How does the concentration of sucrose affect the level of yeast population?

Saccharomyces cerevisiae, also know as yeast, are unicellular organisms which reproduce at a very high rate asexually by budding. They feed on sugar very well, and so for our experiment we have chose to use sucrose. Dried yeast is available at school, and it will be measured by the top pan balance. The initial state of the yeast solution should be nearly transparent, to suggest minimal population (a group of organisms of the same species populating a given area), as the population increases, the cloudier the solution becomes. Also, to be sure the yeast cells are evenly distributed; they must be stirred to keep the mixtures fair.

My independent variable will be the concentration of sucrose solution. Systematic quantities of them are added to separate incubators of identical amount of dried yeast so that the experiment is fair. Therefore, the change in population would be measured by how much light is able to go through the yeast solution, which is detected by the colorimeter. A very important factor I need to consider while conducting this experiment is to keep the flasks clean and sterile at all times. This decreases the chance of bacteria building up, which not only produces moulds and toxins poisoning the population, but also it will create competition over the sucrose.

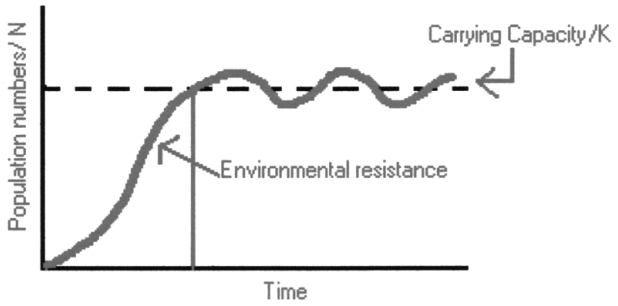
Only providing sucrose for the yeast may not be enough, and therefore I would need to introduce a nutrient source such as the vegemite. The mass added and the intervals of adding must be fixed, or else it may affect the population of the yeast negatively as well as positively. In order to provide a good fermentation environment for the yeast, the incubator will be kept between 20 ℃to 25℃.

PI 1

My prediction to the outcome of this experiment is that by growing yeast at higher concentration of sucrose, it will increase the rate of population growth and the maximum population size. This is because a high amount of resource allows a high "birth" rate, starting a rapid exponential growth of the yeast. And as yeast is a rapid reproducing fungus, it is registered to be an R strategist. This is because R strategists are small in size and reproduce at a speed classified as "the big bang reproduction".

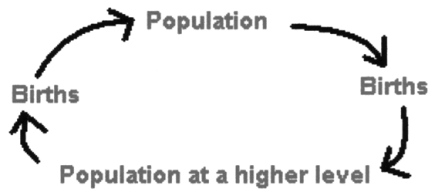
However, our experiment may show a point where the maximum reproduction rate (optimum) is achieved (due to the support the environment can give), and that no matter how much food sources are offered beyond that stage, it will make no change. This is known as the stabilizing level of carrying capacity (k).

My Predictons

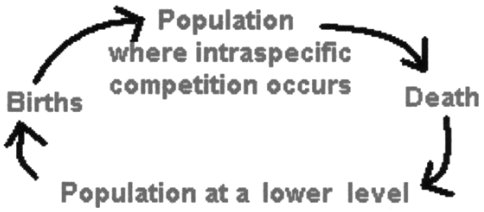


From my prediction, I have drawn this graph to support my view. The dotted line represents the carrying capacity, and it emphasizes that the population numbers are fluctuating above and below it over time. This is an indication of limited resources, where the populations are either overriding the resources, making the population oscillate downwards, or is supported by the resources, making the population go up. This is the same with the yeast experiment I am going to conduct. When the yeast has reached the environmental resistance point (environmental factors which reduce rate of growth), its viable population will immediately drop as limiting factors of space is unable to support the population of yeast. This is the density dependent factor, which affects how much yeasts are there at per unit or volume. By calculating the gradient of the graph, it can also tell us the rate of growth of population. Our experiment will show a population of J curve. However, a weakness of this graph is that it takes in not only counts of viable, but also non- viable organisms (organisms which are dead). This means, even if the yeast is going very cloudy, it does not mean that the population in the incubators are alive, and so therefore the immediate drop of the population cannot be shown.

