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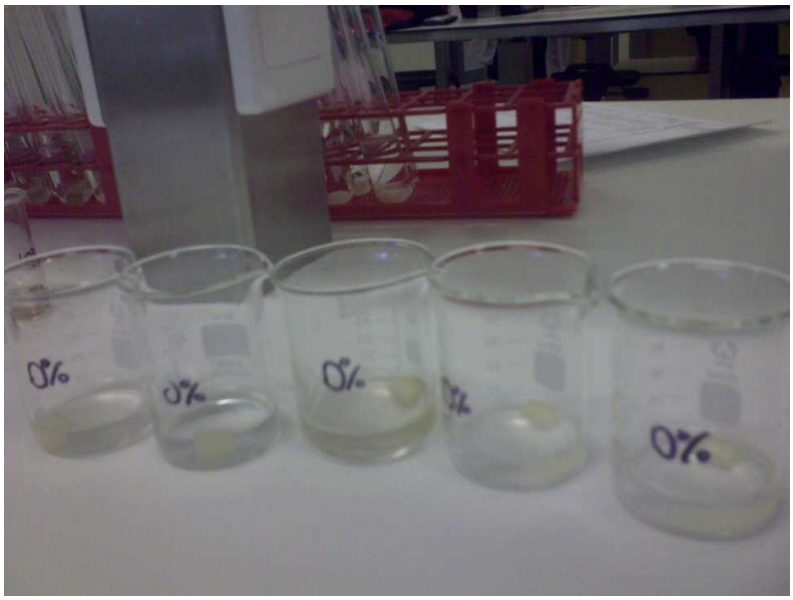
Investigation of the affect of salinity on Osmosis within Solanum tuberosum

Year 10 Biology



Kayla Jackson
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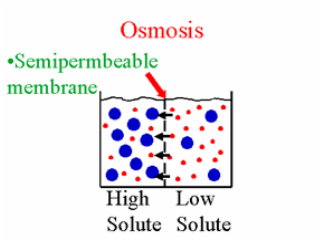
1. Design

1.1 ***Focus Question:*** What is the effect of different concentrations of salt solutions surrounding potato cells, *Solanum tuberosum* have on the osmosis of such cells.

Hypothesis: If a 1 cm cube of *Solanum tuberosum* is covered with a high 40% concentration of sodium solution then the mass of *Solanum tuberosum* will decrease due to osmosis. However, when covered with distilled water the mass will increase as the *Solanum tuberosum* absorbs the water.

Background:

Osmosis is the diffusion of water across a selectively permeable membrane (Bell et al 2004). More specifically, Osmosis involves the movement of water molecules from an area of high concentration of solution to an area of low concentration. As cell membranes allow water to pass through, any high concentration of solute relative to the cell can have a dramatic affect on the diffusion of water from the cell. When a cell is placed in a hypertonic solution, containing a high concentration of any substance, the water easily diffuses out of the cell into the solute, in this case saline solution causing the cell to shrivel. (Biology Online, 2009) By placing the *Solanum tuberosum* in the 40% concentrated salt solution it is possible to predict that the water in the potato will diffuse into the solution, causing the cube of potato to decrease in weight. The opposite occurs when a cell is placed in a hypotonic solution of lower concentration, and the cell will absorb the water to the extent that it could possibly explode.



However when the cube of *Solanum tuberosum* is placed in an isotonic solution, a solution with the same concentration of solute as the cell, water diffuses in and out of the cell as a constant weight resulting in no change of the cells mass. Considering the low amount of sodium found in raw potatoes it is possible to predict that when surrounded by the high concentrations of sodium water that the potato cube will shrivel and decrease in mass. Taking in to consideration the almost equal concentrations of sodium within distilled water and that of the potato it is also plausible that the water will prove an isotonic solution and the potato will not change in weight.

