UNDERSTANDING
Food Additives

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THE UNIVERSITY of York

FAIA
FOOD ADDITIVES AND INGREDIENTS ASSOCIATION

up-to-date information on major food additive groups
& food technology activities for 11-14 & 14-16 year olds

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Contents

The teaching of concepts related to food and nutrition are extremely important as they form an integral part of many syllabuses. In addition, the ability to feed oneself, and maybe a family, with due regard to nutritional content and safety is an essential life skill that should be nurtured in all young people.

We all need food and most of us derive great pleasure from it. The modern day consumer demands ever increasing standards of quality, choice, convenience and, of course, safety. The ways in which the food manufacturers meet this challenge can be technologically fascinating, if sometimes, controversial.

Food additives are not a new invention. Since early times, there has been a need to preserve food from one harvest to another and to improve the presentation and nutritional value of food. The use of salt and smoke for preservation dates back to early history. The Egyptians used colours and flavourings, while the Romans used saltpetre, spices and colours. Some of these substances, which we would now call additives, were quite costly and only the rich could afford them.

Since the first half of this century, new substances have been discovered which fulfil these and other beneficial functions at relatively low cost. Examples of such early food additives are colours in cheese, emulsifiers in margarine, baking powder in cake mixes and gelling agent in jams. In the last 40 years, developments in food science and technology, as well as changes in consumer demand, have led to a substantial increase in the use of food additives. This has enabled the food industry to produce a wide range of foodstuffs of good and uniform quality at reasonable prices.

Some people, of course, still bake their own bread, make their own jam and make a conscious effort to prepare much of their food at home in their own kitchen. For most people, however, changing lifestyles has meant that they have come increasingly to rely on factory-made food, so called processed food. Unlike food made in the kitchen - whether at home, in a canteen or in a restaurant - processed food must maintain its taste, texture and appearance and still remain safe to eat weeks and even months after it has been made. Food additives play an important part in this. In summary their role is:

(i) to improve the **keeping quality** of food (e.g. preservatives and antioxidants);

(ii) to provide **texture, consistency and stability** to food (e.g. gelling and thickening agents, emulsifiers and stabilisers);

(iii) to maintain and improve **sensory properties** such as taste, aroma and colour (e.g. flavourings, acidulants and colours);

(iv) to facilitate the **manufacture** and **use** of particular foods (e.g. anti-caking agents);

(v) to provide food for consumers with **particular nutritional requirements** (e.g. intense sweeteners for diabetics).

Additives need to be used only in small quantities to be effective, typically less than 1% in the final food. Many additives, e.g. antioxidants, preservatives and flavourings, are effective at levels below 0.1%.

The use of additives in food is regulated and controlled on a European wide basis and all food additives must be tested and shown to be safe before food manufacturers are able to use them.

We hope that the classroom activities, teachers notes and reference material that follow will help pupils (and teachers) to arrive at a better understanding of this important topic.

Place in the curriculum

The subject of food appears in the National Curricula for both Science and Design and Technology.

The statutory orders for Design and Technology make the study of food compulsory for all children from 5 to 11 years. It is anticipated that in the majority of secondary schools, Food Technology will be part of every child's Key Stage 3 curriculum. At Key Stage 4 pupils can opt to study a full GCSE examination course in Food Technology.

The statutory orders for Science include reference to the nutrition of humans as organisms in the Life Processes and Living Things section. Science is, of course, compulsory for all pupils up to the age of 16.

There are also examples of food related topics appearing in a number of post-16 courses.

About this publication

Understanding Food Additives is aimed at pupils at Key Stages 3 and 4, and tackles aspects of the teaching of food and related topics by using food additives as a focus for study. The package contains:

(i) a reference section aimed specifically at teachers explains the functions and origins of the major classes of food additives.

(ii) and in the second section, there are a variety of associated activities for pupils that could be used in the food technology laboratory and/or science laboratory; these are accompanied by teachers' notes.

Words which appear in the text in normal **bold** type are defined in the glossary. *Italics* are used to emphasise key words or phrases.

Summary of pupil activities (teacher notes and pupil sheet).

page	Additive	Activity	Food Technology		Science		Content
		KS3	KS3	KS4	KS3	KS4	
37		**I1**. Card games (**I**ntroductary activities)	✓	✓	✓	✓	Games which enable pupils to gain nutritional information about common foods.
40		**I2**. Guess the food	✓	✓	✓	✓	2 worksheet activities where common foods/dishes have to be identified from a list of ingredients only.
40		**I3**. Would you eat these for breakfast?	✓	✓	✓	✓	
40	All	**I4**. What can be added to the food you buy?	✓		✓		Pupil information sheets describing the functions, etc. of the main classes of food additives.
40	Various	**I5**. Reading the label	✓		✓		An exercise looking at information on food labels.
41	Various	**I6**. Finding the additives	✓		✓		Looking for food additives from food labels.
43	Acidulants	**A1**. Some reactions between acids and alkalis *How much acid is in fizzy drinks?*				✓	Solubility comparisons; pH of acidic and alkaline solutions, neutralisation reaction. Testing the pH of drinks; estimating the amount of citric acid in drinks using titration
44	Acidulants	**A2**. Boiling dumplings (raising agents)				✓	Investigating the reaction between an acid and an alkali (carbonate) to produce a raising agent.
45	Acidulants	**A3**. Acids and alkalis in food *Making sherbet* *Find the acid* *Do we drink acids?*	✓	✓			Production of edible sherbet using icing sugar and the reaction between an acid and an alkali (carbonate). Looking for the use of acids in food. Using universal indicator to test drinks for acidity.
45	Acidulants	**A4**. Baking scones (raising agents)	✓	✓			Testing the pH of flours; production of scones with and without raising agents.
47	Acidulants	**A5**. Citric acid	✓	✓	✓	✓	Written exercise on the uses of citric acid.
49	Anti-caking agents	**AC1**. The action of anti-caking agent			✓	✓	Designing an investigation to examine the effect of an anti-caking agent on the flow of powdered cocoa.
49	Anti-caking agents	**AC2**. The function of anti-caking agents - a case study			✓	✓	A model investigation is reported and can be used as the basis of discussion.
51	Antioxidants	**AO1**. Oxygen – friend or foe *Why has my apple gone brown?*		✓		✓	Investigating the browning reaction in apples
52	Antioxidants	**AO2**. Fats					
53	Antioxidants	**AO3**. Further fat research		✓		✓	Written exercise which revises fat structure and related dietary issues.
55	Colours	**C1**. "It looks good enough to eat!"	✓		✓		Exploring colour changes of natural and synthetic substances with the addition of water, acid and alkali.
56	Colours	**C2**. How do you colour a jelly baby?	✓		✓		Extracting coloured substances from jelly babies.