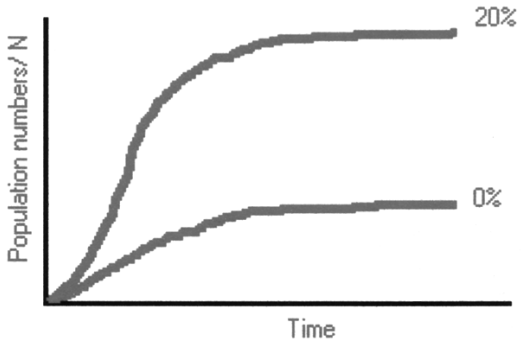
This graph then brings us to another method of analyzing population growth of the yeast due to varying amount of sucrose provided. This is the positive and negative feedback. Looking at the J shape curve, that tells us when population reproduces, it increases the population and the population increased will reproduce to result in another population increase.



But when the graph shows an S curve (which will not happen to my experiment, but as competitors may be present (such as bacteria), the feedback shown would be negative. This is due to intra- specific competition of the yeast), and also the limited amount of nutrients such as sucrose and space (which is only added once at the beginning, but not continually). And of which will result in death of organisms.



PI 1



I think the concentration of sucrose will positively affect the population growth of the yeast, also increasing the rate of reproduction. The 20% solution should hold a higher gradient (signifying the higher rate of reproduction), and also that its carrying capacity is higher, as the food level is higher. On the other hand, the 0% solution last result should be much lower than the 20% line as the maximum population size should not yet been reached. The gradient would be more gradual, and the other solution results would fit in between these two extremes.

The growth of yeast would be measured by the colorimeter. This is an apparatus which sends a beam of light through a solution, and calculate how much of the light can pass through, indicating the transparency of the solution. It is a suitable tool to use for my experiment as yeast solutions go cloudy when the population increases. The machine must be preset to 0 by sending a light beam through water (which should be most transparent, and act as the control of the machine), so that the readings for each of the solutions do not vary due to a different scale. The cap must be fitted onto the solution when the light is being sent through so that in insures no light escapes from the top.

However, the problem of using so is that is does not take in account of viability of the organisms inside. Also, a note to remember whilst reading results from this

apparatus is that as the percentages go up, it does not mean the population goes up, but it means that more fraction of the light is able to pass through, meaning there is no growth of population size. On the other hand, whilst readings go down, it means that less light is able to pass through, signifying an increase in population numbers.

PI 1

Variables

Independent Variable

Concentration of sucrose	Measured by measuring cylinders/ pipettes, as a percentage to the water solution Concentration: 0%, 5%, 10%, 15% and 20% to volume of distilled water

Controlled Variables

Vegemite	Measured by teaspoon (we did not choose to measure it on a top pan balance as the vegemite is a jelly substance, which will easily stick onto the pan, causing inaccurate measurements.) Quantity: Half a tea spoon
Water	Measured by measuring cylinders/ pipettes Volume: 200ml
pH	Same distilled water is used pH: 7 (Measured by adding 5cm3 of ph7 buffer)
Mass of Yeast	Measured by a top pan balance (So that it gives a fair test, as different amount of yeast = different amount of population) Grams: 1.5g of dried yeast
Temperature	Measured by a thermometer (So that each environment is identical and gives the best surroundings for yeast to grow) ℃: Varies throughout the day, but each of the yeast solutions receives the same temperature

Dependent Variable

Colorimeter	Placing portions of the different concentration of yeast solution separately into the apparatus Recorded by % of passing light beam

Apparatus

Measuring flask of 200 ml (x5)
100ml measuring cylinder
Pipette
Colorimeter
Tube (to fit in the colorimeter)
Distilled water/ vegemite/ dried yeast/sucrose
Tin foil
Labels (x5)
Stirrer
Top Pan Balance
Tea spoon

