Nuffield Advanced Chemistry Special Study
FOOD SCIENCE
Teachers' and Technicians' guide

Contents

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Health and Safety

See the safety notes given with each experiment.

Health and safety in school and college science affects all concerned: teachers and technicians, their employers, students, their parents or guardians, as well as authors and publishers.

As part of the reviewing process, these publications have been checked for health and safety. In particular, we have attempted to ensure that:

- all recognized hazards have been identified,
- suitable precautions are suggested,
- where possible, the procedures are in accordance with commonly adopted model (general) risk assessments,
- if a special risk assessment is likely to be necessary this has been pointed out
- where model (general) risk assessments are not available, we have done our best to judge the procedures to be satisfactory and of an equivalent standard.

It is assumed that:

- practical work is conducted in a properly equipped and maintained laboratory,
- rules for student behaviour are strictly enforced,
- mains-operated equipment is regularly inspected, properly maintained and appropriate records are kept,
- care is taken with normal laboratory operations such as heating substances and handling heavy objects,
- good laboratory practice is observed when chemicals are handled,
- eye protection is worn whenever the risk assessment requires it,
- any fume cupboard required operates at least to the standard of Building Bulletin 88,
- students are taught safe techniques for such activities as heating chemicals, smelling them, or pouring from bottles,
- hand-washing facilities are readily available in the laboratory.

Under the COSSH and Management of Health and Safety at Work regulations, employers are responsible for carrying out risk assessments before hazardous procedures are undertaken or hazardous chemicals used or made. Teachers are required to co-operate with their employers by complying with such risk assessments.

However, teachers should be aware that mistakes can be made and, in any case, different employers adopt different standards. Therefore, before carrying out any practical activity, teachers should always check that what they are proposing is compatible with their employer's risk assessments and does not need modification for their particular circumstances. Any local rules issued by the employer must always be followed, whatever is recommended here.

Model (general) risk assessments have been taken from, or are compatible with:

CLEAPSS Hazcards (see annually updated CD-ROM)
CLEAPSS Lab handbook (see annually updated CD-ROM)
CLEAPSS Recipe cards (see annually updated CD-ROM)
ASE Safeguards in the school laboratory 10th edition 1996
ASE Topics in Safety 3rd edition, 2001
ASE Safety reprints, 2000 or later

Clearly, you must follow whatever procedures for risk assessment your employers have laid down. As far as we know, all the practical work and demonstrations in this course are covered by the model (general) risk assessments detailed in the above publications, and so, in most schools and colleges, you will not need to take further action.

If you or your students decide to try some procedure with hazardous substances beyond what is in this course, and you cannot find it in these or other model (general) assessments, then your employer will have to make a special risk assessment. If your employer is a member, then CLEAPSS will act for them. Otherwise the ASE may be able to help.

Only you can know when your school or college needs a special risk assessment. But thereafter, the responsibility for taking all the steps demanded by the regulations lies with your employer.

Investigations will involve independent action by the student. Our notes on investigations warn students to carry out a risk assessment; students should be responsible for safety in the first instance and credited in any assessment for making safe plans. Nevertheless, proposals must be seen by you the teacher and you must ensure that you make an appropriate check, particularly with respect to safety, on what will go on. You will need to take particular care if students consult library books published before modern safety standards came into force or get ideas from the internet.

Nuffield Advanced Chemistry Special Study
Food Science: Teachers' and Technicians' notes

Aims of the *Food science* special study

1 To introduce students to the chemical aspects of food science, and to explain the nature of food.
2 To illustrate the application of physical and biological sciences to the processing, preservation, and storage of food, and the development of new and improved food products.
3 To provide experimental work to illustrate how chemistry is applied to food science.
4 To introduce students to some of the legal and moral issues raised by food.