Summary of pupil activities (teacher notes and pupil sheet) continued.

page	Additive	Activity	Food Technology		Science		Content
		KS3	KS3	KS4	KS3	KS4	
57	**C**olours	**C3**. Using chromatography to analyse colours in jelly babies	✓	✓	✓	✓	Producing paper chromatograms of the coloured substances in jelly babies.
59	**E**mulsifiers	**E1**. Making salad dressings		✓			Investigations about the use of emulsifiers and stabilisers; making a salad dressing using a stabilisers; the coating abilities of this dressing; production of a coleslaw salad including packaging.
59		**E2**. The function of emulsifiers and stabilisers;					
61	**F**lavourings	**F1**. What's in a flavour?	✓	✓			The production of milky drinks which taste of vanilla.
63	**G**elling agents	**G1**. A jamming session	✓	✓	✓	✓	Investigating the conditions needed for pectin to be able to produce a set.
64	**G**elling agents	**G2**. An introduction to pectin		✓		✓	Written exercise which looks at the commercial production and uses of pectin.
67	**P**reservatives	**P1**. The conditions necessary for the growth of microbes	✓		✓		Investigating the conditions that make rice go 'off'.
67	**P**reservatives	**P2**. Food preservation	✓		✓		Investigating different methods of preserving food.
70	**P**reservatives	**P3**. Methods of food preservation	✓		✓		Written exercise which reviews common methods of food preservation.
71	**S**weeteners	**S1**. Diabetes Mellitus	✓		✓		An introduction to this disease.
71	**S**weeteners	**S2**. Diagnosis of diabetes mellitus			✓	✓	Testing synthetic urine for the presence of glucose.
71	**S**weeteners	**S3**. Controlling the level of glucose in the blood				✓	Hormonal control of blood glucose levels; data interpretation.
72	**S**weeteners	**S4**. A Case History		✓		✓	An extension exercise which looks further at diabetes.
73	**S**weeteners	**S5**. Sweeter than sugar		✓		✓	Investigations to compare sugar (sucrose) with artificial sweeteners; the properties of 'ordinary' and 'diet' drinks; estimating sugar content of drinks.
74	**S**weeteners	**S6**. Food for diabetics		✓			A project to look at the dietary needs of diabetics.
77	**S**afety and **r**egulation	**SR1**. A recipe for disaster	✓	✓	✓	✓	Written exercise on the 'mistakes' made during food preparation.

Acidulants are **food additives** used to impart a sharp, characteristic taste to foods. They also assist in the setting of gels and to act as preservatives.

The **pH** of a system is an extremely important physical parameter. pH is a measure of the *acidity, alkalinity* or *neutrality* of a chemical system, including food systems.

pH is a mathematical expression of the concentration of hydrogen ions in aqueous solutions. It is expressed as a number ranging from 1 to 14. Values below 7 are acidic; the lower the number, the more acidic the solution. Values above 7 are alkaline; the higher the number, the more alkaline the solution. A value of 7 is said to be neutral.

In biological systems, it is extremely important to maintain a constant pH. The delicate balance of processes within the living cell can easily be upset by fluctuations in acidity or alkalinity. Living systems contain within them solutions called **buffers** which are capable of 'mopping up' any chemicals which may significantly alter the pH. In this way buffers are acting as pH regulators.

Many natural foods are acidic, for example, oranges, lemons, apples, tomatoes, cheese and yoghurt. The natural acids present in these foods give them their characteristic taste. Baking soda (sodium hydrogencarbonate) is an example of an alkali.

Food acids, with the exception of phosphoric acid, are all **organic** acids and are present within the living cells of plants and animals. Many of these acids are involved with the biochemical reactions of **respiration**.

As the food industry has developed, so has the growth in production of processed foods. Many of these need the inclusion of an acidulant to impart an acidic or sour taste.

*Food acids and their salts also perform other functions such as antioxidant **synergists, chelators** and buffering agents.*

Functions

Acids, alkalis and buffers all have important roles in the food industry. Acids have been used in food preparations for centuries as important contributors to flavour. They also have significant preservative properties. The acid environment created by these substances will prevent the growth of many microorganisms. Bicarbonates, particularly bicarbonate of soda, are used as mild alkalis. Many phosphates are used for their buffering action as well as for their characteristic taste.

Acids and applications

By far the most important, versatile and widely used organic acid is *citric acid*. It is used in food products, beverages and the pharmaceutical industry.

In 1997, 750 000 tonnes of citric acid were used by industry worldwide of which about 320 000 tonnes went into food and beverages.

The uses of citric acid and/or sodium citrate in food and beverages include:

- to provide tartness in carbonated/non-carbonated beverages and sugar confectionary (sweets)
- to provide optimum conditions for gelation in jams, jellies, confectionary and desserts
- to provide optimum conditions for the stabilisation of emulsions (e.g. processed cheese and dairy products)
- prevention of browning in salads
- in frozen food to enhance the action of antioxidants and prevent deterioration
- to reduce heat treatment of canned fruit and vegetables
- as an antioxidant in fats and oils
- as a preservative, a processing aid and a texture modifier in meat products.

Citric acid also has various medical, industrial and agricultural uses.

Citric acid
Citric acid occurs naturally in a wide variety of fruits and has a central role to play in human metabolism. It is estimated that 1.5-2.0 kg of citric acid (as citrate) is produced and completely metabolised within the body each day.

*Citric acid was originally extracted from lemons and limes. This process has now been superseded by a fermentation process. The mould **Aspergillus niger** is used to ferment a carbohydrate source such as molasses. The manufacturers involved in this process are large scale, each typically producing in excess of 25 000 tonnes a year.*

Phosphoric acid
Cola drinks are the best selling flavoured soft drink in the world. The acid used in these drinks is exclusively phosphoric acid. This has a harsh, biting taste which complements the cola flavour.

Phosphoric acid is manufactured commercially from phosphate rock mined principally in North Africa and North America, either directly or via the production of elemental phosphorous.

Phosphorus itself is important to us all because it is the second most abundant element in the human body and is involved in countless key functions including controlling energy balance. It is essential to life.

Malic acid
Malic acid is found naturally in apples, pears, tomatoes, bananas and cherries. It is produced commercially from maleic anhydride.

Lactic acid
Lactic acid is produced naturally during anaerobic respiration. It is responsible for the painful effects of exercise!

Lactic acid is manufactured naturally by a fermentation process but can also be produced synthetically. The fermentation method is the one most commonly used.

Tartaric acid
Tartaric acid can be manufactured by natural and synthetic routes. The natural route involves the recovery of tartaric acid from wine. The synthetic route involves the chemical reactions of maleic anhydride.

Acetic acid
Only acetic acid produced naturally by ***fermentation*** *can legally be called vinegar.*

Vinegar is made by the alcoholic fermentation of a carbohydrate source. In Britain the carbohydrate used is usually malt. Acetic acid is manufactured synthetically by various methods all of which produce good purity acetic acid.

Fumaric acid
It is manufactured synthetically from malic acid.

Phosphoric acid is the acidulant used in the second largest amounts by the food industry. It owes this position and its importance to one single product - cola.

Salts of phosphoric acid have many uses in the food industry. They can act as buffers, acidulants for baking powders and emulsifying salts in the production of processed cheese.

Salts of phosphoric acid also act as synergists in the interaction of salt with muscle protein giving excellent water, meat and fat binding effects when used in the production of cooked meat products such as hams and processed poultry products - though this use is controversial. There is understandable concern around products in which the consumer appears to be paying merely for water. The nutritional content of such products has, therefore, been questioned. However, it should be noted that the water content must be clearly labelled on the packaging.

Polyphosphates are used as emulsifying salts in the production of processed cheese.

Malic acid has similar applications to citric acid and has the advantage of being the preferred acid in low calorie drinks, cider and apple drinks. It has the disadvantage of being slightly more expensive than citric acid.

Lactic acid is widely used:

- in the sugar confectionery industry for the production of boiled sweets
- in the pickling industry
- as a raw material in the manufacture of important emulsifiers which are used by the baking industry.

This latter use is probably the major use of lactic acid.

Tartaric acid was the first food acidulant to be used in significant quantities by the food industry. Most of its applications have been replaced by citric acid. The largest single application for tartaric acid is as a raw material for the manufacture of the so-called Datem **emulsifiers** (diacetyl tartaric acid esters of monoglycerides). These are very important protein and starch complexing emulsifiers and are used as bread improvers.

An important salt of tartaric acid, potassium hydrogen tartrate (or cream of tartar), has applications as an acidulant for baking powder and sugar confectionery.

Acetic acid is the acid found in vinegar. It is a volatile acidulant with a characteristic pungent aroma.

