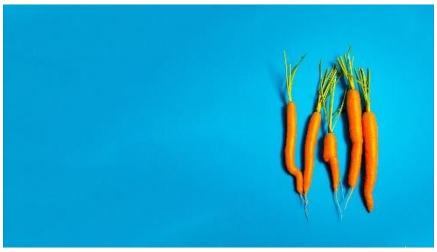
NPL

Measurement At Home

Report on ‘Osmosis’



1. Overview

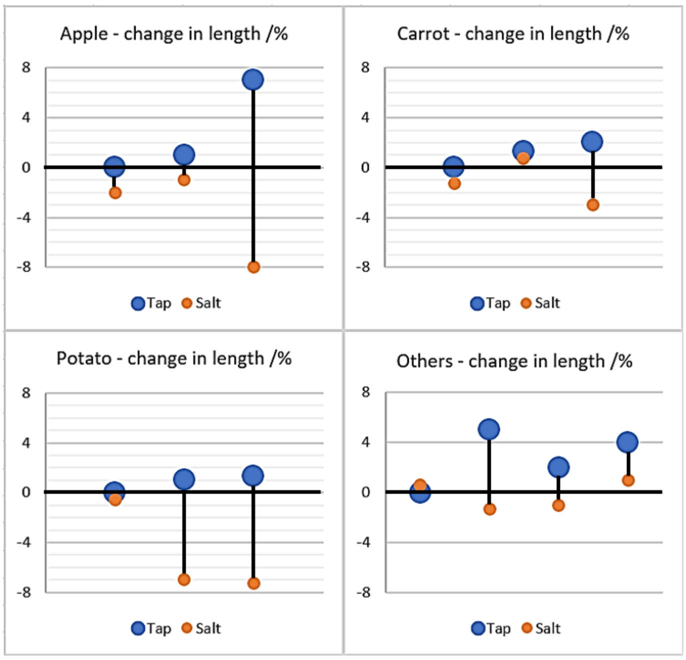
This challenge investigates how water flows into or out of vegetables and fruit samples - through the process osmosis- to affect their size. We wanted to prove osmosis can occur in all cellular living tissue (not just potatoes which schools use to demonstrate it) – hence the carrot picture. **Thank you, Alastair, Elizabeth, Gordon, Oliver and Sas** for sharing results with us in the first couple of weeks. Key findings are that whilst most samples expand in tap water and contract in salt water (at a concentration of 50 ml of salt per litre of tap water), the amount of change differs by sample type, and not all samples of the same type (e.g. apples) change identically.

2. Percentage changes in the length of samples

Apples	Water type	Gordon	Sas	Alastair	
	Tap	0.0	+1.0	+7	
	Salt	-2.0	-1.0	-8	
Carrots	Water type	Gordon	Sas	Elisabeth	
	Tap	0.0	+1.3	+2.0	
	Salt	-1.3	+0.7	-3.0	
Potatoes	Water type	Gordon	Sas	Elisabeth	
	Tap	0	+1.0	+1.3	
	Salt	-0.6	-7.0	-7.3	
Others	Water type	Gordon - Banana	Oliver - Broccoli	Sas - Melon	Sas - Yam
	Tap	0.0	+5.0	+2.0	+4.0
	Salt	+0.6	-1.3	-1.0	+1.0

The table (above), gives % changes in length of different samples when placed in tap or salt water.

The charts (right) display the same data. The first three show apples, carrots and potatoes, while the final one shows results for a variety of samples. The results are in pairs connected by a vertical line – the larger dot represents the % change in size for a sample in tap water, while the smaller dot represents the change in salty water. 0 on the vertical axis means no change in sample size.



3. How did samples change in the two liquids?

Generally (though not always) samples in tap water expanded while those in salt water shrank.

In tap water typical expansion was about 1%. Significant exceptions were melon, yam and broccoli (2%, 4% and 5% respectively), and the apple measured by Alastair which increased by an incredible 7%.

Most samples shrank in salty water (exceptions were banana and yam with 0.6% and 1% increases in length). There was much variation in the amount of shrinking between different vegetables – the greatest changes were for potatoes which (usually) reduced to 7% of their original length. Again, Alastair's apple stood out with an amazing shrinkage of 8% - the greatest change of all.

In most cases potato changed most when immersed in salty or tap water. This (plus its cost and cutting easiness) is why it is so popular for school practicals, rather than carrots or other vegetables.

Alastair's apple? It is a puzzle to know why Alastair's apple behaved so differently to the other two apple samples and stood out as the sample that grew or shrank more than any other. It may be that it was cut up into more pieces than others' so more water entered/left over the greater surface area. Possibly the liquids Alastair used were significantly different from other people's, or maybe he had a particularly unusual apple.

4. What is the science behind osmosis?

Flow of water - through the process **osmosis** - between the vegetable samples and the surrounding liquid causes the sample size changes. The process is illustrated in the video for this resource. A 'semi-permeable membrane surrounding each plant cell allows water molecules to pass through, though not dissolved salt. Water molecules travel both into and out of the cell, though more move (through the process of diffusion – the same process by which smells spread through air in a room) from places of high water concentration to places of lower water concentration than in the opposite direction. Osmotic pressure (OP) is a measure of the tendency of water to move from one solution to another by osmosis.

If the sample has the same OP as the liquid surrounding it, there will be no net water movement either way, and the sample will stay the same size. A variation of this experiment in schools has students adjusting salt concentration to find which gives an OP identical to that of the vegetable.

Tap water has an OP which - because it contains dissolved minerals - is different to that of 'pure' water (properly known as distilled or deionised water). If we did this experiment with distilled water, we would see sample length increases greater than those obtained with tap water.

It can be dangerous to drink distilled water as our bodies are designed to work with water containing minerals. Animal cells (which don't have the strong cell walls plant cells do) can explode if they get too much. For similar reasons, fish tend to live exclusively in fresh <u>or</u> sea water - unusual exceptions include the salmon and flounder.

5. How to get more accurate results

As is always the case, **more results** would help us draw more accurate conclusions.

There were several **uncontrolled variables** when people did this experiment - we did not know if everyone used tap water of the same OP, or how many pieces of vegetable they used (which would have affected the surface area and thus water flow rate). We expected quite a range in results for each vegetable type as water content varies and they dry out with age.

We have not given sample lengths in this report, though we did receive them. Most people used total sample lengths of 15 cm (following our video) though Elisabeth, Oliver and Alastair described samples of total initial length about ten times that (it is possible they mistook mm for cm). Longer initial lengths give better **precision** as if the **resolution** of your ruler is 1 mm, 1 mm in 15 cm is 1/150th whilst for a 150 cm sample, it is 1/1500th.

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