Contents and timing

Chapter 1	Introducing food science	homework
Chapter 2	The nutrients in food	1 week
Chapter 3	The quality of food	1/2 week
Chapter 4	Microbial and biochemical changes in food	1 week
Chapter 5	Food preservation	homework
Chapter 6	Cereal science	1 week
Chapter 7	Food legislation	homework
Chapter 8	The hungry world	homework
Discussion of homework:		allow 1/2 week

The Special Study occupies about four weeks, assuming about 4 hours of contact time per week. The practical work is mainly to be found in Chapters 2, 4 and 6. The chapters which can be read for homework will need discussion time in class, but most contact time should be devoted to practical work.

Notes on this 2005 edition

We are publishing this edition of the *Food science* Special Study on the *Re:act* website (www.chemistry-react.org). This gives us the opportunity to take advantage of the interactivity of the Internet to make it easier for students to do more of the work on their own and prepare for the examination. For each chapter we now offer:

- a study guide under the tutorial headings in *Re:act* to lead students through the work,
- the illustrated text of the chapter as a downloadable file,
- instructions for the experiments as a downloadable file,
- webguides which link to other internet sites of specific relevance to the module,
- questions to help students revise.

Experiment 1 Investigating the glucose content of drinks *(see Chapter 2 Nutrients in foods)*

Each group of students will need:

Apparatus for titration, 25 cm^3 pipette and safety filter,
50 cm^3 burette, 250 cm^3 wide-mouth conical flask
Bunsen burner, tripod, gauze and heatproof mat
Quantitative Benedict's solution, 110 cm^3
Sodium carbonate, anhydrous, 40 g IRRITANT
0.50% glucose solution
1% methylene blue indicator (optional)
Drinks containing glucose
Boiling stones

Procedure

The quantities suggested are sufficient for four titrations.
This is not an easy titration to perform, and the student experiment sheet describes the procedure to follow in order to obtain accurate results. Results correct to only $^1/_2$ cm^3 are sufficient to introduce the method.

It is not necessary to dissolve all the sodium carbonate before starting the titration. The methylene blue indicator will reoxidise on the surface of the solution.

Quantitative Benedict's solution can be purchased, or prepared using the following method. Only the copper sulphate need be measured accurately, and potassium salts can be substituted for sodium salts.

Dissolve in about 600 cm^3 of warm water, filtering the solution if necessary:
290 g sodium carbonate 10-water IRRITANT
200 g trisodium citrate 2-water
125 g potassium thiocyanate HARMFUL

Dissolve in about 100 cm^3 of water
18.0 g copper sulphate 5-water HARMFUL

Mix the two solutions, add 5 cm^3 0.1M potassium hexacyanoferrate(II), and make up to exactly 1.0 dm^3.

National Centre for Biotechnology Education (NCBE)
supply a special pack for this Food Science special study.
See 'Enzymes for education' on their website.
NCBE, Science & Technology Centre, University of Reading,
Whiteknights, PO Box 226 Reading RG6 6BZ
tel 0118 987 37 43
web www.ncbe.reading.ac.uk

Experiment 2 Investigating the effect of cooking on the vitamin C content of cabbage

(see Chapter 2 Nutrients in foods)

Each group of students will need:

Apparatus for titration, 25 cm^3 pipette, 50 cm^3 burette, 250 cm^3 conical flask
Bunsen burner, tripod, gauze and heatproof mat
Measuring cylinder, 500 cm^3 and 250 cm^3
Beaker, 250 cm^3
Liquidiser (subject to portable electric appliance test) or large pestle and mortar
Filter funnel
Muslin for filtration
Stop clock
Cabbage, 100 g
5% phosphoric(v) acid solution, 600 cm^3
2,6-dichlorophenolindophenol (dcpip) (0.4 g dm^{-3}) in water, 100 cm^3
Ascorbic acid (0.20 g dm^{-3}) in
5% phosphoric(v) acid solution, 75 cm^3
Pure water, which has been boiled to remove dissolved air and then allowed to cool (see Note below)

(Note that distilled water, if not freshly prepared, contains enough dissolved oxygen to interfere with the results of the vitamin C determination. Consequently all purified water should be boiled and cooled just before being used.)

