

Current Biofuels

Activity 1E - Extracting sugar from sugar beet

Learning outcomes: By the end of the session students should be able to:

- Describe the process of extracting sugar from sugar beet.
- Calculate the yield of sugar from sugar beet.
- Suggest ways of improving the process for more efficient extraction of sugar and commercialisation.

Background

Sugar (in the form of sucrose) is the main feedstock used to produce bioethanol in Brazil. In countries that produce sufficient quantities of sugar cane it is an economically viable alternative to biodiesel production. In colder climates the majority of this sugar is obtained from sugar beet. This activity involves the extraction of sugar from sugar beet. The sugar is extracted from the beet by heating in water and then evaporating off the excess water. It is best to conduct this activity in the autumn term when the supply of sugar beet is most plentiful.

Age range: This activity is suitable for GCSE and A-level students.

Duration: 10-20 minutes.

Suggested prior knowledge: It is recommended that you elicit the existing student knowledge of properties of compounds, methods of separation, states of matter and a basic understanding of the anatomy of plants.

What you will need

- Sugar beet
- Peelers
- Knives
- Chopping board
- Beakers
- Bunsen burner
- Heatproof mat
- Tripod
- Gauze
- Evaporating basin
- Balance
- Water
- Timer
- Eye protection

Health and Safety

Eye protection must be worn.

CLEAPSS® laboratory handbook – section 15.5 Plants and seeds (choosing suitable plant material, growing and cultivating plants, sources and suppliers of plants)

CLEAPSS® Hazcards 40C (Carbohydrates)

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Method

1. The sugar beet should be cleaned and peeled.
2. The sugar beet should be sliced into strips about half a centimetre wide and weighed.
3. The strips of sugar beet should be added to a glass beaker along with enough water to cover it. Note: fill the beaker to the half way mark to avoid boiling over.
4. Set up a Bunsen burner with heatproof mat, tripod and gauze.
5. Heat the beaker of sugar beet and water with the Bunsen burner until almost boiling and simmer for 15 minutes with occasional stirring.
6. Weigh an evaporating basin on a balance that is accurate to at least two decimal points before adding any of the beet extract and make a note of the weight.
7. Carefully add enough of the liquid from the beaker to half fill the evaporating basin. Note: use heatproof gloves and take care to avoid splashes, as the liquid will be hot.
8. Heat the evaporating basin gently over the Bunsen burner to evaporate the water.
9. Leave the solution to cool then check for crystals.
10. Add more beet extract solution to the evaporating basin and repeat steps 7-9.
11. Once you have evaporated all the water from the beet extract weigh the evaporating basin containing the sugar crystals.

You can then calculate the actual yield of sugar produced using the equation below.

$$\text{Yield} = \text{weight of sugar extracted} / \text{weight of sugar beet}$$

Mass of sugar beet	g
Mass of evaporating basin	g
Mass of evaporating basin and sugar crystals	g
Actual yield of sugar	%

Make a flow chart of your extraction procedure. Use words and diagrams to show each step.

Extension activities

Test the extract for the presence of sugars, see [activity 1F](#) Carbohydrate testing.

Calculate the relative concentrations of sucrose and glucose extracted from the sugar beet. A refractometer can be used to measure sugar content and glucose test strips or blood glucose monitors used to measure the glucose solutions.

Discuss the requirements of sugar beet plants and how farmers increase yields while coping with drought, pests, disease and climate change.

The sugar together with oil from [activity 1B](#), biodiesel from [activity 1D](#), and ethanol from [activity 1G](#) can be collected and tested for their combustion energy – see Gatsby SEP: Biofuels activity A7 'How much energy is

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released when a fuel burns?’ or ‘Energy values of food’ from Practical Chemistry www.practicalchemistry.org/experiments/energy-values-of-food.225.EX.html . These activities should be carried out in a fume cupboard.

Suppliers

Sugar beet can be grown from seed or obtained as complete beets during the harvesting season September to Christmas (contact Ian Pettitt at Brooms Barn Research Centre www.bertiethethebeet.co.uk).

Further reading and links

Jaggard, K. W. Qi, A. and Armstrong, M. J. 2009. A meta-analysis of sugarbeet yield responses to nitrogen fertilizer measured in England since 1980. *Journal of Agricultural Science*, **147** 287-301

Jaggard, K. W. Qi, A. and Ober, E. S. 2009. Capture and use of solar radiation, water, and nitrogen by sugar beet (*Beta vulgaris* L.). *Journal of Experimental Botany*, **60** (7) 1919-1925

www.bertiethethebeet.co.uk/bertie-the-beet Broom's Barn Model Farm project has been set up in a field at Broom's Barn designed so that it is managed in exactly the same way as the rest of the farm, using commercial methods and machinery. This will ensure that the plots will be representative of commercially grown crops and the production of sugar beet from year to year can be monitored.

www.britishsugar.co.uk/Education-Resources.aspx Education resources from British Sugar covering the topics of sugar production and processing.

Norbert Rillieux and the sugar industry, Royal Society of Chemistry, Chemists in a social and historical context <http://media.rsc.org/Chemists%20in%20a%20social%20&%20historical%20context/CSHC-sugar.pdf>

Renewable Fuels Association (2010) Climate of opportunity: 2010 ethanol industry outlook, available at: http://ethanolrfa.org/page/-/objects/pdf/outlook/RFAoutlook2010_fin.pdf?nocdn=1 .

The Royal Society, January 2008. *Sustainable biofuels: prospects and challenges*, ISBN 978 0 85403 662 2. <http://royalsociety.org/Sustainable-biofuels-prospects-and-challenges/>

Nuffield Council on Bioethics, April 2011, *Biofuels: ethical issues* www.nuffieldbioethics.org/biofuels-0

Research groups

Broom's Barn is the UK's national centre for sugar beet research, located 20 miles east of Cambridge. Research spans a range of crops and scientific disciplines and includes liaison/extension work with growers and the industry. www.rothamsted.ac.uk/broom/sbrindex.php