Acetic acid is widely used, particularly in the pickling industry. Naturally fermented vinegar has a variable pH. Acetic acid is added to this to form a pickling liquor with a specified acidity. The range of pickles available to the consumer is considerable.

Acetic acid is also used in confectionery goods and flavourings. The flavouring sodium diacetate is commonly known as 'salt 'n' vinegar' and is widely used in crisps.

Acetic acid has excellent **bacteriostatic** properties and hence has considerable importance as a preservative.

Fumaric acid is the strongest tasting food acidulant. It has limited applications due to its very low solubility. In the main, it is used in gelatin dessert powders, cheesecake mixes and some powdered drinks.

A substantial amount of fumaric acid is used in animal feedstuffs mainly because of its strong flavour and favourable price.

Function

Food additives can be classified by their functional purpose. Most fall into just two categories:

- those that assist in manufacture or use
- those that produce end-product characteristics.

Free-flow or anti-caking agents fall into the first category. They are added to foods and food ingredients, usually when they are in a powdered form. Many food processing plants have problems with handling powders due to:

- the nature of the powders
- the design of the machinery
- a combination of these factors.

Thus, improving the *flow characteristics* of the powders can dramatically improve the efficiency of the manufacturing process. In some cases, the agent is added by the supplier of the powdered ingredient in order that their customer, the food manufacturer, can handle the product.

Only a small proportion of the agents find their way into the final products, sold directly to the consumer. The agents rarely have nutritional value.

Some anti-caking agents may extend across the boundary between these categories. For example, magnesium carbonate is used in table salt to improve the flow during manufacture. The substance remains within the product and hence improves the flow of the product at the consumer's table.

Applications

Vending machine powders are exposed to high humidities and temperature. Their flow properties must be maintained to ensure dependable machine operation and consistent dosing. Chocolate, coffee, soup powder, meat extracts and dried fruit drinks are all materials which can manifest flow problems.

Milk and cream powder substitutes (non-dairy creamers) normally have a high vegetable oil content, causing the particles to stick together during processing, packing and subsequent storage and use.

Cheese which has been grated for convenience of use, e.g. pizza topping, tends to reagglomerate. This is because of its reaction to compressive forces during storage. This undermines the benefit of the grating to the end user.

Sugar, when subjected to a humid atmosphere, tends to cake easily. Incorporation of a free-flow aid before grinding will prevent adhesion of the sugar to processing equipment. It also reduces the tendency of the powdered sugar to cake.

Examples of foods that contain anti-caking agents include:

- *vending machine powders*
- *milk and cream powdered substitutes*
- *grated cheese*
- *icing sugar*
- *vegetable powders*
- *powdered flavours*
- *dextrose*
- *topping powders*
- *baking powder*
- *cake mixes*
- *soup mixes*
- *powdered spices*
- *drinking chocolate*
- *tomato powders*
- *powdered egg*
- *salt*
- *dried fruit*

How do these agents work?

In order to answer this question, it is necessary to look at the causes of flow problems in powders. They can be caused by several factors which can occur singly or in combinations.

Flow problems in powders:
- *Moisture*

Moisture is a prime cause of caking and it can affect flow through several mechanisms:

- Water contained in powder particles often tends to migrate to the surface. This makes the particles damp. Insoluble products tend to draw water towards them, also causing dampness.
- **Hygroscopic** powders absorb moisture in the air. In extreme cases this can lead to the breaking up of the material and cause 'tackiness'.
- Variations in relative humidity can lead to caking.

- *Particle size and shape*

Particle size and shape can affect the way in which a powder settles. It is particularly exacerbated by the presence of small particles. Particular size/shape combinations can severely affect flow properties.

• *Temperature*

Temperature is an important factor for some powders. Organic based powders with low softening points tend to become mobile and sticky as temperature increases. This effect becomes more pronounced under any form of compression (see below).

• *Surface activity*

Surface activity of some powders can lead to chemical reactions with substances in the air such as water vapour or oxygen. It is also possible for particles to react with adjacent particles with which they are in contact. This will cause flow problems as well as producing undesirable changes in the chemical composition of the original product.

• *Compression*

Compression is an obvious cause of caking. Powders with plastic properties will deform and 'weld' under pressure. An immiscible component which migrates to the surface of the powder can have a similar effect if it is susceptible to compression.

Any substance added to the powder which reduces the number of contacts, or which modifies the effect of them, is acting as an *anti-caking agent.*

Free-flow agents work in slightly different ways to overcome the specific problems described above. They may:

- absorb water vapour which then prevents caking
- absorb fats to prevent compression or temperature effects
- modify the particle size distribution to ensure a more suitable distribution which increases flow.

The range of anti-caking agents

Silicon dioxide

One of the most important anti-caking agents is *silicon dioxide* (E551). Silicon dioxide (silica, SiO_2), used in the food industry, is manufactured, although chemically it is the same substance as ordinary sand. However, its physical properties are significantly modified and it is much purer than beach sand. Silicon dioxide has a large number of pores, the size and frequency of which can be varied. The particle size can be exactly tailored to meet specific requirements. It has a surface which is **hydrophilic** and carries a negative charge. These properties make it a versatile and useful product in many of the situations described in the previous section.

Other manufactured products

Other manufactured anti-caking agents include:

- calcium silicate (E552)
- sodium aluminosilicate (E554)
- dicalcium phosphate (E341).

Natural products

Natural products used as anti-caking agents include:

- talc
- kaolin
- potato starch
- microcrystalline cellulose (E460(i)).

Salt is commonly kept free flowing by using small quantities (up to 20 mg/kg) of potassium ferrocyanide or other ferrocyanides (sodium or calcium). A more traditional method of ensuring free flowing table salt is to add grains of rice to the salt in the salt cellar.

There are a number of factors which influence the choice of anti-caking agent. Some products have very specific uses, e.g. table salt, and only specific anti-caking agents are suitable. Other anti-caking agents are more general purpose and can be used in a variety of situations, such as carrying liquid ingredients in a powder form, e.g. silica. The ease of application and/or the effect on the end product's other properties are also important considerations. As with most industries, cost effectiveness is a major consideration.

Oxidation can be a very destructive process. Oxidation of food can result in loss of nutritional value and changes in chemical composition; the unpleasant and undesirable oxidation of **fats** and oils leading to the characteristic development of **rancidity**.

Rancidity caused by the oxidation of fats and oils is one of the major obstacles preventing longer shelf life of many food products.

In natural conditions, animal and plant tissues contain their own antioxidants and protective enzyme systems. However, in killed or harvested products these natural systems inevitably break down and oxidation is bound to follow.

Functions

Antioxidants are added to food in order to slow down the rate of oxidation. None are capable of preventing the process of oxidation completely. If used properly they can usefully extend shelf life of the ingredient and/or the food product in which they have been used.

Applications

Antioxidants can be used in pure fats and oils as well as products which merely contain them. Even if a food has a very low fat content it may still be necessary to employ the benefits of an antioxidant.

Potatoes contain usually less than 1% fat. However it is in such a form as to make it very prone to oxidation. In processing potato to make dried potato, the plant cell structure is destroyed. This releases the potato **lipid** into the bulk of the product. The potato lipid will rapidly oxidise and be inedible if not protected by a suitable antioxidant.

The products in which antioxidants are most commonly used are:

- *vegetable oil*
- *snacks (extruded)*
- *animal fat*
- *meat, fish, poultry*
- *margarine*
- *dairy products*
- *mayonnaise/dressing*
- *baked products*
- *potato products,*

Technological needs/benefits

In recent years there has been a gradual change in the eating habits of the population with respect to fats. There has been a move away from the hard saturated fats towards the softer **unsaturated/polyunsaturated** fats and oils.

Importantly for food manufacturers, the softer fats are naturally more susceptible to oxidation.

