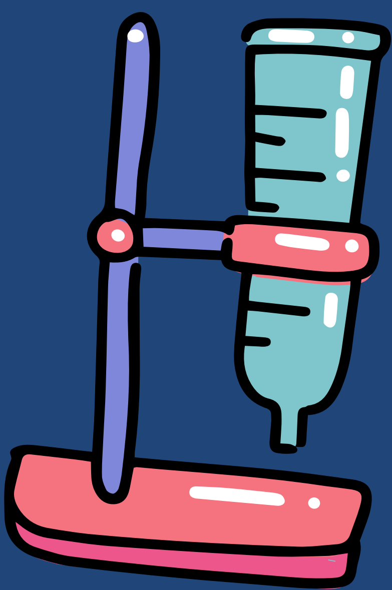
MICROSCALE TITRATION

Comparing the nutritional content of fruit using a simple titration

For CfE Third Level Science benchmark SCN3-13a, learners should explore the structure and function of organ systems, including the digestive system. As part of wider discussions of health and wellbeing and a balanced diet, it would be appropriate to consider the role of vitamins and minerals. This experiment introduces BGE learners to a simple titration that aims to establish the relative vitamin C content of citrus fruits.

In this experiment, vitamin C (or ascorbic acid) is oxidised to produce dehydroascorbic acid when iodine is titrated into the solution. As this happens, iodine is reduced to iodide ions. This continues until all the ascorbic acid has been oxidised.

$$\text{ascorbic acid} + I_2 \rightarrow 2I^- + \text{dehydroascorbic acid}$$



- After this point, the iodine reacts with a starch indicator and a blue-black complex is formed.

The more vitamin C present in the solution, the more iodine it takes to reach the "end-point" of the titration.

HEALTH & SAFETY

When starting an experiment with a class, you must ensure you are comfortable and familiar with the risk assessment. What are the hazards, the level of risk and control measures that must be put in place? Is the current risk assessment appropriate for your learners? Do you need to make adjustments? This page on the SSERC website provides a Risk Assessment template and information about Dynamic Risk Assessments.

HAZARD	RISK	CONTROL MEASURES
0.005 mol/L Iodine solution SSERC Chemical Database	At this concentration, iodine poses no health risk. However, iodine can stain skin, clothing and surfaces. Care should be taken to avoid spills.	No control measures required.

MATERIALS

This experiment investigates the relative vitamin C content of citrus fruits. using a simple, microscale titration. The protocol can be adapted to include a range of vegetables or fruit juices. A further layer of complexity could be included by performing a "standard" titration of vitamin C solutions of known concentration. This could then be used to estimate the vitamin C concentration of each juice sample.

AIM

To compare the vitamin C content of citrus fruits.

INDEPENDENT VARIABLE

Type of fruit juice.

DEPENDENT VARIABLE

Relative vitamin C content, determined by the number of drops of iodine required to reach the end-point of the titration.

SAMPLE SIZE

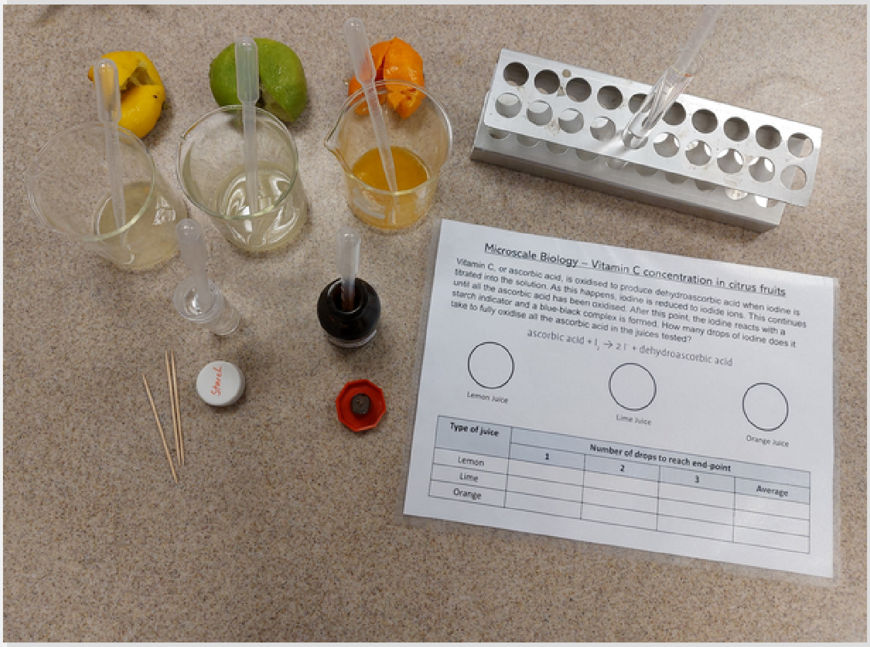
The titration should be repeated three times. Alternatively, it can be repeated until "concordant" results are achieved.