Preparation of 2,6-dichlorophenolindophenol indicator solution

2,6-dichlorophenolindophenol (dcpip) is a dye which is blue when dissolved in water, is red in acid conditions, and is reduced by ascorbic acid to a colourless compound. It is used in a titration for estimating the concentration of vitamin C in food.
All dyes, especially the direct dyes, should be treated as HARMFUL.

Dissolve 0.4 g of dcpip in 200 cm^3 of hot distilled 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 indicator solution

It is not possible to make up the indicator solution accurately and it is advisable to standardise it by titrating against a standard solution of ascorbic acid (0.20 g dm^{-3}). The standard solution may be made up by dissolving 0.20 g of ascorbic acid in 1 dm^3 of 5% phosphoric(v) acid solution.

As part of the experiment, the students are expected to standardise the solution by titrating 25.0 cm^3 of the standard ascorbic acid solution with the indicator solution, and to calculate the dye factor (F). The dye factor is the number of mg of ascorbic acid equivalent to 1 cm^3 of the indicator solution.

Procedure

The amount of sample taken will depend on the vegetable under investigation.

Use about 50 g of cabbage. This will give a titration of about 10 cm^3 of dye solution. The amount of vitamin C in a given vegetable or fruit may vary considerably. This is due to natural variations and to losses during the time between harvesting and consumption.

The purpose of the 5% phosphoric(v) acid solution is to provide acid conditions to inactivate the enzyme ascorbic acid oxidase and to extract the ascorbic acid from the food.

For information

Since vitamin C is water-soluble it is readily leached out. Washing and boiling considerably reduce the vitamin C content. Boiling in a large amount of water will increase the loss; steaming, on the other hand, will reduce the loss, unless it is carried out for a long time.

The presence of the enzyme ascorbic acid oxidase will readily destroy the vitamin C. By putting vegetables in small amounts of hot water, the enzyme is destroyed before it can have any effect. On the other hand, if vegetables are put in cold water and brought to the boil slowly, or if the water is cooled by putting a large amount of cold vegetables in the hot water, the enzyme can destroy a large proportion of the vitamin C before the enzyme itself is destroyed. If vegetables are put in briskly boiling water, although a large proportion of the vitamin C will be leached out, very little will be destroyed.

Vitamin C content of vegetables and fuit / mg per 100 g

Brussels sprouts	87	Lettuce	15
Cabbage	53	Orange	50
Cauliflower	64	Lemon	50
Potatoes	8–30		

Percentage of ascorbic acid lost in cooking

Brussels sprouts	25–50%	Potatoes	15–30%
Cabbage	40–60%	Lettuce	50–70%
Cauliflower	25–40%		

The minimum quantity of water should be used in cooking vegetables so that large amounts of vitamin C are not dissolved. This is very important with vegetables such as cabbage, which have a large surface area from which the vitamin can be lost. With potatoes, which have a smaller surface area, and in which gelatinisation of the starch prevents the diffusion and the subsequent loss of vitamin C, cooking has a much smaller effect on the vitamin C lost.

Cooked vegetables should not be kept hot for long periods before being eaten, because this can destroy a large proportion of the vitamin C. It has been found that approximately 25% of the vitamin C of cooked vegetables is lost on keeping hot for 15 minutes, and 75% on keeping hot for 90 minutes.

Notes on Experiments 3a and b Investigating texture and taste

(see Chapter 3 Quality of food)

⚠ HAZARD It is contrary to COSHH regulations to eat or drink in any laboratory which could be contaminated with hazardous chemicals. These tasting experiments must therefore be conducted in a food technology room or another room where eating is permitted.

When food is being used in experiments, the temptation for the students to sample it or to finish off unused portions is very great. The dangers of eating any food in a chemistry laboratory are very obvious. An additional hazard in food experiments is for a treated sample to be mistaken for an unused sample.