Modern processing techniques themselves may increase the risks of oxidation. Consequently, lipid oxidation is a problem that many food manufacturers must address.

Processing techniques have been improved in many areas to reduce the risk of oxidation. For example, many snack food manufacturers fry crisps and similar products under a blanket of steam. This reduces the amount of oxygen that can get into the frying oil. This extends the life of both the oil itself and the product fried in it.

Antioxidants are only one way of fending off the inevitable. The use of barrier packaging, vacuum or gas flushing and refrigeration can all be used to delay the oxidation process. Many manufacturers have increasingly used these methods in recent years to meet the consumer demand for fewer additives. However, these measures can still be inefficient and antioxidants can be a relatively inexpensive, yet effective way of extending the shelf life of a product.

How do antioxidants work?

One family of products resulting from the oxidation of fats are the *peroxides*. It is possible to measure the rate of production of these substances as a guide to the rate of oxidation.

In a 'fresh' product the amount of peroxides is very low. As the fat decomposes and reacts with oxygen, the amount of peroxides rises. As all the fat becomes broken down, the amount of peroxides reaches a maximum. The peroxides then change into the substances characteristic of the odour and soapy flavour of a rancid fat.

Antioxidants prevent the formation of peroxides. Some of them are described as oxygen scavengers since they react with oxygen itself thereby preventing the formation of peroxides.

This process, leading to the decomposition of fats, is sometimes known as the cycle of events. Antioxidants work by breaking this cycle.

The range of antioxidants

The number of antioxidants available to the food technologist is not large. The choice of which to use is usually based on the three factors of:

- performance
- labelling issues
- cost.

For example:
BHA (E320 butylated hydroxyanisole) may be used with BHT (E321 butylated hydroxytoluene);
and
ascorbyl palmitate (E304) with tocopherol (E306-309).

Synthetic and natural antioxidants give similar performance. Typically, they are used together. This results in a *synergistic* effect, that is, their individual performance is enhanced when used together.

Ascorbyl palmitate is an ester derived from ascorbic acid, vitamin C. One of the tocophenols, α-tocophenol is vitamin E. They work in harness in the body as antioxidants.

If the product incorporating the antioxidant is to be heated or fried, then stability and lasting properties are often important. BHA and tocopherol are quite good in this respect. Most other antioxidants are quite volatile and would be driven off during processing.

Sometimes metal chelators, such as citric acid, are used. These substances act by removing metal ions such as iron and copper. These ions, if present, are extremely effective at speeding up the oxidation process.

Where labelling is an important issue, then natural antioxidants will usually be selected. However, their cost is higher than that of their synthetic counterparts for the same level of performance. Consequently, synthetic antioxidants are still widely chosen by the food industry.

Antioxidants and health benefits

There may well be potential health benefits from the use of antioxidants. Recent medical evidence suggests that oxidation reactions in the body could be linked to the incidence of atherosclerosis (blocking of blood vessels) leading to heart attacks. The use of antioxidants may, therefore, be important in preventing these oxidation reactions. There could also be a link with the prevention of certain cancers, arthritis and other conditions. The picture is not yet clear and a great deal of research needs to be undertaken.

Colour has played, and will continue to play, an important role in the production and presentation of food. Our first impressions of food are influenced by its appearance. Food has to look good for us to eat it.

Adding colours to food products is a controversial subject. Certainly the use of added colour is more difficult to justify in technical terms than the use of other categories of additives such as emulsifiers which fulfil a clear technological purpose.

Colour has a number of important biological functions, as peacocks and zebras ably demonstrate. In the case of black and yellow striped caterpillars, colour can say 'be warned! eat me at your peril!'; in the case of fruit such as strawberries, colour can say 'eat me! I taste good!'.

Functions

The purpose of adding colours to food is to improve its general appearance. Or, in other words, colour additives are used for sensory purposes such as taste, smell and appearance, and not for more clearly defined technological purposes.

The appearance of our food is important in many nutritional situations - from introducing young children to new foods to encouraging patients to take food to aid recovery.

Applications

The examples of foods which contain added colours is extremely varied. They range from soft drinks, confectionery and sauces through to tinned peas, soups and fish fingers.

Technological needs/benefits

Colouring of food products takes place to:

- *enhance* the natural colour. The ingredients used to produce a particular food may well have their own colour. However, this is often weaker than the colour normally associated with this food and with its flavour.
- ensure *uniformity* of colour in foods from batch to batch. A food such as a jam bought in December would be expected to look like a similar pot bought in July.
- *replace* colour which may have been lost during the processing procedures and subsequent storage of the product. Colour can also be bleached out by the use of preservatives or affected by light during lengthy storage.
- *add* colour to those products which would otherwise be entirely colourless. Many drinks and boiled sweets fall into this category.

Adding colours help consumers to recognise products, for example, flavoured yoghurts and pickles such as piccalilli.

Brands of jam can be compared since they are packaged in transparent containers.

Our perception of taste, colour and smell seem to be related. It may be that food has to 'look like' the 'correct' taste for us to perceive the taste accurately. For example, a colourless, shapeless product is very difficult to identify and clues such as colour seem to enhance our perception.

The fine discrimination which we are capable of demonstrating, between very closely related flavours, is almost certainly attributable to our sense of smell.

The merit, or otherwise, of the use of colours in processed foods is a matter of consumer perception or, to be more precise, the perceptions which food manufacturers have of their customers' needs.

Critics have accused food manufacturers of using colours unnecessarily and, in particular, of using colour to make nutritionally inferior products appealing to the consumer.

Food manufacturers insist that they must always be sensitive to concerns of their customers and claim that trials of foods with no added colours, e.g. canned peas and strawberries, demonstrate that such products have no consumer appeal. By the same token, food manufacturers did not hesitate to reduce their reliance on artificial colours following adverse publicity about them in the late 1980s.

For example, tinned strawberries would be a dull brown and tinned peas a khaki green colour.

Origin and chemistry of food colours

Food colours are divided into 3 main types:
***Natural colours** which are derived by various procedures from a natural source.*
***Nature identical colours** which are chemically synthesised but also occur as coloured substances in nature.*
***Synthetic colours** which are chemically synthesised but do not occur in nature.*

The main chemical classes of *natural/nature identical* colours are:

- flavanoids, from many flowers, fruits and vegetables
- carotenoids, from carrots, tomatoes and oranges
- porphyrins, from chlorophyll
- indigoid, from beetroot
- anthraquinones, substances such as cochineal found in insects of the species *Dactilopius coccus*
- phenalones, substances such as curcumin from the dried rhizome of Curcuma longa (turmeric).

The main chemical classes/examples of synthetic colours are:

- azo dyes, such as tartrazine and amaranth
- 'other' dyes, such as, quinoline, (known as quinoline yellow), xanthene, (known as erythrosine), triarylmethanes, indigoid, (known as indigo carmine).

Colours from natural sources can be obtained from many plant and animal materials. Some of which have already been mentioned. Others include grasses, leafy vegetables, fruit skins and seeds.

Most natural and nature identical colours are soluble in oil rather than water. To make them suitable for use in food products, other additives like emulsifiers are used to disperse them in water. They are then re-processed to form salts of sodium or potassium, thereby becoming water soluble.

Synthetic colours are usually water soluble. There are some commercially available products which have been produced from water soluble colours which actually behave as pigments, the so-called 'lakes'. These dyes are rendered insoluble by being absorbed onto hydrated alumina (aluminium oxide).

The range of colours

In Europe, a total of 43 colours with E-numbers are permitted according to an European Community (EC) directive. The directive also lists the foods which may be coloured and maximum levels of colour added to those foods. The large number of colours allows many different shades to be produced.