PI 2

Method

1) Collect equipment
2) Measure 200 ml of water into 5 flask
3) Measure and place 5% (10ml), 10% (20ml), 15% (30ml), 20% (40ml) and 0% (0ml) of sucrose in the 5 flasks
4) Label them and place tin foil on the top to cover it
5) Measure 5 sets of 1.5g dried yeast using a top pan balance
6) Carefully pour this into the solutions and quickly cover the tin foil back over the top
7) Measure half a tea spoon of vegemite (5 sets) and put them into the solution, quickly cover the tin foil back over the top
8) Collect a colorimeter and set the reference of it by pouring distilled water into the tube
9) Press the button and make sure the readings go to 100
10) Take the distilled water back out
11) Collect a 5 100cm3 measuring cylinder, pour 90 ml of distilled water in all of them
12) Using a pipette, put 10ml of concentration from the flask labeled 0% into the measuring cylinder (remember to fit the tin foil back on as soon as you collect enough solution!)
13) Stir it well and put some of the concentration into the tube

PI 2/3

14) Fit the tube inside the colorimeter and record the readings
15) Repeat step 12 to 14 for the 5 flasks including different concentration of sucrose
16) Repeat steps 11 to 14 at an interval (Such as two times a day, one in the morning, one in the afternoon), so that enough data can be collected.

DCP 1

Data Collection

		Concentration of Surcrose				
		0%	5%	10%	15%	20%
		% Transmission				
Time	21/6/05 1:00pm	20	10	15	22	26
	22/6/05 8:45am	27	20	10	14	40
	22/6/05 1:00pm	67	19	75	23	23
	23/6/05 10:00am	26	15	18	23	33
	23/6/05 1:05pm	24	11	11	15	13

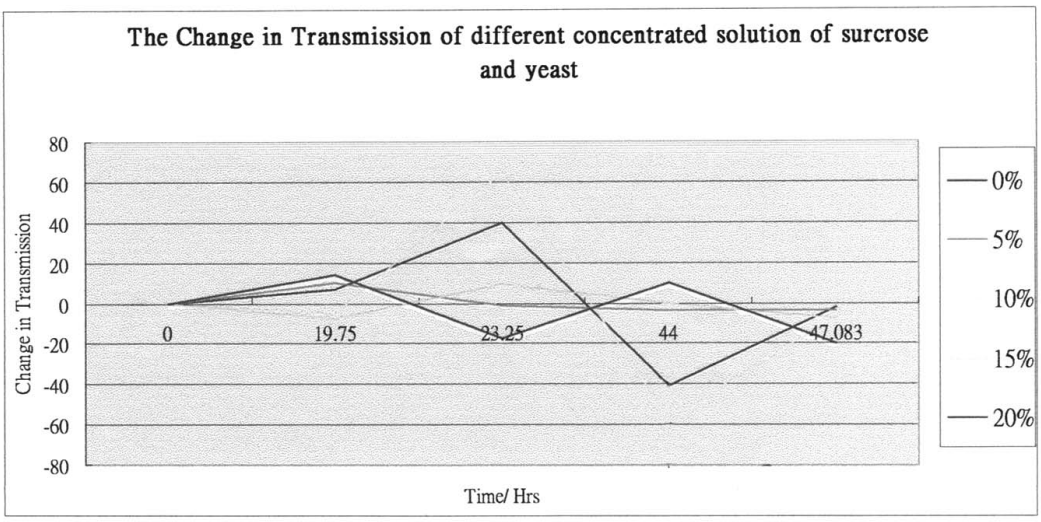
(Only considering the % transmission shown from the colorimeter gives each set of the results a different starting point, and also does not allow us to understand how much the transmission rate has dropped or fluctuate. If not, it will be very hard for us to predict if the population within the solution is growing. Therefore the change would need to be calculated.)