It is most important to impose a rule that, except for properly organized tasting experiments, nothing should be eaten during this Special Study, and none of the material should be taken from the laboratory or tasting sessions.

It is also important to ensure that all material which has been used in the experiments be gathered together at the end of the period and, if finished with, taken to a dustbin. This avoids the possibility of it being eaten by students from other classes or by a cleaner.

Experiment 3a Taste

⚠ HAZARD The solutions used in this experiment will be tasted. Glassware should be washed and dried separately from other laboratory apparatus. Chemicals should be taken from fresh bottles or from bottles kept apart specially for this *Food science* special study.

Each student will need:

4 drinking straws (preferably from a new packet)

Access to:

The following labelled solutions:
A sodium chloride solution, 2% and 4%
B citric acid monohydrate solution, 0.2% and 0.4%
C sucrose solution, 2% and 4%
D caffeine solution, 0.2% and 0.4%

Drinking water and disposable plastic cups

Procedure

Solid caffeine is TOXIC

The four solutions represent the four basic tastes: salt, sour, sweet and bitter respectively. The students should first taste each of the less concentrated solutions and see whether they can detect any taste. If they can detect the taste they should try to identify it as salt, sour, sweet or bitter. Those who cannot detect the flavours should be given the more concentrated solutions to taste.

Experiment 3b The tongue and the primary taste sensations

⚠ HAZARD The solutions used in this experiment will be tasted. Glassware should be washed and dried separately from other laboratory apparatus. Chemicals should be taken from fresh bottles or from bottles kept apart specially for this special study.

Each student will need:

4 drinking straws (preferably from a new packet)

Access to:

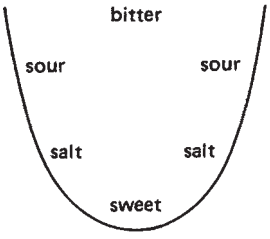
The following solutions:
Sodium chloride solution, 4%
Citric acid solution, 0.4%
Sucrose solution, 4%
Caffeine solution, 0.4%

Drinking water and clean cups

Procedure

Solid caffeine is HARMFUL

The students should work in pairs. The tester should rinse his or her mouth out with water after each sample is put on the tongue, in preparation for the next sample.



Regions of the tongue where primary taste sensations are detected.

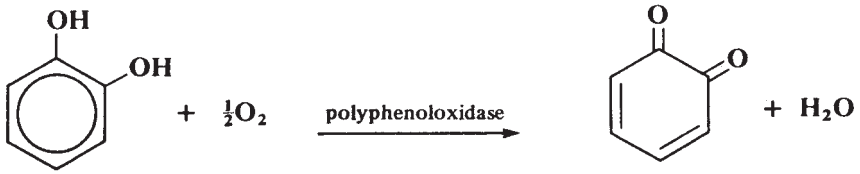
Notes on section 4.6
Investigating browning reactions in fruit and vegetables

(see Chapter 4 Microbial and biochemical changes in food)

Food is unstable, both as a raw material and as a processed product. Chemical reactions are occurring at varying rates, which affect the eating qualities and the nutritional value of a food.

Fruit-browning reactions are chosen for experimental investigation because they are relatively simple and safe, when compared with many more complicated kinds of food spoilage, such as fat oxidation and maturation of meat. However, the same principles apply. First it is essential to understand the chemical changes taking place and then to use this knowledge to devise methods of controlling the reaction.

The browning in apples and potatoes is due to the enzymic oxidation of polyphenolic compounds, via quinones, into brown pigments. The reaction taking place can best be illustrated by reference to benzene-1,2-diol, although this is not a naturally-occurring substrate.

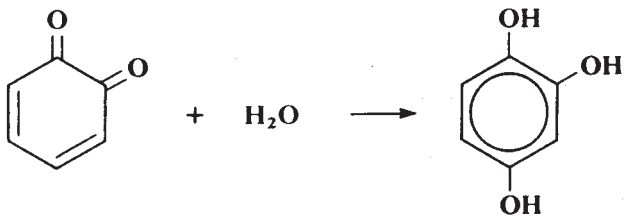


benzene-1,2-diol (catechol)

cyclohexadiene-1,2-dione (a quinone)

The first stage in browning is an enzyme-catalysed oxidation of benzene-1,2-diol to a quinone.

