1. Introduction:

a. Title

The effect of the tempereature on yeast metabolism.

b. Research Question

What is the effect of a temperature on yeast metabolism? Five different water baths with different temperature of water inside (30°C, 40°C, 50°C, 60°C, 70°C) and a solution called TTC which is absorbed by the yeast cells turning them pink when hydrogen is removed from the metabolic pathway by the dehydrogenase enzyme will be used to see how the temperature affects the yeast metabolism. The effect of yeast metabolism will be measure by comparing 5 test tubes (as I measure five different temperature effects) with the cultures to the standards which are our samples. It is expected that the temperature will affect the metabolism of yeast.

c. Knowledge background

There are many ideas to suggest that the change in temperature will cause an increase of respiration in yeast. Yeast is a single celled fungus made up mostly of protein, which is used in fermentation. Fermentation is the breakdown of sugars by bacteria and yeast using a method of respiration without oxygen (anaerobic respiration). It involves a culture of yeast and a solution of sugar (in my investigation it is a glucose), producing ethanol and carbon dioxide with the aid of the enzymes. The alcohol produced has been used in making wines and beers and the carbon dioxide produced has been used in baking as it gets trapped in the dough and causes it to rise.

Enzymes are catalysts that speed up reactions; they are made from protein and are specific as to which substrate they work on. For example a zymase-complex enzyme will only bind with a glucose molecule to produce the ferments carbon dioxide and alcohol.

Yeast has to make energy, stored as ATP to carry out all cellular functions. To do this they respire. They can respire both aerobically (when there is plenty of oxygen and the cells reproduce rapidly), or, where oxygen is short, they can respire anaerobically; in this process
they are called partial anaerobes. This is because less energy is released as the glucose sugar is only partially broken down, but still keeps the yeast alive. In my experiment the yeast is respiring by anaerobic respiration.

Here is the equation for anaerobic respiration:

$$\text{Glucose} \longrightarrow 2 \text{ ethanol} + 2CO_2 + 2ATP$$

The Kinetic theory states that, with an increase in temperature, the rate of reactions will increase. This is due to the increase of speed of the particles, brought about by the extra energy given to them by heat. The faster particles will bring about more particle collisions and so the reaction will take place faster. Enzymes are sensitive to temperature changes up until a certain temperature and will increase in their activity up to this point. The reactions that take place in the enzymes will be quicker and so will create more of their products.

But once you reach a certain temperature the rate of respiration slows down and drops. This happens because; all the enzymes are made up of protein chains of amino acids. They exist in the form of a helix structure with hydrogen bonds holding them together. When heat is applied to the enzyme, energy is given off. The active enzyme cell deforms and the hydrogen bonds break, denaturing the yeast enzyme. It would not be able to function as usual, and this process is irreversible.

c. Hypothesis

If the temperature increased, then the metabolism of yeast will also increase to some point and then slows down and drops.

d. Variables

Independent Variable: Temperature.

Dependant Variable: Percentage change in color of the solution (due to TTC), the rate of respiration.

e. Control of Variables

Temperature of the experiment, according to the kinetic theory will have an effect on the results; therefore I will try to control it by using water bath which automatically controls already set temperature, so I can be sure the temperature in the water bath will remain constant. Also, as it will take longer for the temperature inside the test tube the same as the water bath, I will leave them to equilibrate for 5 minutes and then mix the solutions together (glucose-yeast and TTC a redox indicator.)

2. Materials & Methods:

a. Materials

- 15 cm^3 of TTC, a redox indicator solution.
- 50 cm^3 of glucose yeast culture solution.
- 100 cm^3 of distilled water.
- 15 test tubes.
- Two pipettes.
- Measuring cylinder.
- Stop clock.
- 5 water bath.
- Glass rod.

b. Method

1. Pipette 10cm^3 glucose-yest culture into a clean test tube.
2. Into another tube place 10cm^3 distilled water, use a measuring cylinder to measure the amount of distilled water.
3. In third test tube place 3cm^3 of TTC, remember to use different pipette.
4. Incubate the tubes in a water bath at 30^{o}C for 5 minutes, so the solution will have the same temperature as in water bath.
5. After equilibration place 1cm^3 of TTC (from the tube you have already prepared and placed in water bath) into each solution (the solution with glucose-yest culture and with distilled water)
6. Shake or mix the solution in order to help activate the yeast. If it is improperly mixed,
   to temperature or activated, the results would not be fair and inaccurate.
7. Start the stop clock.
8. Compare the colour of the cultures to the standards every 5 minutes for 20 minutes and record percentage reduction.
9. Repeat the investigation at four more temperature: 40^{o}C, 50^{o}C, 60^{o}C and 70^{o}C