INDICATOR REQUIRED

0.5% starch solution

MATERIALS REQUIRED (PER PAIR)

- 0.005 mol/L iodine solution
- 0.5% starch solution
- Selection of fruit (e.g. lime, lemon, orange)
- knife
- 3x beakers
- muslin
- filter funnel
- 5x 3ml plastic pipettes
- 3x cocktail sticks
- activity board

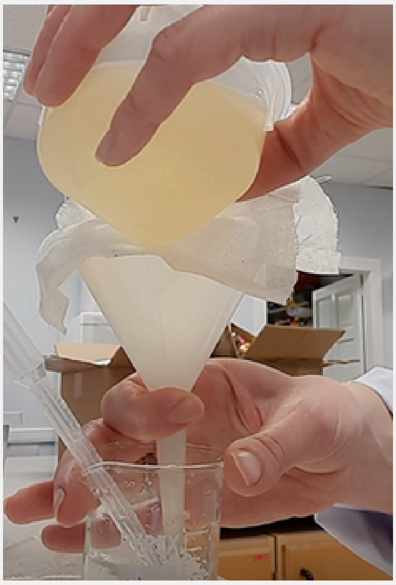


METHOD

STEP 1

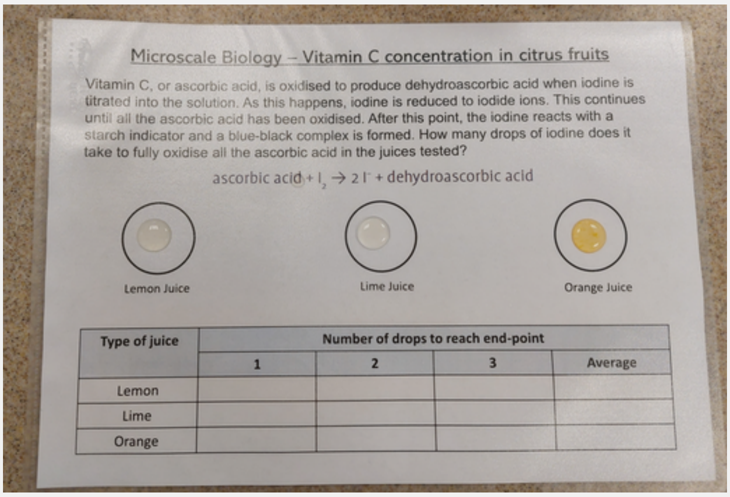
Cut the fruit in half and squeeze the juice into a beaker. Pass through muslin, sitting within a filter funnel, to remove any pulp.

Repeat this process for each of the fruits. It is best to use fruits that have a light colour juice – this makes it easier to identify the end-point in the titration.



STEP 2

Use the reaction table below to add each reagent to the activity board. Do this in the order listed in the table. Volumes are in "drops".