In the second state the quinone reacts with water to form benzene-1,2,4-triol.

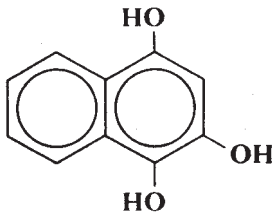


benzene-1,2,4-triol

Benzene-1,2,4-triol then reacts with any unchanged quinone, followed by a rearrangement to form a dicyclic compound.

This then polymerises further to give highly coloured pigments of unknown structure.

The students need only know that the browning in fruits is due to enzymic oxidation of benzene-1,2-diol compounds to a quinone.



This information should only be given after students have established experimentally that the browning in apples or potatoes is due to an enzymic oxidation of benzene-1,2-diol compounds. Students must understand the importance of knowing as much as possible about the deterioration.

Stress that the control of the browning reaction is not just of academic interest, but is of importance in the processing of various fruit products.

Notes on Experiments 4 to 9

(see Chapter 4 Microbial and biochemical changes in food)

⚠ HAZARD The benzene derivatives used in solutions A to D are all HARMFUL. Phenol is TOXIC and CORROSIVE and readily absorbed through the skin. Protective gloves should therefore be worn when preparing and using phenol solutions, and particular care taken to wipe up any spillages at once.

Once started, the students can work at their own rate through the experiments. The teacher should ensure that enough correct information is extracted from each experiment.

Experiment 4 is carried out first to establish that discolouration is due to substrates such as benzene-1,2-diol and benzene-1,2,3-triol. This is so that benzene-1,2-diol can be added to the samples in the subsequent experiments to intensify the colour and to accelerate the rate of browning.

Experiment 4 Which substances are involved in the browning reaction?

Each group of students will need:

Protective gloves
Apple or potato
Tweezers or tongs
Knife
6 watch-glasses or Petri dishes

Access to:

1% aqueous solutions of the following in labelled bottles with droppers:

A benzene-1,2-diol (catechol)
B benzene-1,2,3-triol (pyrogallol)
C benzene-1,3-diol (resorcinol)
D benzene-1,4-diol (hydroquinone)
E phenol HARMFUL
F pure water

Procedure

Remind students about the rules for the safe handling and disposal of food samples.

Benzene-1,2-diol and benzene-1,2,3-triol should cause discolouration very rapidly, but the other compounds react only slowly. For browning to take place a benzene-1,2-diol group is required.

Experiment 5 When does the browning reaction take place?

Each group of students will need:

Apple or potato
Tweezers or tongs
Knife
4 watch-glasses or Petri dishes

Access to:

1% aqueous benzene-1,2-diol in a bottle with a dropper
Liquidiser

Procedure

Pulping produces extensive cell damage and allows rapid diffusion of oxygen throughout the tissue. Intact plant cells have a reducing system designed to reduce oxygen, in a controlled way, so as to provide energy for the cell. When the cell is damaged, its reducing properties are lost. Furthermore, pulping destroys the cell and causes the enzymes and substrates, which are normally kept apart, to mix.

Rapid discolouration of a freshly-cut surface suggests that the reaction is an oxidation, and, as it is rapid, possibly enzymic.

When an apple is broken it tends to break between cells rather than through cells. This breaking causes less cell damage and hence less discolouration, than cutting.

Bruising has the same effect as pulping.

(see Chapter 4 Microbial and biochemical changes in food)

Experiment 6 Is the reaction due to micro-organisms?