DCP 2

	Concentration of Surcrose				
	0%	5%	10%	15%	20%
Time/ hrs	Change in Transmission				
0	0	0	0	0	0
19.75	7	10	-5	-8	14
23.25	40	-1	65	9	-17
44	-41	-4	-57	0	10
47.083	-2	-4	-7	-8	-20

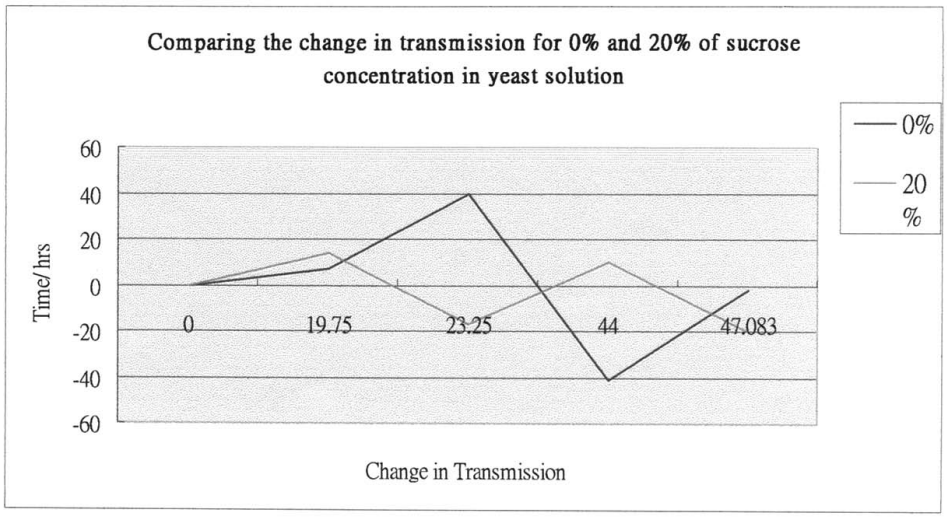
(The time here is changed into hour's format to prevent any confusion with the change in days as there are with the time format above.)

DCP 3



All of the results are plotted on this graph. However, as there are too many sets of conclusions, no specific trends can be identified to assist me in proving or disproving my predictions.

DCP 3



Here, only two sets of results are plot, the lowest and the highest concentration of sucrose within the yeast solution. This enables me to compare the statistics easier, reaching a more accurate conclusion.

Conclusion

As the population of yeast increases, it will cause the transmission rate to go down.

DEC 1

Looking at the first graph, the 5% line actually is very close to 0 throughout the experiment. This means the population did not grow too much to make a dramatic change in the colorimeter's readings. However, considering back to the percentage of transmission table, it does show a trend of the results going down, except for the peak of 20% that it hit on the 19.75 hrs reading. This tells us that the population did grow throughout time.

The 10% sucrose solution made the most dramatic changes out of them all, it first took a drop with a difference of -5% during the second reading, and then took a big increase of 750% from 10% to 75%. This is very awkward as it means the solution suddenly became transparent, allowing more light to be detected by the colorimeter. It then took a big drop of 24%, down to only 18% of transmission. The last reading we took was only 1% off from the initial reading taken of that solution 3 days before hand. This tells us that, something might have gone wrong in the process of the experiment for this solution, and that the population is the same at the end.

The 15% line is similar to the 5% line in the sense that they stayed fairly close to the 0 line. However, whilst the 5% line rise in the beginning, the 15% line dropped in the beginning, and when the 5% line dropped around 23.25 hrs, the 15% line rise.

DEC 3

However, since the percentage of transmission from the table shows us that the ending reading is smaller than the initial reading, it proves to us that the population has grown through my experiment.

DEC 1

The first graph also tells us that both the 10% and the 15% solution's population begin to grow as soon as the second reading is taken.

