy produced and so the more the molecules will move around and collide. Also the higher quantity of glucose molecules the higher chance of them colliding with the enzymes.

I believe the reaction will slow down and eventually stop when the sugar reaches a certain concentration because the yeast will be killed by either:

1. The high concentration of ethanol produced as a by-product.
2. The temperature of the reaction, as some of the energy produced converts into heat energy. At really high temperatures

the reaction will stop because the heat will have denatured the enzymes.

3. When there is a high sugar concentration the sugar molecules diffuse into the yeast. But when the concentration of sugar is too low the water in the yeast will diffuse out to equalise the concentration, creating a net of movement of water into an area where there is less water. The respiration goes down because more of the yeast is dying as the sugar molecules are much larger and so enter the yeast at a much slower rate than the water in the yeast diffuses out. Water actually moves both ways but as not all the sugar will have dissolved in the sugar solution the water mixes with the sugar and so can not go back into the yeast through the tiny halls in the cell membrane as sugar particles are much larger than water ones.

The apparatus used for this experiment is:

· Water bath, to keep a constant temperature of yeast through out the tests. This will be kept at body temperature, as
· Stop clock, to time how many bubbles there are in a minute.
· Yeast.
· Sugar solution.
· Test tube with bung, to put yeast and sugar solution.
· Long tube, to attach one end to bung and other end in water filled beaker.
· Water filled beaker, to see the carbon dioxide bubbles being released.

To do the experiment we…

· First need to warm the yeast to body temperature (37°C) in the water bath, as this is the best temperature enzymes work in. After heating the yeast to the right temperature we leave the test tube with the yeast in the water bath so the temperature stays constant through the test.

· We then measure the amount of sugar needed and we prepare a beaker with water.

· Once we add the sugar into the yeast we place a bung to close the test tube with the solution and attach a tube from the bung to the water filled beaker.

· Once the first bubble appears out of the tube and into the water filled beaker, we start the stop clock and count the number of carbon dioxide bubbles appearing. We must wait for the first bubble to appear because the enzymes do not collide straight away with the glucose. We do this for one minute then do the experiment again with a different concentration of sugar.

We did a preliminary experiment that helped me choose my method. Instead of finding the respiration rate by the number of bubbles we tried to find the volume of carbon dioxide being produced. We used the same apparatus but instead of leaving the end of the tube in the water beaker we placed it in a water-filled upside down beaker. When the bubbles came out of the tube the cylinder began filling with carbon dioxide. So instead of counting the number of bubbles we had to measure the difference between the starting volume of water and the end volume to see how much carbon dioxide had been used. This experiment resulted being very impractical, as the respiration rate was far too small to be able to detect with the measuring cylinder.

It is necessary to:

· Keep the temperature the same through out all the tests because the temperature of the yeast causes the enzymes to work faster or slower.

· Heat the yeast before adding the sugar because as soon as we add the sugar the enzymes will begin to break down the glucose. This will then not be a fair test, as the reactions will have begun at different temperatures.

· Keep the amount of yeast used in the test constant so there is the same amount of enzymes working each time. More enzymes would cause more collisions with the glucose and so a higher respiration rate.

· Not shake or help mix the sugar solution with the yeast, as this will help the enzymes and glucose to collide faster and so the respiration rate to increase. We would also not be able to mix all the solutions at the same rate causing an unfair test, as some solutions would be more mixed than others would.
· Use the same sugar and yeast for all experiment as some sugars break down more easily than others do and there are different types of yeast's with different properties which could affect the way the enzymes work.

We will investigate five different concentrations of sugar to get as many results as possible to see if my prediction is correct. We will time each concentration for five minutes and time the number of bubbles released each minute. This will give us five repeats of the same concentration to be able to find the average

Amount of sugar added to yeast (g)

to get as much of an accurate result as possible.

Results:

Number of CO_2 bubbles released per min	1	2	3	4	5
1	*16	18	14	10	14
2	23	16	15	12	16
3	24	15	17	12	13
4	23	15	16	10	12
5	23	12	16	14	12
Average	23	15	16	12	13

* This number is not included to form the average, as it is obviously an error.

The graph shows that the higher the concentration of sugar the lower the respiration rate. I believe this is because the more amount of sugar added the more yeast die. This is due to either:

1. The high concentration of ethanol produced as a by-product poisoning the yeast.
2. The temperature of the reaction being too high causing the yeast to die or the enzymes to be denatured.
3. The water in the yeast diffusing out to equalise the concentration causing the yeast to dehydrate, contracts and eventually dies.

The results fit with the second part of my prediction were eventually the respiration rate begins to decrease and eventually stops.

I believe the experiment was accurate. The rate of fermentation was very slow and so the bubbles could not be miscounted. All things were kept constant for a fair test. We used the same apparatus through out all the experiment.

I believe the results are inaccurate as the pattern is very vague and the range in the numbers of the repeats is very large. The average respiration rate results for the sugar concentrations of 3g and 5g did not follow the pattern of the rest of the results. They were only 2g out of place so I believe a minor mistake might have been made like a mistiming, miscounting of the bubbles, inaccurate concentration of sugar, etc…. The first reading of the respiration rate of the sugar concentration of 1g was very inaccurate. This was due to an early timing, before the first bubble appeared.

If I were to repeat this experiment I would begin with a much lower sugar concentration as these results only showed the decrease of the respiration rate and not the increase. I would also try a range of more varied concentrations to see if this would produce a larger difference in the results, as the respiration rate results were very similar and close together (apart from the average result for the sugar concentration of 1g compared to the rest).