The hunt for vitamin C; the effect of cooking processes on the vitamin C content of cabbage

Time

2 h.

Curriculum links

Mole calculations. Vitamins, enzymes.

Group size

2 – 4.

Materials and equipment

Materials per group

- 100 g green cabbage
- 1 dm^3 of a solution containing 5% phosphoric acid (H_3PO_4)
- 100 cm^3 of aqueous 2, 6-dichlorophenolindophenol (dcpip) (0.4 g dm^{-3})
- 75 cm^3 of ascorbic acid (0.20 g dm^{-3}) in 5% phosphoric acid solution
- Deionised water, boiled to remove dissolved oxygen which could otherwise interfere with the results of the vitamin C determination.

Equipment per group

- filter funnel
- muslin or glass wool for filtration
- 25 cm^3 pipette with safety filler
- 50 cm^3 burette
- 250 cm^3 conical flask
- 500 cm^3 measuring cylinder
- 250 cm^3 beaker
- Bunsen burner, tripod and gauze
- liquidiser, blender (or large pestle and mortar)
- safety glasses.

Although not essential, during trialling, some institutions used a fume cupboard to reduce the smell of over-cooked cabbage!

Safety

All solutions are of low hazard. Though eye protection is advisable when heating any liquid.

Risk assessment

It is the responsibility of the teacher to carry out a suitable risk assessment.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [*http://science.cleapss.org.uk/*] in England, Wales and Northern Ireland and, in Scotland, SSERC [*https://www.sserc.org.uk/*].

Commentary

If cabbage is not cooked carefully the ascorbic acid (vitamin C) is broken down by the enzyme ascorbic acid oxidase. The secret of preparing nutritious cabbage is to plunge it rapidly into boiling water which inactivates this enzyme. Nevertheless, more than 50% of the vitamin C will be leached out into the water and therefore lost unless the liquid is used as an ingredient in another item on the menu.

This problem is based on an experiment described in *Nuffield advanced science chemistry.*[1] To determine the vitamin C content in uncooked cabbage, it is essential to have an efficient blender which grinds the raw material into a fine slurry.

Otherwise it will be impossible to extract all of the ascorbic acid. Once the cabbage has been softened by cooking the blending process is quite easy. Unless a very efficient blender is available it is suggested that the first sample of cabbage is cooked by the 'nutritionally sound' method described below. The vitamin C content of the solid and the liquid can then be determined separately. It should be found that the sum of the quantities determined agrees with the value for raw cabbage quoted in the standard reference books on food and nutrition *ie* green cabbage[2] contains about 50 mg per 100 g.

A second sample can be cooked 'badly' by putting it into cold water and slowly bringing it up to the boil. It could be cooked for too long and left to stand. The vitamin C content in this sample will be lower.

Details of a recommended procedure for carrying out the analysis are given below, but during trialling more experienced students found a shorter version of these instructions sufficient. The challenge in this problem lies in devising a satisfactory sampling technique and controlling the cooking time, temperature and method. It is therefore recommended that more able groups of students are left to work out their own method of sampling while others are given the full instructions.

A method of calculating the results is suggested below.

Procedure

Preparation of 2,6-dichlorophenolindophenol solution

2,6-dichlorophenolindophenol (dcpip) is a dye which is blue when dissolved in water, is red in acid conditions, and is reduced to a colourless compound by ascorbic acid. Dissolve 0.4 g of dcpip in 200 cm^3 of hot deionised water, filter the solution, and make the volume up to 1 dm^3. The dye does not keep well and should be stored in a cool dark place.

Standardisation of the 2,6-dichlorophenolindophenol solution

The solution should be standardised because it is not possible to make it up accurately.

By using a pipette, with safety filler, transfer 25.0 cm^3 of standard ascorbic acid solution (0.20 g dm^{-3} vitamin C) to a conical flask and titrate rapidly with the dye solution from a burette. As the dye is run in the deep blue colour of the dye is discharged to give a colourless solution. The end point is taken to be when the pink colouration, due to the dye, persists for 10 s. A blank titration using 25.0 cm^3 of 5% phosphoric acid solution must be carried out to the same end point.

$$F = \frac{\text{volume of standard vitamin C solution} \times \text{concentration of vitamin C/mg dm}^{-3}}{(\text{standardisation titre} - \text{blank titre}) \times 1000}$$

These quantities are then used to calculate the dye factor (F)

F = mg of vitamin C equivalent to 1 cm^3 of dye solution

Estimation of vitamin C in a sample of cabbage

Cut up the cabbage as if preparing it for a meal. Weigh out 50 g to an accuracy of ±0.5 g. Put the cabbage into 100 cm^3 of briskly boiling deionised water and simmer the cabbage for 10 minutes. Some of the liquid will have evaporated. Pour off the hot water and measure its volume (V_c).

At this point one person should measure out 250 cm^3 of 5% phosphoric acid and add this to the cooking water then transfer 25 cm^3 of this solution to a conical flask, using a pipette, and titrate it with the dye.

Meanwhile someone else should quickly liquidise the cooked cabbage. They should then remove it from the liquidizer and add 250 cm^3 of 5 % phosphoric acid solution and the mixture stirred. It should then be weighed (mass M_c).

About $^1/_{12}$ of the mixture should be removed and weighed (mass m_c). This fraction should be filtered through the muslin or glass wool and the filtrate and washings should be made up to about 25 cm^3 (the exact volume at this stage is not necessary for the calculation).

Calculation

(i) Liquidised cabbage

Mass treated	= 50 g
Mass sampled for titration	$= \frac{m_c}{M_c} \times 50$ g
Volume of dye titre	= V cm^3
Dye factor	= F mg cm^{-3}
50 g of sample contains	$V \times F \times \frac{M_c}{m_c}$ mg vitamin C
100 g of sample contains	$V \times F \times \frac{M_c}{m_c} \times 2$ mg vitamin C

(ii) Cabbage water

Original quantity of cabbage	= 50 g
Proportion sampled for titration	$= \frac{25}{V_c + 250}$
Volume of dye titre	= V cm^3
Dye factor	= F mg cm^{-3}
50 g of sample contains	$V \times F \times \frac{V_c + 250}{25}$ mg vitamin C

100 g of sample contains $$\frac{V \times F \times V_c + 250 \times 2}{25} \text{ mg vitamin C}$$

Extension

Experiments could be carried out to find the effect of other cooking methods on the vitamin C content of cabbage – *eg* samples could be stir-fried, microwaved, or steamed.

The techniques described above could also be used to find out how freezing affects the nutritional value of cabbage. Freezing slows down deterioration because of the inactivation of the enzymes. However, if the blanching process is carried out correctly, before freezing, the enzymes should be destroyed.

References

1. *Nuffield advanced science chemistry: food science, A special study*. London: Longmans, 1970.
2. B. Holland *et al*, McCance and Widdowson's *The composition of foods*, 5th edn. London: RSC, 1992.

Credits

Health & safety checked May 2018

Page last updated October 2018