Investigation Variables:

TABLE 1: Practical Investigation Variables

TYPE OF VARIABLE	IDENTIFIED VARIABLE
Independent	Percentage of sodium in the solution surrounding the cube of potato.
Dependant	Change of weight of the potato. ± 0.001 grams
Controlled	• Amount of solution surrounding the potato. • Time samples are surrounded by solution • Source of biological materials • Room temperature
Uncontrolled	• Disease that could possible affect potato

1.2 **TABLE 2: Control Treatment of Variables**

VARIABLE	CONTROL TREATMENT
Percentage of sodium	Prepared using a measuring beaker. With 0%, 10%, 20%, 30% and 40% concentration
Change of weight of potato	Measured using electronic scales. ± 0.001 grams

Amount of solution surrounding the potato.	Measured as accurately as possible using a measuring beaker
Time samples are surrounded by solution	All samples left in for the same period of time, 24 hours
Source of biological materials	Obtained from the same source
Disease that could possible affect potato	Obtained from the same source reducing chance of variable occurring
Room temperature	Tested in the same temperature, no change in environment for each sample

Control Experiment: The control for this experiment is the distilled water test. This will be used to judge any changes caused by the higher concentrations of sodium in the solutions surrounding the potato samples.

1.3 ***Experimental Method:***

Materials:

Apparatus Required	**Quantity**
25 ml Test Tubes	25
Large potatoes	2
Apple corer	1
Cutting knife	1
50 ml of distilled water	1
50 ml of 10% sodium solution	1
50 ml of 20% sodium solution	1
50 ml of 30% sodium solution	1
50 ml of 40% sodium solution	1
10 ml Measuring cylinder	1
Electronic balance ± 0.01 g	1
Ruler (300 mm) ± 1 mm	1
Cutting board	1
Test tube rack	1
Paper towel	5

Practical Safety and Risk Assessment

Refer to Appendix A - QAHS STUDENT ACTVITY RISK ASSESSMENT and PRAC ORDER FORM

Method:

1. First gather all equipment and place gently on surface.
2. Then using the apple corer, remove amounts of potato and using the knife, slice so that the potato pieces are 1 cm long.
3. Once 25 pieces of potato have been cut, measure and record the mass of the samples using the electronic balance.
4. Next pour 10 mls of distilled water into five of the test tubes and add one cube of potato to each test tube.
5. Then repeat this step using the different concentrations of solution. Starting with 10% concentration until five of each of the test tubes are filled with a different concentration.
6. Leave the samples for 24 hours.
7. Remove each sample from its test tube and record the change in weight.
8. Lastly, pack up and remove all equipment.

Diagram 1: Experimental set up

2. Data collection and processing

Qualitative Data: Setting up- Some potato pieces where brownish in colour and so were not used in the experiment and replaced with fresher potato pieces.

After testing- The 10% concentration samples seemed to have blackened and the sodium solutionhad taken on a darker colour.(Appendix C) In all the samples salt crystals had started to form along the rim of the test tubes and the potato samples had shrunk in size.

Quantitative Data: Table 1: Initial Weight ± 0.001 grams

Test sample	0%- Distilled water	10% concentration	20% concentration	30% concentration	40% concentration
1	0.876	0.762	0.841	0.921	0.894
2	0.845	0.784	0.932	0.893	0.906
3	0.821	0.865	0.873	0.882	0.832
4	0.881	0.761	0.842	0.915	0.943
5	0.798	0.904	0.912	0.872	0.971

Table 2: Final Weight ± 0.001 grams

Test sample	0%- Distilled water	10% concentration	20% concentration	30% concentration	40% concentration
1	0.656	0.436	0.528	0.553	0.516
2	0.630	0.402	0.517	0.530	0.508
3	0.650	0.530	0.535	0.494	0.465
4	0.696	0.450	0.508	0.417	0.491
5	0.600	0.615	0.517	0.530	0.527

Processing Raw Data:

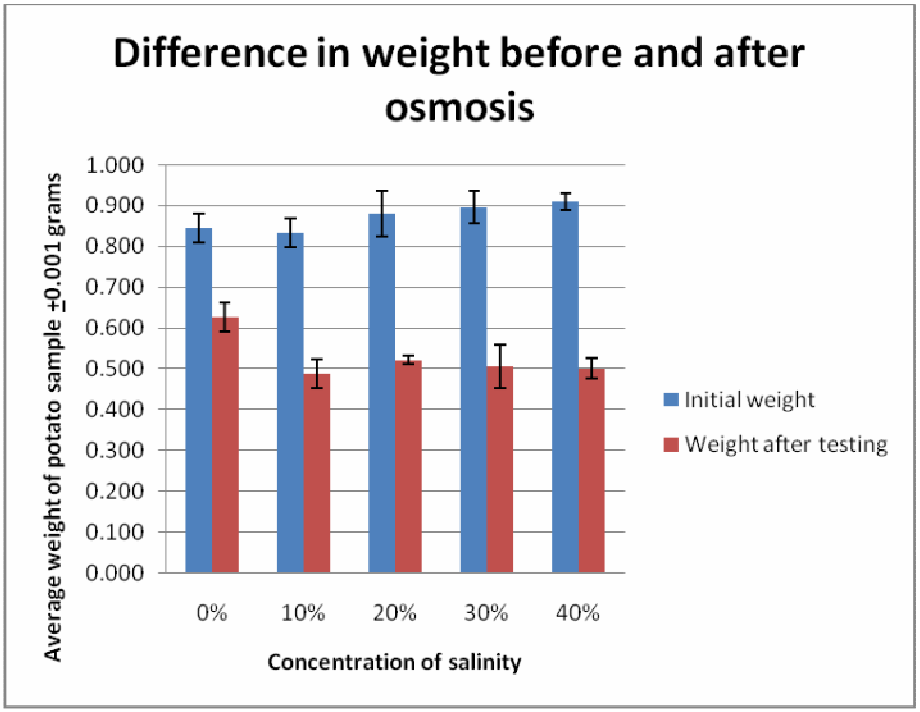
Statistical Analysis	Formulae	Sample Calculation
Mean	$\overline{X} = \frac{\sum X}{n}$	$\overline{X}$ $\frac{2.2+3.1+3.8+3.2+4.1}{5}$ = 3.1
Standard Deviation	$s = \sqrt{\frac{\sum (x - \overline{x})^2}{N-1}}$	S= $\sqrt{\frac{(2.2+3.1+3.8+3.2+4.1)-(3.1)}{5-1}}$

Presenting Processed Data:

Table 3: Average Weight before and after osmosis ± 0.001 grams

Test sample	0%- Distilled water	10% concentration	20% concentration	30% concentration	40% concentration
Initial Weight	0.844	0.833	0.880	0.897	0.909
Final Weight	0.626	0.487	0.521	0.505	0.501
Difference in weight	0.218	0.346	0.359	0.392	0.408

Graph 1: Average Weight before and after osmosis ± 0.001 grams



This graph demonstrates the relationship between the weight of the potato samples before and after the experiment took place and osmosis occurred. It displays the large decrease in weight in the salt concentrations after osmosis and shows that higher concentration the larger the difference between initial weight and final weight after osmosis. From the graph it is possible to determine that the higher concentration the greater amount of water will diffuse via the permeable membrane into the solution.

3. Conclusion and Evaluation

Statement: The aim of this experiment was to ascertain the effect different concentrations of salt solutions have on *Solanum tuberosum* samples and whether or not the higher the concentration (the highest in this experiment being 40%) the more water would diffuse via the process of osmosis into the solution causing the potato sample to lose weight. The data and graphs from this experiment show that the higher in concentration the larger the loss in weight over 24 hours. This supports the predicted hypothesis however the second claim that distilled water would have the same weight was proven to be incorrect.

Explanation: The original hypothesis was supported in this experiment as the results were reflective of those expected. However the initial belief that distilled water would not undergo a loss in weight as the distilled water was predicted to be an isotonic solution. This suggests that the knowledge of the relationship between the salinity of the *Solanum tuberosum* and distilled water was under researched and more researched needed to be conducted regarding the salinity of the actually potato in order to determine what liquid would be completely isotonic. From the large decrease in weight of the *Solanum tuberosum* as osmosis occurred it is plausible to reach the assumption that the distilled water itself also hypertonic solution in comparison to the potato cells.

However the data from this experiment supports the hypothesis that solutions of high concentrations of salt, i.e. 40% salt solution. Though the average weight of the potato samples fluctuate, Table 3, displaying the actual difference between these weights makes it apparent that as the concentration became stronger the difference in weight increased by a number of grams. In the distilled water sample, the difference between the original and final weight was that of merely 0.218 grams ± 0.001, however when the concentration was increased to 40% the difference in weight was equal to 0.408 grams ±

0.001. This increase in difference is due to the water molecules attempting to balance out the cell by moving through the cells permeable membrane, (Bowen, 2000)

Reliability: This experiment can be considered as reliable due to the large number of test samples used and this reduces the chance of random error affecting the results. However as this experiment involved a large amount of measuring using equipment, it is highly plausible that systematic error could have resulted in the weight recorded being inaccurate or an unsuitable amount of solution being used. This could cause the concentrations to be incorrect or some the data as being regarded irrelevant.