The levels allowed in a product are very low. Synthetic colours have a strong hue and are allowed at typical concentrations of 0.01g/kg to 0.02g/kg (0.001%-0.002%). Levels of natural/nature identical colours are from 0.05-10g/kg of food product. Caramel colours are allowed at these higher levels which explains why they account for over 90% of all colour use in volume terms.

The choice of colour is dependent on a number of factors:

- for products with a long shelf life, such as soft drinks which are bottled in transparent containers, light stability is an important consideration.
- some colours are sensitive to the decolorisation brought about by reducing agents such as vitamin C. In these cases colours not sensitive to this particular reaction must be used.

Safety (see Safety and regulation of food additives, page 22)

Safety to do with the use of food colour is controversial. Concern has been expressed, in particular, about synthetic colours. However, there is no logical or scientific reason to suggest that the coloured chemicals present in nature are inherently safer than those which are manufactured. All additives, including those used to colour food, have to be tested and shown to be safe. Nevertheless, some people are sensitive to certain colours, and there are claims of links with hyperactivity, asthma and other allergic reactions, (see Food Allergy and intolerance, page 24).

Emulsions found in the context of food can be of two sorts. In an *oil-in-water* emulsion (o/w), small droplets of oil are dispersed through the water. The water is said to be the *continuous* phase. In a *water-in-oil* emulsion (w/o), small droplets of water are dispersed through the oil.

An **emulsifier** or *emulsifying agent* has the ability to keep an emulsion mixture in a stable state, that is, the two immiscible liquids are prevented from separating.

*Oil is **immiscible** with water. Together, they form two separate layers; and as oil is less dense than water it floats on top. When shaken vigorously it is possible to get them to mix temporarily to form an emulsion. This is where tiny drops of one liquid will be dispersed in the other liquid. On leaving to stand the mixture will revert to its two layers.*

Functions

Emulsifiers are widely used in food manufacturing. They actually possess a broad range of functional properties which find many applications in food products.

The most important functional types are:-

Emulsion stabilisation

Food emulsions are either oil-in-water emulsions, e.g. liquid milk, in which the milk fat is the dispersed phase and water the continuous phase; or water-in-oil emulsions, e.g. margarine, in which water is the dispersed phase and oil the continuous phase.

The emulsifiers allow the oil and water to be mixed more easily resulting in a finer droplet size of whichever phase is dispersed within the continuous phase.

Dough-conditioning

Wheat is by far the most important cereal crop in the UK diet. Wheat flour is used in the production of bread. During the processing of a wheat dough, a wheat protein called **gluten** forms a *network* which is responsible for the dough's elastic nature. A high quality product will only be produced if this network is of a good quality. If it is weakened during processing, the carbon dioxide produced during yeast fermentation will escape resulting in bread of poor quality. Emulsifiers with larger molecular structures, particularly *diacetyl tartaric esters* of **monoglycerides** (E472e), interact with the gluten in such a way as to strengthen the gluten network.

See page 2, paragraph; tartaric acid

Starch complexing

Starch, which is present in flour, consists of two types of carbohydrate. These are called **amylose** and **amylopectin**.

Amylose is a smaller molecule than amylopectin. Its molecular weight varies from about 10 000 to about 50 000. This corresponds to the molecule being made up of 70-350 units of the sugar **glucose**.

The structure of amylopectin is more complicated. It may contain as many as 100 000 glucose units and consists of short parallel chains of glucose linked together.

When flour is mixed with water, both carbohydrates swell and form a **gel**. However, with time, the starch components will re-crystallise and squeeze the water out of the gel. This phenomenon is known as **retrogradation**. This is responsible for, amongst other things, the staling process in bread.

Amylose retrogradation occurs more rapidly than amylopectin retrogradation. Some emulsifiers, e.g. monoglycerides (E471), can form complexes specifically with amylose and hence retard the rate of retrogradation. They are used as anti-staling agents in bread.

This amylose complexing effect is also used to prevent stickiness in extruded products, pasta and instant potato.

Aeration and foam stabilisation

Examples of emulsifiers often used for this application are lactylated monoglyceride (E472b) and propylene glycol esters of fatty acids (E477).

A **foam** consists of a *gas* dispersed in a continuous *liquid* phase. A great number of food emulsions (o/w) are *aerated* to produce foams, e.g. dairy and non-dairy cream, ice-cream, re-hydrated spray toppings. When milk is used in these products, the presence of milk proteins act as natural emulsifiers. Thus if other emulsifiers are added it is for a different function. They are used to influence whipping and improve properties such as stiffness, volume and stability of the finished foam. During the whipping/aeration process they promote the agglomeration (clustering together) of the fat globules. The fat globules are then capable of coating the small pockets of air which are introduced during whipping. Therefore, the foam produced is stabilised.

True sponge cakes are completely fatless. Many other cakes contain very little fat. It is more difficult to produce a stable product in these examples. Specially produced emulsifiers facilitate aeration and increase the whipping rate of the cake batter in these cases. This helps to produce a more even cell structure and better volume in the finished cake. Emulsifier preparations, typically of monoglycerides in a special gel form, are used.

Crystal modification

Most fats are **polymorphic** (poly = many, morph = shapes/forms). They can exist in more than one *crystalline* form. These are called alpha, beta-prime or beta.

In chocolate containing cocoa butter substitute, the fat tends to rise to the surface of the chocolate as crystal form changes resulting in a white layer or fat bloom being created. The emulsifier sorbitan tristerate (E492) is used to prevent this from happening.

If fats are melted and cooled rapidly they will crystallise into their alpha form. Alpha crystals have the lowest melting point of all three forms and are also the most unstable. They will soon convert into the more stable beta or beta-prime form. There can be several practical consequences of this. As the crystal form changes, the new crystals are larger and coarser than the original. This will have a negative effect on the texture of the products, for example, this could occur in margarine made from hardened sunflower or rapeseed oils.

Applications

The foods in which they are most commonly used are given below:

- *biscuits*
- *extruded snacks/breakfast cereals*
- *cakes*
- *bread*
- *margarine/spreads*
- *coffee whiteners/topping powders*
- *desserts/mousses*
- *peanut butter*
- *soft drinks*
- *chocolate coatings*
- *caramels/toffees*
- *chewing gum*
- *frozen desserts/ice-cream*
- *dried potato*

Emulsifiers are among the most frequently used types of food additives.

The use of emulsifiers in bread:

- gives the fermented dough more tolerance to mechanical handling as it is moved around the bakery
- inhibits the rate at which bread goes stale.

Technological needs/benefits

It can be seen that the range of products in which emulsifiers are used is wide. The reasons for this include:

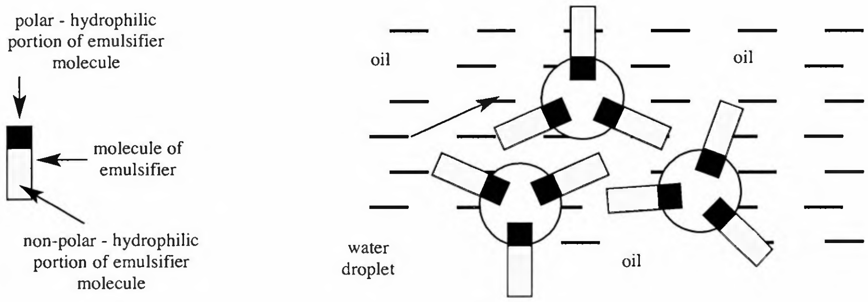
- To make foods *appealing* - emulsifiers have a pronounced effect on the structure and texture of many products.
- To aid in the *processing and preparation* of foods - modern high speed food processing techniques often require the use of emulsifiers to give the product the required tolerance to the production process.
- To maintain product *quality* and *freshness* - this role may well be expected to be filled by **preservatives** or *antioxidants*. However, in many products emulsifiers play a similar role, for example, the control of mould growth in low fat spreads by creating an emulsion with a finely dispersed water phase of a small droplet size.