Looking at the second graph of the two "extremes", we can distinctly see the difference. It corresponds with the statement from above about the 5% and the 15% line. As the 0% line goes up, the 20% line goes down. This tells us that the concentration of sucrose do make a difference to the population as the results shows opposing readings. Both of their percentage of transmission rises during the second reading, nevertheless, the 20% line rises above the 0% line by 6%, indicating that its population is growing slower than the 0% concentration by a little. After the reading taken at 19.75 hrs, the two solutions took different directions and 20%'s population quickly increase, whilst the 0% population remains. This may due to the presence of the large concentration of sucrose, acting as a very good food source for the yeast to feed on. But since the 0% solution has no accessible food, the growth of that

DEC 1

population would be slower.

However, during the 44 hrs reading, we can see the situation has changed. The 20% transmission is much higher than the 0%, telling us that the 0% solution is growing in population. This suggests to us that the sucrose in the 20% should be used up, and so the population is not growing anymore. Or it may also suggest that the carrying capacity of the habitat has been reached, and so no more new yeast can be carried. On the other hand, the 0% solution is growing from its natural pace, and is duplicating successfully.

The last reading of 47.083 hrs shows the two solutions goes back to the initial direction, where the 0% line starts to go back up, telling us that it has reach its environment's carrying capacity. On the other hand, the 20% solution is growing again; maybe they have developed its natural pace of growth. These two sets of results can clearly tell us that the level of sucrose do have an influence on the population of yeast. But, my prediction might actually be wrong.

DEC 3

DEC 1

This is due to the rate of change in transmission of the solutions. Let us take the change of the first drop in transmission for the two solutions.

Concentration of Sucrose	Change in Transmission		The Difference	Rate Change in Transmission /Time
0%	40	-41	81	81/ 20.75= 3.9
20%	-17	10	-27	27/20.75= 1.3

By taking away the change in transmission from 23.25 hrs and 44 hrs, we work out the difference of the change. And then by finding how many hours are between 23.25 hrs and 44 hrs (subtracting 44 by 23.25); we have the amount of time. By dividing the two statistics, we can find out the rate. And here, we can see that the solution with 0% of sucrose actually grows faster in mean of rate change over time. This contradicts my prediction, however is unable to prove that my prediction is total wrong. This is because I have not yet assessed the errors and reliability of this experiment.

DEC 3

Evaluation

DEC 2

The J curve can be seen in the 0% solution line, but it is not clear in other areas. And this maybe due to errors or inefficiencies during the method and the progress of the experiment.

Since yeast is the only organism we are investigating in, we tried to keep the solution "clean". But it is very hard to prevent the occurrence of other organisms to get into the solution when we are transferring it into the colorimeter. With the presence of other organisms, competition is created and it causes the results to become unreliable.

The adding of vegemite might have also interfered with the results as the amount that is added to each solution is not exact identical. This is because the substance is hard to measure and it is only predicted by the human eye, which involves human errors. The stirring of the mixture also varies solution from solution. Maybe the most concentrated solution is being sucked by the pipette, but that is unable to represent the whole of the solution within the beaker.

The colorimeter was able to lead me in searching for my conclusion, and was able to give me reasonably accurate results; however the process involved in using this tool was easy to go wrong. As it only can calculate the cloudiness of the solution, but not the vitality of the organisms, it actually is unable to tell us if the population is actually growing or has stopped. To increase the speed of the experiment during one reading (preventing enter of other organisms to the solution), my group used more than one of the tubes for the colorimeter for different solutions. With our naked eye, we are unable to see or evaluate if they are "clean", and nothing is on the tube to influence our readings.

In order to improve this experiment, not only should we take more readings, we should have more secure beakers or containers to keep our solutions away from other organisms. Maybe a protected lid for each solution or a smaller opening to reduce the chance of other organisms entering. By doing so, I think the accuracy of the experiment would increase already. With the statistics I have now, and the considerations of the errors that may have changed my results, I don't think it is strong enough to prove or disprove my prediction. But I am confident, that the level of sucrose does have an effect on the population of dried yeast.

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