Microscale Biology – Vitamin C concentration in citrus fruits

Vitamin C, or ascorbic acid, is oxidised to produce dehydroascorbic acid when iodine is titrated into the solution. As this happens, iodine is reduced to iodide ions. This continues until all the ascorbic acid has been oxidised. After this point, the iodine reacts with a starch indicator and a blue-black complex is formed. How many drops of iodine does it take to fully oxidise all the ascorbic acid in the juices tested?

ascorbic acid + $I_2 \rightarrow 2I^-$ + dehydroascorbic acid

Lemon Juice

Lime Juice

Orange Juice

Type of juice	Number of drops to reach end-point			
	1	2	3	Average
Lemon				
Lime				
Orange				

Reagent	Number of drops added to reaction circle
Juice	9
Starch indicator	1

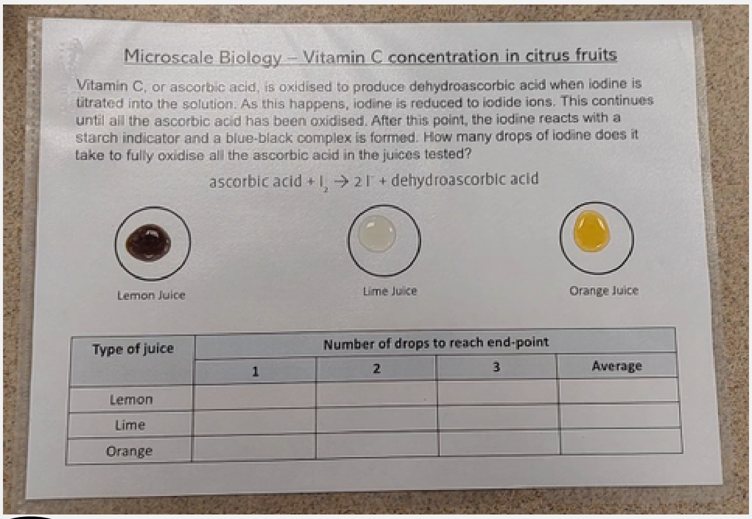
STEP 3

Starting with the first juice in the left-hand circle, add iodine drop-wise to the reactants. After each drop, mix with a clean cocktail stick. If the blue-black complex disappears, continue adding iodine. When the blue-black complex remains after mixing, record the total number of drops of iodine that were added.

STEP 4

Repeat Step 3 with the remaining juices, using a fresh cocktail stick each time.

Repeat each titration a further two times. Alternatively, your teacher might wish for you to repeat this until you achieve "concordant results".



Type of juice	Number of drops of iodine required to reach end-point			
	1	2	3	Average
Lemon				
Lime				
Orange				

STEP 5

Clean the activity board with water. Form a conclusion in response to the aim and evaluate the method.

Which citrus fruit contains the most vitamin C?

What was the purpose of the starch solution that was combined with the fruit juice?

Alternative ideas:

- Test the effect of cooking processes on the vitamin C content
- Compare the vitamin C content of fresh fruit juices with packaged fruit juices.

- **To prepare 1L iodine solution (0.005 mol/L):** Combine 2 g of potassium iodide and 1.3 g of iodine in a small beaker. Dissolve in a few drops of distilled water. Transfer contents to a 1L volumetric flask, washing down to rinse all traces of the solution. Make up to 1L with distilled water.
- **To prepare 50cm^3 starch indicator (0.5%):** In a beaker, add 0.25g soluble starch to a small volume of distilled water. Stir to form a paste. Add distilled water to a final volume of 50cm^3 and mix over heat until dissolved. Cool before use.
- **To prepare standard ascorbic acid solutions**: Use a vitamin C tablet (1000mg/ml) dissolved in 200cm^3 water. This gives a stock solution of 5 mg/ml. Use this stock to produce your series of working solutions.
- **Sources of vitamin C:** This protocol has used lime, lemon and pineapple juice squeezed from fresh fruit and then passed through muslin. As noted above, packaged fruit juice could also be compared. Vegetables could be blended with water and used in this protocol. However, the colour of the resulting “juice” should be considered – lighter coloured juices are easier when detecting the endpoint blue-black colour.