- To increase *choice* - the functional properties of emulsifiers often allow a much wider choice of raw materials for the manufacturer resulting in greater choice for the consumer in the different product variations. Indeed, many common products simply would not exist at all, for example, low fat spreads, fatless sponges. Costs too can be lowered without reducing the nutritional value of food.

How do emulsifiers work?

Essentially emulsifiers can be thought of as consisting of two parts. One of these parts is described as being **hydrophilic** (hydro = water, philus = loving). The other part is a **lipophilic** (lipo = fat/lipid) structure.

In a w/o emulsion, the emulsifier is orientated in such a way so that the **polar** part dissolves in the water and the lipophilic part dissolves in the oil (see diagram). In effect, the emulsifier forms a complete protective film around the water droplets and yet allows them to be dispersed evenly through the oil.



This property makes emulsifiers indispensable in the modern food industry where foams, suspensions (particles of solid dispersed evenly through a liquid) and emulsions are used so frequently.

Origin and manufacture of emulsifiers

The raw materials used in the production of emulsifiers are primarily *natural* **organic** products. However, organic acids such as lactic acid, citric acid, acetic acid and tartaric acid are used in the production of emulsifiers. So too are polyols, such as sorbitol and propylene glycol.

Natural organic materials include vegetable oils, such as soya and palm oils, and animal fats, such as lard and glycerol.

By far the most common type of emulsifier used in the world are the monoglycerides. These are produced by reacting **fatty acids** with **glycerol**. This reaction produces a mixture where about 40% of the product is monoglycerides. This is a commercial product in its own right. However, it can be concentrated in a process known as *molecular distillation* so that a product containing 90-95% monoglycerides is formed.

Most of the other emulsifiers are produced by the **esterification** of other materials, such as lactic acid with mono-diglycerides or distilled monoglyceride, i.e. the E472 a-e group of additives.

Esterification reactions are those which produce ester groups between reactants; ester groups are found in the animal fats and vegetable oils commonly used as food ingredients.

The range of emulsifiers

One might question why there seem to be so many different emulsifiers. A particular emulsifier is capable of producing very subtle but desirable differences to similar products. Each food manufacturer wishes to optimise the product or process so that slight differences in functionality become commercially very important.

By far the most commonly used emulsifiers are lecithin (E322) and the mono- and diglycerides of fatty acids (E471).

There are specific areas of the tongue which can detect the different tastes. The tip perceives both salt and sweet tastes. The sides detect sour and the back perceives the bitter sensation. Each of these sensations may have different qualities depending on the chemical structure of the food ingredient applied.

It is our sense of smell which enables us to distinguish between similar types of food such as oranges and lemons.

Some cheeses, such as parmesan and camembert, smell different once they are in the mouth.

There is really only one way to demonstrate that a particular flavour is suitable for a particular product. This is by incorporating it into the food and then evaluating the product ***organoleptically.*** *This involves using specialised facilities for smelling and tasting in both flavour and food companies. The results from taste panels can then be statistically analysed.*

The acceptability of any food product greatly depends on the impression of *taste* when it is eaten. Our sense of taste is really a combination of two of our senses, taste and *smell*. Both of these senses are responses to certain *chemicals*.

The **receptors** for the human sense of taste are located on the tongue and on the soft palate. There are just four *stimuli* to which these receptors respond. These are sweet (as in sugar), sour (as in acidic substances), bitter (exemplified by strong coffee or quinine in tonic water) and salt.

Our sense of smell is far more complicated than our sense of taste. The area which is sensitive to odour is located at the back of the nose. It consists of several million receptor cells which make up just one square centimetre of nasal tissue. The receptor cells respond individually to many thousands of discrete, volatile chemicals. One function of the brain is to integrate these responses and turn them into an impression of an odour. How the receptor cells function, or what the characteristics of individual chemicals which actually stimulate them are, is not well known or understood.

Before a food is eaten, an odour impression is obtained by our sense of smell. When the food is taken into the mouth, a taste impression is made. This is enhanced by the chewing process and because more odour is transferred from the mouth to the back of the nose. In many instances this second odour profile is quite different to the initial impressions gained.

It might be that sight plays an unexpectedly important role in our perception of flavours. The taste of a colourless, shapeless food is extremely difficult to recognise. We may need visual 'clues' to enable us to identify taste and flavour accurately.

Function

Flavourings are added to food products to give, enhance or intensify flavour.

Applications

Flavourings are used in a wide range of food products.

The performance of any flavouring will depend upon the medium in which it is used. Some foods are high in water content; other foods have a high fat content. Each of these situations, and others in between, will significantly modify the performance of a specific flavouring.

Different media will selectively extract certain ingredients and will alter the perceived flavour profile. It is essential, therefore, that flavours are designed with their end use in mind. Most flavour producing companies have application facilities in which flavours can be tested in a variety of food products which closely resemble those on sale. These facilities are used to ensure that flavourings will satisfy the production conditions of the food which is to be flavoured.

Technological needs/benefits

- Some products, like ice cream and margarine, would be unacceptable without the addition of flavourings.
- New foods such as meat analogues made from spun vegetable protein would, without added flavour, be uninteresting, despite being extremely nutritious.
- Some products, like table jelly, would have no flavour at all without the addition of flavourings.

- Some products, like strawberry yoghurt, have natural flavour present but possibly at a low intensity. Flavourings may be added to enhance the natural flavour.

The chemistry, origins and manufacture of flavourings

Different foods may contain more than a thousand volatile compounds and many non-volatile compounds. Many of the naturally occurring compounds may be too unstable to use in the preparation of commercial flavourings where adequate shelf life is a prerequisite. It is almost impossible to identify exactly the compounds which are responsible for a specific flavour. Hence, it is incredibly difficult to precisely copy a natural flavour.

Bitter almonds contain only a few (5 or 6) volatile compounds responsible for their characteristic flavour, whereas coffee or strawberries contain more than 1 500 discrete identified chemical substances within their flavour volatiles.

Flavourings are used in food products in very low concentrations. They are normally made from a mixture of substances which are combined with a neutral solvent or carrier. This provides a product with a flavouring that can be physically handled and yet is of a suitable strength.

Flavouring ingredients are classified into four categories:-

Flavouring substances

Flavouring substances are well defined chemical substances with flavouring properties. They are sub-divided into *natural, nature identical* and *artificial* depending on their method of preparation and their occurence in nature or otherwise.

The starting materials for *natural* flavouring substances are animal and vegetable matter. This material may be used raw or can be processed solely by physical, microbiological or enzymatic methods during food processing.

Natural citral is extracted from lemon grass and natural benzaldehyde from bitter almonds.

Nature identical flavouring substances are chemically identical to natural flavouring substances. They are prepared by, or extracted using, chemical methods.

Nature identical flavouring substances include: ethyl acetate (identical in nature to many fruits) and decanal (nature identical to orange).

It is very important to remember that naturally occurring compounds that are built up in the laboratory are exactly identical to those substances found in nature. The body cannot distinguish between them and metabolises them in the same way. The best example of this is vanilla.

Vanilla was originally prepared from vanilla beans but is now produced chemically from a plant material called lignin.

Artificial flavouring substances are compounds which are not chemically identical to natural flavouring substances. Examples are ethyl vanillin or ethyl maltol which have not been identified in nature.

Flavouring preparations

Flavouring preparations are materials other than flavouring substances which also have flavouring properties. They too are obtained from animal or vegetable material by solely physical, microbiological or enzymatic processes. They are classified as *natural.*

Essential oils, extracts, tinctures and even fruit juices come into this category if they are used for their flavouring properties.