Each group of students will need:

Protective gloves
Half an apple or potato
Knife
Tweezers or tongs
2 watch-glasses or Petri dishes
Beaker, 100 cm^3
Bunsen burner, tripod, gauze and heatproof mat
Thermometer, 0–100 °C
Stop clock
Pure water

Access to:

1% aqueous phenol solution in bottle with dropper
HARMFUL
1% aqueous benzene-1,2-diol solution in bottle with dropper

Procedure

The rapidity of the browning reaction suggests that the spoilage is too fast to be microbial. Also, the interior of apples or potatoes is normally free from bacteria.

Washing with 1% aqueous phenol solution should kill off any micro-organisms but will not alter the rate of browning.

Short heat treatment should greatly reduce browning. Sample **A** should brown more slowly than sample **C**. If it were a non-enzymic reaction, the rate should be greater at a higher temperature. The fact that it is slower indicates that the enzyme polyphenol oxidase has been destroyed by heat.

Experiment 7 Does the reaction require air or some part of the air?

Each group of students will need:

Quarter of an apple or potato
Knife
3 boiling-tubes equipped with delivery-tubes and clips (see the diagram below)
Tweezers or tongs
Stop clock

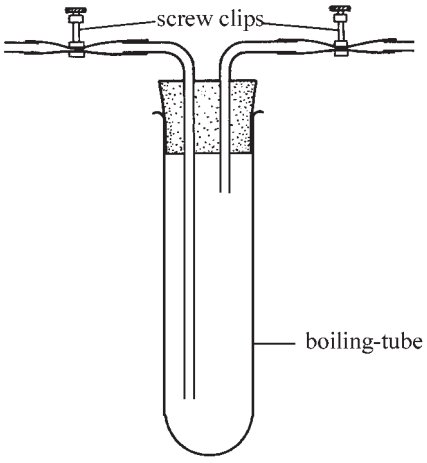
Access to:

1% aqueous benzene-1,2-diol, in a bottle with a dropper
Gas supply, oxygen, nitrogen, carbon dioxide

Procedure

Students will need access to gas cylinders, or generators, supplying oxygen, nitrogen and carbon dioxide.

The students should now be able to summarise the reaction as occurring in damaged tissue and being an enzyme-catalysed oxidation of compounds containing a benzene-1,2-diol group.



Gas apparatus

(see Chapter 4 Microbial and biochemical changes in food)

Experiment 8 Can ascorbic acid be used to control the browning reaction?

Each group of students will need:

Apple or potato
Knife
Tweezers or tongs
6 watch-glasses or Petri dishes
Stop clock
Access to:
1% aqueous benzene-1,2-diol solution in bottle with dropper

Labelled beakers containing aqueous solutions of ascorbic acid having the following concentrations:
A 5%, **B** 3.5%, **C** 2.5%, **D** 2%, **E** 1%, and **F** pure water

Procedure

Students should observe a delay period before browning starts. The delay period increases with increasing concentration of ascorbic acid. This is intended to be a qualitative test. The students should place the samples in order of increased delay period.

Ascorbic acid acts by reducing the quinone, as it is formed, back to the hydroquinone. It is itself oxidised in the process. Thus no pigment can be formed until all the ascorbic acid is oxidised, but once this has occurred the browning reaction proceeds at its normal rate. However, the enzyme slowly loses its activity during the reaction and so, if enough ascorbic acid is present, the enzyme loses its activity before all the ascorbic acid is oxidised and no discolouration occurs.

Ascorbic acid (vitamin C) is widely distributed in nature, acting as a control on the redox systems in living cells. It has a great advantage as an antioxidant in the food industry because it is completely harmless when added to food and is a nutrient (vitamin).

Experiment 9 Controlling browning by inactivating the enzyme

Each group of students will need:

Protective gloves
Apple or potato
Knife
Tweezers or tongs
Beaker, 100 cm^3
8 watch-glasses or Petri dishes
Stop clock
Bunsen burner, tripod, gauze and heatproof mat

Access to:

1% aqueous benzene-1,2-diol solution in a bottle with a dropper
Labelled beakers containing the following aqueous solutions:
A 2% (0.5M) hydrochloric acid
B 2% citric acid
C 2% sodium hydrogensulphite (gives TOXIC gas with acid)
D 2% sodium chloride
E 2% sucrose
F boiling water
G pure cold water

Procedure

Enzyme activity is at its greatest between pH 6.0 and 8.0. Outside this range the rate of browning is greatly reduced. Below pH 3.0, the reaction is almost completely inhibited.

