Oranges and lemons

You are provided with one orange and one lemon.

- Your task

Find out which of the two contains the greater total amount of acid. You have laboratory glassware and equipment available, but no chemicals other than those which you are able to extract from the plant material provided. You are also provided with the ash from a charcoal barbecue or garden bonfire, which is rich in potassium carbonate.

- **HINT:** It is unwise to use all of your sample.

Based on a suggestion by P. Borrows.

Time

100 minutes. Needs time before practical session to plan.

Group size

2–3.

Equipment & materials

Eye protection.

General
Beakers, burettes, pipettes (& safety fillers), graduated volumetric flasks, conical flasks, measuring cylinders, glass droppers, plastic syringes. Spatulas, glass stirring rods, watch glasses, test tubes, filter funnels and papers. Glass juicers, fine-mesh sieves, knives, white tiles to cut fruit on. Bunsen burners, tripods, gauzes, heatproof mats, clampstands. A centrifuge and balances should be available.

THE 'ASHING' PROCESS: (ash prepared before lesson by technician).

A large quantity of leaves, seaweed or other plant material can be 'ashed' to provide an alkali (largely sodium carbonate from sea plants, and potassium carbonate from land plants). [Some investigation may be needed to determine suitable plants & suitable quantities. See Annales de Chimie, xix, 157 and 194.]

Apparatus needed for 'Ashing'

Container for ashing, a large bulk of plant material (*eg* catering size coffee tin), Bunsen burner, tripod and heatproof mat. Access to a fume cupboard needed as ashing produces a lot of smoke and is smelly. 'Ashing process' likely to be very time-consuming!

NB Alternative ashes!

Ash from charcoal barbecue or garden bonfire/cigarette ash/'synthetic ash' = potassium carbonate.

Per group
Pestles and mortars – as big as possible (1 for each group).

Plant material
Unpickled beetroot or red cabbage leaves as indicator. 1 orange and 1 lemon of approximately equal size. 25 g of 'ash'(see ashing process or list of alternative ashes).

Solvent.

Hot water.

Health & Safety notes

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/*].

Ashing must be done in the fume-cupboard.

Eye protection should be worn during the 'ashing' process or when using boiling water to make the indicator, but the rest of the activity is low risk.

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

Curriculum links

Acids and alkalis, indicators, neutralisation.

Possible approaches

Note that graduated apparatus not needed to answer problem as stated (burettes and volumetric flasks are great distractors). Approaches already noted:-

1 The ash is dissolved in water to make an alkaline solution, this is then filtered. The oranges & lemons are sliced up and all the juice squeezed out of them; the juice and chopped pieces are boiled in water and then filtered. The red cabbage leaves are boiled in water (the dye goes into solution), the red cabbage solution is filtered. A titration is then performed with both the acids from the lemon and the acids from the orange. The cabbage dye is used as an indicator (end point: red to green). The alkaline solution from the ash is placed in the burette.

Quantitative result
Typically lemons contain approximately 3.5 times more 'acid' than oranges. This result can be linked with taste.

2 Alternatively, an acid and a carbonate react to give off CO_2. This emission of CO_2 will result in a weight loss. By calculating this weight loss the relative amount of CO_2 given off can be calculated. As more acid will react to give off more CO_2, the quantity of CO_2 emitted can be used to determine which contains more acid.

Evaluation of solution

Credit could be given for:

Appropriate technique for preparing alkali solution;

preparing indicator;

extracting juice from fruit;

suitably diluting & titrating;

comments, explanation, presentation, accuracy.

Extension work

- Does acidity depend on variety of fruit, age, ripeness?
- Is peel different from flesh? Titrate separately.
- Experiment could also be allied to some work on wine-making (the wine producer needing to know the acidity of the grape).

Credits

Health & safety checked May 2018

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