Process flavourings

Process flavourings are produced by heating together materials which themselves need not have flavouring properties. One of these materials must contain *nitrogen* in the form of an amino group (e.g. $-NH_2$) and another must be a *reducing sugar*. This process is analogous to the processes that occur when meat, or other similar material containing protein and reducing sugar, is cooked.

Smoke flavourings

Smoke flavourings are smoke extracts which are obtained by the extraction of smoke generated in a similar way to that used in traditional smoking processes.

The creation of flavours

The average flavouring contains between 5 and 50 ingredients. A few flavourings contain many more.

Most flavourings are an imitation of the flavour of a known foodstuff. Because of the complexity of natural foods, it would not be possible or practical to produce a commercially viable flavouring which contains the huge number of ingredients present in the original flavour. The job of a *creative flavourist* is to identify the substances present in a food and evaluate the contribution of these compounds to the overall flavour. The task is then to combine the most important of these compounds, and other ingredients, into a *flavour profile* which mimics the particular food in the most effective way.

A word on monosodium glutamate

Monosodium glutamate, MSG (E621) is technically known as a *flavour enhancer*. Glutamate is an **anion** of the **amino acid,** glutamic acid which is a building block of all proteins. It is a naturally occurring substance which is found in many plant and animal tissues. It occurs naturally in mushrooms and tomatoes. Human breast milk contains 22 mg per 100 ml of milk.

Since ancient times, oriental cooks have used a particular seaweed to make a stock which added richness to their foods. Early in the twentieth century a Japanese scientist identified the active substance in the seaweed as glutamic acid. It was not long before monosodium glutamate was commercially produced. The taste perception caused by glutamic acid was described as a fifth taste sensation. The Japanese scientist called it 'umami' which roughly translates as 'deliciousness'. It is perceived as a mouth-filling or mouth watering sensation.

Restaurants serving oriental foods often supply shakers of monosodium glutamate. Doubt was thrown on its safety with the appearance of symptoms which were collectively called the 'Chinese restaurant syndrome'. These symptoms included nausea, numbness and dizziness. However, the link between MSG and the syndrome has been proved to be tenuous in the least. At the concentrations used in food production, MSG has no adverse effects except for those individuals who are acutely sensitive to it.

See chapter on Food allergy and intolerance, page 24.

Many natural raw materials are used in the stabiliser industry. The stabilising properties of many natural raw materials have been used in foods for hundreds of years. The ingredients used in the stabiliser industry are varied and widespread.

Functions

The functions of these substances is fairly self explanatory:

- Gelling agents gel foods, i.e. they give shape and structure.
- Thickeners or thickening agents make foods thicker.
- **Stabilisers** help to retain the physical and textural properties of foodstuffs which have been through many different processes such as production, transport, storage and cooking.

There are many different situations where stabilisers are employed - from preventing separation of oil and water components in a sauce or spread, to reducing ice crystal formation in frozen desserts.

Applications (See next section for details)

Some examples of common applications include:

for gelling agents

- Jams and marmalade, which often use **pectin** (see below).
- Fruit preparations used in dairy desserts and in bakery products such as pies, tarts and biscuits.
- Desserts and confectionery jellies - to enable them to set.
- Vegetarian burgers, sausages, etc. - to hold them together as they cook.

for stabilisers

- Ice cream and ice lollies - to prevent the appearance of large, grainy ice crystals or ice lumps and give ice cream the firm texture, smooth taste and good keeping qualities associated with the modern product.
- Many reduced fat or low fat products - in their manufacture.
- Sauces and dressings - to avoid the separation of the oil and aqueous components.

Stabilisers are often confused with preservatives. Stabilisers maintain the physical characteristics of a product whereas preservatives help to maintain its microbiological qualities.

for thickeners

- Many sugar reduced or low sugar products require gelling agents or thickeners to substitute the performance effects of sugar in the traditional product.

Technological needs/benefits

Many of the foods already mentioned can be made at home without the addition of gelling agents, thickeners or stabilisers. So why are these additives used so widely in the food industry? Food cooked at home is often produced in small quantities. It is usually eaten shortly after it has been prepared and cooked. Processed foods, on the other hand, are produced in comparatively large quantities. They are expected to have a far longer shelf life, which could even be years in some cases. This may require processes such as freezing or the high temperatures of canning or UHT processing.

Products such as jam, marmalade, syrup and treacle all have a high sugar content. However, jam and marmalade are set whereas syrup and treacle flow. This is because a mixture of polysaccharides called pectin is responsible for the formation of a gel which sets preserves.

The formation of a gel is affected by the amount of sugar and the pH of the mixture; the best sets being obtained when the pH is quite acidic, around a low value of pH 3.5.

Fruits such as currants, damsons, gooseberries, lemons and bitter oranges are rich in both acid and pectin. These can easily be made into jams. The home jam maker will know that it is more difficult to make jam from fruits such as strawberries, raspberries and cherries.

Other specialist types of pectin known as low ester pectins are used to produce the reduced-sugar jams. Without these it would only be possible to have reduced-sugar runny fruit syrups!

Fruits, such as strawberries, which are very low in pectin need extra pectin added before jam can be successfully made from them. It is possible to rectify the situation by adding a small amount of a fruit rich in pectin to the mixture. Alternatively, commercially produced pectin can be used.

Gelling agents are important in the fillings for commercial fruit pies. Without them the filling would boil out during cooking or soak through the crust of the pie during the period that the pie spends in the supermarket and at home after purchase; both are unacceptable situations to the consumer.

Low calorie (kilocalorie) drinks, just like reduced sugar jams, often need a thickener to give body and remove wateriness.

Sugar obviously provides sweetness and energy **(kilocalories)** to foods. Less obviously it also contributes to the body and structure of the food. When reduced sugar products are produced it is often necessary to add a gelling agent or thickener to restore a texture comparable to the high sugar product.

Many long-life yoghurt products could not have a long shelf life without a stabiliser to protect the milk protein. Thick milk shakes would be difficult to produce without the help of thickeners.

Many desserts rely on gelling agents to gel or set. Many milk desserts and water based jellies would remain liquid without the assistance of gelling agents. Cocoa powder in chocolate milk drinks would settle to the bottom of the pack or bottle without the help of a suitable stabiliser.

Vegetarian foods are becoming more popular and readily available. The protein used in vegetarian burgers and sausages is often based on soya protein. However, the proteins used in these products do not have very good binding properties. Such products would easily disintegrate during cooking. This can be overcome by the use of special gelling agents which retain their properties at cooking temperatures.

A smooth textured ice cream will become grainy with storage and with repeated variations in temperature. Transportation between shop and home and taking the product in and out of the freezer is enough to encourage the formation of ice crystals.

Ice creams or ice lollies made without stabilisers tend to have a grainy feel in the mouth. This is due to the formation of undesirable, large ice crystals. The use of stabilisers helps to assist the formation of a weak network of molecules through the ice cream which enhances the texture, resists melting and, just as importantly, retains these qualities until the product is consumed.

Low fat spreads, dips and dressings would have a watery consistency and may separate into their oil and water components without the addition of stabilisers or gelling agents.

Many consumers are aware of the health benefits of reducing their intake of fats and oils. Even so, the average diet still contains too much fat compared to medical recommendations. Reduced fat or low fat versions of traditional products are now being produced. When a quantity of fat or oil is removed from a product, the equivalent mass must be replaced if the product is to be comparable with the traditional one. Often the mass is replaced by adding water and either a gel, thickener or stabiliser to restore the texture.

Stabilisers help to maintain many sauces in good condition. Without their use the sauces, both in sweet and savoury products, would at least partly separate into their original components. This is not unsafe but it is unattractive to the consumer.

How do they work?