The natural pH of apples is between 3.0 and 4.0, and that of potatoes is between 5.0 and 6.0, depending on ripeness, variety, and the time of year. Acids may be added to reduce browning. Citric and malic acids occur naturally in fruits and can be added to fruits without significantly affecting their flavour.

Sulphur dioxide is an enzyme inhibitor and is commonly used as a preservative in food. It not act by bleaching the colour but by preventing colour formation: it is a reducing agent. Sulphur dioxide is TOXIC and CORROSIVE.

Soaking in 2% sodium chloride or 2% sugar solution should delay or stop browning, but this will affect the flavour. Sodium chloride inhibits the enzyme mainly by raising the ionic concentration. Sucrose acts mainly by reducing the solubility of oxygen in the surface tissues.

Sodium fluoride, which is TOXIC, will inhibit enzyme activity. The effect may be demonstrated, taking care.

(see Chapter 4 Microbial and biochemical changes in food)

Experiment 10 Making curd from milk

Each group of students will need:

4 boiling tubes
Water bath at 37 °C
Whole pasteurised milk, 80 cm^3
Rennet essence, 1 cm^3
Maxiren, 1 cm^3
Rennilase™, 1 cm^3

Optional:

The same materials plus:
1M acids and 1M bases (acids may be IRRITANT or CORROSIVE depending on which is used;
bases are CORROSIVE)

Notes

Rennet essence can be bought from delicatessens and health food shops; Maxiren from a genetically modified yeast and Rennilase™, a fungal protease, can be bought from the National Centre for Biotechnology Education (NCBE) – see below.

Procedure

The process depends on a protease enzyme such as chymosin breaking specific bonds in a glycopeptide on the surface of soluble calcium caseinate particles in the milk. The caseinate can then reform into a relatively insoluble form which coagulates in the presence of calcium ions.

The enzymes should be stored in a refrigerator where they will maintain their full activity for at least six months.

National Centre for Biotechnology Education (NCBE)
supply a special pack for this Food Science special study.
See 'Enzymes for education' on their website.
NCBE, Science & Technology Centre, University of Reading,
Whiteknights, PO Box 226 Reading RG6 6BZ
tel 0118 987 37 43
web www.ncbe.reading.ac.uk

Notes on Chapter 6 Cereal science

To appreciate the chapter on cereal science, all students should have first-hand experience of making bread. Some will have made bread at home, others will have done so in food technology or in junior science lessons in school. Students could be asked to try making some bread rolls at home and to bring samples to school for the first lesson on this chapter.

Experiment 11 The SDS sedimentation test for gluten

Each group of students will need:

2 measuring cylinders, 50 cm^3
2 stoppered measuring cylinders, 100 cm^3
Stop clock
Bakers' flour (higher gluten content), 6 g
Soft cake or biscuit flour (lower gluten content), 6 g
SDS-lactic acid test solution, 100 cm^3

Procedure

The SDS-lactic acid solution is prepared from

Sodium dodecyl sulphate (SDS), 20 g dm^{-3}
Lactic acid, 1 part 88% aqueous solution CORROSIVE
mixed with 8 parts water

The test solution consists of 1 dm^3 of SDS solution mixed with 20 cm^3 diluted lactic acid solution.

The method described in the student experiment sheet is based on the standard industrial method. In industry the flour would be produced by a standard grinding procedure, the quantity of flour would be adjusted for moisture content (5.7 g for 10% moisture, 6.1 g for 17%), and the temperature would be controlled to 20 ± 2 °C.

Strong flour and plain flour should give comparable results; 'superfine' flour is likely to give an anomalous result.