3. Data

a. Data

Table 1: A raw date table for the effect of temperature on the rate of respiration % in yeast cells																									
	Temperature/ °C ±0.05 °C																								
Student	30°C					40°C					50°C					60°C					70°C				
Recorded after time taken /minutes of being in water bath	5 minutes	10 minutes	15 minutes	20 minutes	25minutes	5 minutes	10 minutes	15 minutes	20 minutes	25minutes	5 minutes	10 minutes	15 minutes	20 minutes	25minutes	5 minutes	10 minutes	15 minutes	20 minutes	25minutes	5 minutes	10 minutes	15 minutes	20 minutes	25minutes
Ellie	0	0	5	5	10	0	0	10	10	10	0	15	25	30	35	0	15	35	35	40	0	15	25	30	30
Angelika	0	5	5	10	10	0	5	10	15	15	0	15	25	35	40	0	20	30	40	40	0	30	35	40	35
Christina	0	0	0	0	10	0	10	10	10	20	0	20	10	10	10	0	30	50	60	65	0	10	20	40	45
Pauline	0	0	0	0	0	0	0	5	15	15	0	0	15	35	45	0	10	40	50	50	0	5	35	45	45
Ninarh	0	0	0	0	0	0	0	5	10	10	0	10	20	25	35	0	35	45	45	50	0	20	25	35	40
Jack	0	0	0	0	0	0	0	10	10	15	0	0	15	25	40	0	0	35	40	55	0	10	30	45	55

Table 2: A table for mean rate of respiration/ %in yeast cells in each temperature.					
Temperature/ °C ±0.05 °C	30°C	40°C	50°C	60°C	70°C
Mean rate of respiration %	2,00	5,50	17,83	30,50	24,83

b. processing data

mean of 30°C=

0+0+5+5+10+0+5+5+10+10+0+0+0+0+10+0+0+0+0+0+0+0+0+0+0+0+0+0+0+=60/30=2

c. Graphs

Attached on a graph paper.

4. Results/Conclusion

a. Conclusion

I have found that as the temperature increased, the rate of respiration of the yeast increased to a certain point where, as the temperature rose to a certain level which in my case was 60°C, the rate of respiration drops down as shown on my graph (figure 1). My hypothesis is supported by these findings and on the graph and tables (table 1, table 2) you can see the rise and fall of respiration. It clearly shows the reaction of enzymes sensitivity to temperature. Thus my hypothesis and prediction are shown to be present and displayed to a large extent. As well as, according to Kinetic theory and enzyme-substrate theory, my results follow these theories. The active site began to denaturating at certain temperature (after 60°C) as it is sensitive to the heat. Thus, the experiment follows the rules, and was accurate.

I would like to compare my results to a figure from IB book.

At this figure, we can see that the temperature had similar effect on enzyme reaction as in my experiment. The difference of the temperature in which the enzyme denaturates and the rate drops can be due to different enzyme been used because not all enzyme have the same optimum temperature. However, it supports an idea of the kinetic theory and that the increase will rose to certain point and then drop down.

Another strength of this experiment is a number of taken samples as you can see on table 1. I have taken 6 samples for every temperature which gave me huge account to compare and to represents my results without any doubt of any uncertainties and gave me clear representive date.

5. Discussion

a. *E*valuation

The experiment follows the theories therefore any errors did not have a huge impact on the results. However, systematic errors could occur. For example, the thermometer was reading temperature of 52^{o}C when it was actually 51.02^{0}C. This might have effect on calculated values. Also, the temperature in water bath cannot be always constant, sometimes it needs a heat up, or a cool up. To make sure, this would not happen again, the best way is use two thermometers as a control.

Another error which could have slight effect on the results could be pH. Change in pH can have a dramatic effect on the rate of an enzyme-catalysed reaction. *E*ach enzyme has a range of pH in which it functions efficiently. This is often at or close to neutrality point (pH 7.0)

Also, instead of measuring the rate of reduction, we could measure using pH scale indicator to measure the number of hydrogen and gain more accurate results as well as

controlling the changes in pH. However, it did not affect my results in the experiment and the overall trend in the curve supports the hypothesis.

If I were to further investigate this experiment and my results, I would probably want to calculate the exact point where the enzymes begin to denature for respiration in yeast and use a pH indicator.

6. References

1. C.J Clegg, Biology for the IB diploma, Hodder Education, 2007 p.56 Figure 2.18