Investigating water relations in two plant tissues

Results:

Table 5
Table to show the sucrose concentration and water potential of each tissue.
The sucrose solution was extrapolated from graph 1, which shows the percentage change of mass of the tissues when immersed in the different sucrose solutions. A line of best fit was drawn, where the line of best fit intercepts the x-axis (concentration of sucrose solution) is the sucrose concentration of the tissue because at this point there is no mass loss of gain (read off of y-axis).
The water potential of each tissue was read off of graph 2. The solute potential is equal to the water potential because the pressure potential = 0.

Tissue	**Sucrose concentration in tissue based on extrapolated data from graph 1 /mol dm^{-3}**	**Solute potential read off of graph 2 /Kpa (equal to water potential /Kpa)**
Potato		
Swede		

Table 6
Table to show the results of the iodine test, Benedict's test and test for non-reducing sugars for potato and swede tissues.

Tissue	**Iodine test for starch**	**Benedict's test for reducing sugars**	**Test for non-reducing sugars**
Potato	Turned black/blue	Turned green	Turned yellow/pale orange
Swede	Grey/black	Turned orange	Turned dark orange

Analysis:

The aim of the experiment was to find out the water potential of swede and potato tissues. Firstly 12 potato strips and 12 swede strips were cut to 7cm long, 0.5cm width and 0.5 cm depth. The strips were weighed (start mass in results tables). Two potato strips were put in each petri dish which each contained a different sucrose solution (0.0, 0.2, 0.4, 0.6, 0.8, 1.0 mol dm^{-3}). This was repeated with the swede strips. So in total 12 petri dishes were used (6 for each tissue). Diagram 1 shows how the investigation was carried out.
The next day the strips were taken out of the solutions, dried and weighed (final mass). The percentage change in mass could now be calculated to find out the water potential.

There are many ways in which molecules can move from one place to another such as diffusion or osmosis.
Osmosis is the net movement of water molecules from a region of higher water potential (lower solute concentration) to a region of lower water potential (higher solute concentration) through a partially permeable membrane.
Solute potential (ψ_s) is the potential of a solution to cause water movement into it across a partially permeable membrane as a result of dissolved solutes. As a solute is dissolved in water it reduces the concentration of water molecules and lowers the water potential. Pure water has $\psi_s = 0$.
Pressure potential (ψ_p) of water increases when its pressure increases and decreases when its pressure decreases. When cells are turgid an inward pressure is exerted by the cell wall as the cell contents expand and press outwards. The pressure is known as the pressure potential.
Water potential (ψ) is the potential for water to move out of a solution by osmosis. Pure water has the highest possible water potential. Pure water has a water potential of zero. All solutions have a lower water potential than pure water because their concentration of water molecules is lower than that of pure water.
A high water potential has a lower solute concentration. Therefore a low water potential has a higher solute concentration.
The formula of water potential is $\psi = \psi_s + \psi_p$

Plant cells can be placed in sucrose solutions with a higher or lower water potential than the water potential of the cell.

When plant cells are placed in a solution that has a lower water potential than the cell (hypertonic solution), the cells mass will decrease. As the water potential of the sucrose solution has a lower water potential, then the water potential inside the cell has a higher water potential and a lower sucrose concentration. Water will travel through the partially permeable membrane of the cell by osmosis and the net movement of water will be out of the cell. The plant cell will become flaccid and the protoplast will shrink away from the cell wall, the cell's mass will decrease. A fully plasmolysed cell is where the protoplast completely shrinks away from the cell wall.

In my investigation shows that potato cells became plasmolysed when the concentration of the sucrose solution was higher than 0.0 mol dm^{-3} and that swede cells became plasmolysed when the sucrose concentration was higher than 0.4 mol dm^{-3}.

When plant cells are placed in a solution that has a higher water potential than the cell (hypotonic solution), the cell's mass will increase. As the water potential of the sucrose solution has a higher water potential, then the water potential inside the cell is lower and has a higher sucrose concentration. Water will travel though the partially permeable membrane of the cell by osmosis and the net movement of water will be into the cell. Therefore, the plant cell will become turgid as it is inflated with water and it's mass will increase. When a plant cell is turgid, the protoplast exerts a pressure on the cell wall, the formula for water potential when a cell is turgid is $\psi = \psi s + \psi p$
The potato cells in my investigation became turgid when the concentration of the sucrose solution was less than 0.2 mol dm^{-3} and the swede cells became turgid when immersed in a sucrose solution with a lower concentration than 0.6 mol dm^{-3}.