Extracting gluten from flour: an additional, optional experiment

As additional experiment students could use the instructions given on the next page to extract some gluten from flour.

Each group of students will need:

Bunsen burner, tripod, gauze and heatproof mat
2 large evaporating dishes, or bowls
Measuring cylinder, 50 cm^3
2 beakers, 250 cm^3
Glass rod
Grease-proof paper and scissors

Access to:

Bakers' flour (higher gluten content)
Soft cake or biscuit flour (lower gluten content)
Iodine solution (1 g KI plus 0.05 g I_2 in 100 cm^3 of water)
HARMFUL

Experiment 12 Gelatinization temperature of starch

Each group of students will need:

Measuring cylinder, 10 cm^3
Microscope (with two pieces of Polaroid)
Spatula
Thermometer, 0–100 °C
Test-tubes
Water bath (a large beaker)
Dropping pipette or glass rod
Access to:
Maize starch (cornflour)
Wheat starch
Potato starch

Procedure

Wheat and corn starches gelatinize at a lower temperature than potato starch. Students need not try both methods. If time is a problem then method 2 is quicker.

Two pieces of Polaroid can be used to turn a junior microscope into a polarizing microscope. With crossed Polaroids the 'Maltese Cross' pattern of starch grains shows up in a spectacular way. The pattern disappears as the grains swell and gelatinize.

Additional, optional experiment Extracting gluten from flour

(see Chapter 6 Cereal science)

Instructions for students

Procedure

a Slowly mix about 30 cm^3 of pure water with 50 g of one of the flour samples in a large evaporating dish or bowl, using a glass rod, to make a dough. The dough should be homogeneous and have the consistency of a very stiff chewing-gum.

Allow the dough to stand for about 15 minutes under warm water in a beaker.

b Knead the dough ball under a slow stream of tap water. The starch will be washed away as a milky suspension and the water-insoluble gluten will remain.

c When the water is starch free (how can you test?), squeeze out excess water from the gluten. Mould the gluten in your fingers, drying them occasionally.

d When free water has been reduced the gluten suddenly becomes very sticky.
Put it on grease-proof paper and weigh it.
Repeat for the other flour.

e Stretch both gluten samples by hand and note the consistency and springiness.
Boil the gluten ball for three minutes in water. What has happened to the gluten?

Photocopy these instructions for students

Experiment 13 Comparison of flour colour, and qualitative tests for flour improvers

Each group of students will need:

4 Petri dishes with lids
Spatula
Plastic washing-up bowl, or sink with plug
Standard bakers' flour, see note
Biscuit flour, see note
10% aqueous potassium thiocyanate solution, 1 cm^3
2M hydrochloric acid, 1 cm^3 IRRITANT
2% aqueous iodine solution (in KI), 1 cm^3
Test-tubes

The teacher may need:

0.2% solution of benzene-1,2-diol in ethanol, 1 cm^3 HIGHLY FLAMMABLE

Notes

Biscuit flours are generally untreated and give no reaction for added vitamin mix or improvers. Standard bakers' flour, however, usually contains a vitamin mix containing iron (in the form of very fine iron filings) and ascorbic acid.

It can be helpful to provide flour samples for these experiments to which ascorbic acid has been added, to give a concentrations of 200 p.p.m. (0.2 g to 1 kg)

The darkening is due to the enzyme phenol oxidase, which is mainly in the bran. This reaction can be highlighted as a demonstration by pouring enough 0.2% ethanolic solution of benzene-1,2-diol (TAKE CARE) to just cover the wet flour (on which the enzyme then reacts).

The enzyme-catalysed reaction is speeded up by warming.

Ascorbic acid is a reducing agent and will reduce the iodine to an iodide. The presence of ascorbic acid will produce white flecks on the surface of the flour which will otherwise be coloured a uniform blue by the starch–iodide reaction.

The treated flour will develop a deeper red colour than the control. After 20 minutes the flour containing the iron will show deep red spots, indicating the location of iron particles.