When measuring the pieces of *Solanum tuberosum* it is possible that the water or mixture contained within the potato leaked out while being measured on the scales and this random error may cause some of the results to be inaccurate thus registering the data as unreliable.

In this report, calculations involving the mean and standard deviation were performed in ordered to produce more useful results to be displayed easily in the form of graphs. This was done through the use of a calculator and therefore can be regarded as quite accurate and reliable. The low standard deviation of some of the results indicates that that this experiment was of high precision and allows the data to be regarded as fairly accurate. However the fairly large standard deviation on the average results of the 30% concentration of salinity suggests that the data was fairly varied and therefore may not be able to be considered reliable enough to support the hypothesis. However considering that all points of data incurred a drastic decrease it weight it is plausible to assume that the data is accurate enough to be used in order to support the suggested hypothesis.

Limitations/Weaknesses: The main possible limitations to this experiment are due to the high likelihood of human error that would have occurred during the experimentation period. One of these could be due to any difficultly measuring liquids and the inaccurate reading on a meniscus, though this could have affected the amount of solution added to the *Solanum tuberosum* it is quite unlikely that this would have a dramatic effect on the end results of this experiment.

A limitation to this experiment may be the sudden change of equipment from test tubes to measuring beakers as the experiment was originally designed to be tested using small test tubes, this could have altered the amount of solution covering the *Solanum tuberosum* however as all samples were tested in the same type of equipment the chances of this altering the outcome of the experiment is rather unlikely.

By testing the experiment in only one location with the same temperature and humidity, the results can only be generalised as to the effect of osmosis on *Solanum tuberosum* in that same location rather than places with other variables such as biotic factors. As the results did include some high standard deviation and the size of the potato pieces was dependant on the experiment conductors accuracy when cutting it is difficult to determine how ecologically valid this experiment it in concern with other situations.

Modifications to the Experiment In order to improve this experiment it is necessary to alter the experiment and test under different conditions in order to be able to generalise the results. It may also be required to repeat this experiment with different solutions and concentrations in order to verify the trend of higher concentration the larger the decrease in weight. This repeat of experiment would allow for a build up on the original hypothesis in order to confirm its reliability. It may be beneficial to determine the actual salinity of the *Solanum tuberosum* itself and from there be able to create a control solution in order to compare the results with that of the different concentrations.

As there was a fairly large standard deviation for some of the initial and final weight of the *Solanum tuberosum* samples it is difficult to confirm the precision of this experiment. Considering this, it may be possible to improve this experiment by taking precautions in order to make the initial potato samples are similar in weight and this would make it easier to compare results and verify the trend.

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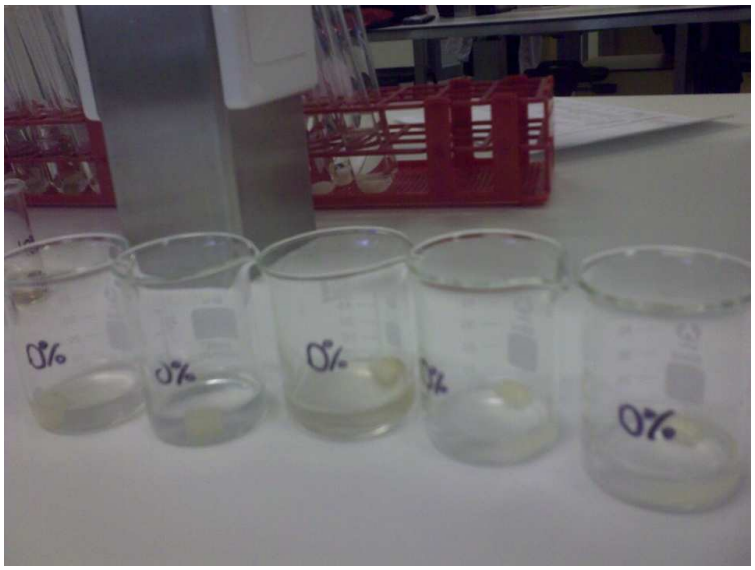
Appendix:

APPENDIX A Risk Assessment and Laboratory Order Form

APPENDIX B Diagram set up



APPENDIX C Salt build up on the rim of measuring beakers