Incipient plasmolysis is the point at which the protoplast stops exerting pressure against the cell wall so the cell is flaccid.
There will be no mass gain or loss when incipient plasmolysis occurs in a cell. There is no net movement of water in or out of the cell because there is equilibrium and osmosis is a passive process. Incipient plasmolysis occurs when the water potential of the sucrose solution outside the cell is equal to the water potential inside the cell so if the water potentials of the sucrose solutions are known then the water potential of the cell can be worked out.
I was unable to find the exact water potential for swede and potato cells because none of the sucrose solutions that the strips of plant tissues were placed in had exactly the same water potential as the cells. However, the water potential can be found by extrapolation from graph 1. The point where the line of best fit crosses the x-axis of graph 1 is roughly the concentration of the sucrose solution within the cell.
I have interpreted the concentrations of the sucrose solutions within the two types of plant cells and then using graph 2 have worked out what the water potentials are within the two types of plant cells. This data is shown in table 3 although I cannot be sure these figures are precise.

Conclusion
The results despite inaccuracies and possible anomalous results are accurate and reliable enough to provide evidence that swede has a higher water potential than potato.

There is also sufficient evidence that the water potentials are between 0.0 and 0.2 for potato and 0.4 and 0.6 for swede. However, this isn't very reliable because the precise sucrose solution where there was no mass gain or loss was not found it was just assumed by extrapolation.

The food tests are accurate enough for this experiment to show that potato has more starch than swede as the test was blue/black. Containing more starch would have no effect on the water potential because starch is insoluble in water.

The food tests show that swede contains more reducing sugars than potato because for the benedicts test potato turned green and swede turned orange. The more orange/brick red a tissue turns when the benedicts test is performed, the more reducing sugars it contains.
The test for non-reducing sugars shows that swede contains more non-reducing sugars than potato because swede turned a darker orange than the potato.
Therefore, swede contains more reducing and non-reducing sugars than potato. More sugar in cell sap means a lower water concentration and therefore the concentration of sucrose solution outside the cell would have to be much higher than that of the potato to turn the swede cells turgid. Sugar is soluble in water so it would have an effect on the water potential.

The food tests can be used to back up my results

this supports my conclusion?

Evaluation:
The results seem to be fairly accurate and reliable. The potato and swede results form distinct trends. I have realised that there were a number of areas of inaccuracy in the method, I have written about these in order of severity. The major errors are more likely to make the results less accurate than the minor errors but both could make the results less reliable.

The removal of excess solution (wiping) was one of the major errors, it could lead to more or less solution removed from each strip so the mass change could …
A way to improve this part of the method would be to wipe gently and consistently so the same amount of liquid is removed from each strip.

The strips were not cut precisely or in the same way this could lead to different surface areas, a larger surface area would mean that osmosis occurs faster. However, the strips were left overnight so each strip reached an equilibrium and a percentage change eliminated original mass differences.
A way to improve this could be to use a cork borer which would cut all the strips the same width and depth and the length would just need to be cut with a knife. This would ensure the masses were almost exactly the same for each type of tissue and the surface areas would be similar too. Also, continue to use a percentage change for mass differences as it is more accurate.

The strips of plant were cut from different areas in the plant e.g. the outside and the centre, it was not taken into consideration that there would be different cell types in the tissues. This could mean that not all the strips of one type of tissue would start off with the same water potential.

This could be improved by using only fresh vegetables and taking the samples from the centre of the plant.

Another major problem was that only 5 sugar solutions were tested so there were only 5 data points for each tissue type on the graph so a line of best fit may not be very accurate. It is only possible to say that the water potential of a cell is between two values unless there was no mass gain or loss of the cell.
An improvement would be to use more sucrose solutions, this would mean a more accurate line of best fit could be found or the exact solution may be found.

The temperature in the room may have varied because this was not controlled. This could lead to evaporation. The water potential would be lower if evaporation of occurred. The temperature varying could lead to osmosis occuring faster or slower although because the strips were left over night an equilibrium for each strip was reached.
A way to avoid evaporation and temperature changes would be to seal the petri dishes and put them in a water bath.