Most thickeners, gelling agents and stabilisers are long chain molecules, or polymers. They are built up of a large number of smaller units or monomers. Glucose is an example of such a monomer. It is possible to have hundreds of monomers in each chain.

Stabilisers improve the stability of a mixture, such as an emulsion, by increasing the **viscosity**. Stabilisers increase the interlocking and interactions between the long chains of molecules present in an emulsion. This reduces the freedom of movement of the dispersed droplets and lessens the chance of their coming into contact and coalescing.

If the molecular interactions are particularly strong - and often this is helped by additional components in the foodstuff – **gelation** may occur. In gelation, commonly the polymers will form a regular ordered structure, similar to crystallisation. This is the case in jams, table jellies, etc.

Origin and manufacture of gelling agents, etc.

The substances belonging to this group are high molecular weight compounds. They are usually **proteins**, such as *gelatin,* or *complex* **carbohydrates**, such as *pectins*, **starches**, *alginates* and *gums*.

Gelling agents, thickeners and stabilisers can be divided into a number of different categories. These categories reflect their different origins.

The *seeds* of certain plants are valuable sources. In these cases the outer husk and protein containing parts of the seed are removed by physical means. The seed endosperm (the seed's food store) is then milled to a powder. Substances obtained in this way include guar gum (from *Cyamopsis tetragonolobus* or C. *psoraloides*), locust bean gum (from the locust or carob tree *Ceratonia silqua*) and tara gum.

Seeds
Agents from seeds include:
- *guar gum*
- *locust bean gum*
- *tara gum.*

Plant exudates (substances which may ooze out of a plant) include gum arabic (acacia gum from *Acacia senegal*), karaya gum (from the *Sterculiaceae* family) and tragacanth gum (from *Astragalus gummifer*). These are normally cleaned and milled or flaked.

Plant exudates
- *gum arabic*
- *karaya gum*
- *tragacanth gum.*

Pectin is present in many plants. It is extracted by dissolving the pectin out of the plant using water. The solution obtained is filtered and the pectin is then precipitated out.

Pectin
Commercially extracted from fruit, especially citrus fruits and apples.

Cellulose is another basic plant material. This is the raw material for a number of cellulose related compounds, such as carboxymethyl cellulose, methyl cellulose and microcrystalline cellulose. In the first two compounds the cellulose molecules have been modified to make them soluble in water.

Cellulose
most plant material

Maize and potato plants are the commonest source of *starch*. Native starches can be used but improved specialist properties can be obtained by chemical treatments.

Starch
- *maize*
- *potato*

Specific types of *seaweed* will yield agar (red seaweeds such as *Gelidium algae*), alginates (brown seaweeds such as *Laminaria*) and carrageenans (from the seaweed *Chondrus crispus*). Nowadays, these seaweeds are often farmed rather than collected from the seashore.

Seaweed
- *agar*
- *alginates*
- *carrageenens*

Special fermentation methods can be used to produce gums such as xanthan gum (from *Xanthomonas campestris*) and gellan gum.

The need for gelling agents, thickeners and stabilisers

The current use of many of these agents in food may seem unnecessary, but the reasons for use reflect:

- the huge range of foods eaten
- the different processing and cooking techniques
- the various storage methods and shelf life requirements
- the different temperatures, forms and states of the foods.

Different textures or effects will be required for different foodstuffs and this may well vary through the seasons of the year. Normally, only a very limited number of additives will function in a specific food or food production process. Sometimes a specific combination of one or two is required.

Factors such as:
- *solubility temperatures*
- *gel formation*
- *stability to acid*
- *stability to high temperatures*
- *stability to freezing temperatures*

affect the choice of this sort of additive to specific food situations.

The oldest known food preservative is probably wood smoke. Prehistoric man may have stumbled across the fact that meat and other foods that came into contact with the smoke from his fires, lasted just that bit longer than normal. This chance find led to the development of smoke houses specifically designed for this purpose. This ancient method survives into our modern times. Some meat, particularly bacon, and fish, such as haddock and salmon, are smoked.

The production of bread, yoghurt, cheese, wine and a host of other products rely on the presence and growth of specific microbes. Any preservative or method of preservation employed in this type of product must take into account the role of these useful microbes.

There are many methods of food preservation currently in use in domestic and commercial situations. All of them attempt to remove one or more of the factors necessary for the growth of microbes. Microbes, like other living organisms, require nutrients, water and energy to multiply. If any one is absent, microbes will not reproduce. Processes such as freezing lower the temperature so it is unsuitable; processes such as drying remove the water necessary for life. The first ever convenience foods were canned. Canning uses temperatures high enough to kill all microbial life. The production of pickles, chutneys and jams still goes on in many households so that large quantities of foods do not go to waste, food can be eaten out of season and variety is added to our diets.

Nor must **preservatives** be seen as being capable of substituting for good food hygiene practice. No preservative can bring spoiled products back to an acceptable level or cover for the effects of poor quality processing. They must be incorporated into stringently clean and hygienic methods of production.

The greatest threat to the quality and safety of our food comes from *microbial spoilage*. Microbial spoilage may result in loss of sensory qualities leading to such things as bad taste, unpleasant smell and poor appearance. It may result in the loss of nutrients. More importantly, it may increase to a dangerous level the presence of harmful microorganisms or the toxins (poisons) they produce.

Important fields of application include:

- *soft drinks and other beverages*
- *cheeses, margarine, mayonnaise and dressings*
- *bakery products*
- *fresh and dried fruit preparations*
- *prepared salads, delicatessen products, pickled vegetables*
- *pasta products, fish and seafood*
- *and many others.*

A single bacterium can double its number every 20 minutes, thus one which has landed on food can give rise to over 16 000 companions in just 4 hours.

Different species, and even different strains of the same microorganism, show different sensitivities to different preservatives. This goes some way to explaining the large number of different preservatives in use today.

Function

The function of preservatives is straightforward; to control the growth of **microorganisms** which cause decay in foods and beverages ensuring this food and drink is safe for human consumption.

Applications

Food preservatives are used in a wide variety of foods and beverages (see margin).

Technological needs/benefits

Microbes are all around us, in the air, on our hands and in the food we have just picked from the garden. Their numbers and types vary according to the situation. A single bacterium, given suitable conditions, is capable of reproducing at a remarkable rate. A number of different preservatives are needed to combat this potential danger.

Most preservatives today are actually **fungistatic** in their action, that is, they are used to prevent the growth and proliferation of fungi, moulds and yeasts. Their antibacterial activity is less pronounced but a combination of preservatives, each with some antibacterial action, can be used to give good all round protection.

Food preservatives reduce the risk of exposure to harmful microorganisms and their products. They help to control the spread of those bacteria which can cause life threatening illnesses such as salmonellosis or botulism.

How do preservatives work?

Food preservatives have to be safe for human consumption. They must not impair the function of the cells of the human body, whilst they are interfering with the normal functioning of microbe cells responsible for decay.

All preservatives have particular optimal impact at specific concentrations. Use of too low a concentration may result in inadequate control of microorganisms. This may extend the shelf life of a product for a limited period only. Preservatives tend to be used at a concentration sufficiently high to suppress microbial growth.

However, there are maximum permitted levels of preservatives so that exaggerated usage is not possible.

There is much concern about the increasing incidence of the phenomenon of **resistance** of bacteria to antibiotics. Over the decades in which preservatives have been used, there has been no need to increase the dosage to maintain their effectiveness. It has been surmised that the use of these substances has not resulted in the selection of bacterial strains which are resistant to preservatives.

*Typically, preservatives attack the **enzyme** systems of cell metabolism leaving the cells unable to carry out normal chemical reactions. The preservatives are also capable of altering the properties of the cell wall of the microorganism so that substances are impaired from normal entry and exit routes. These two processes kill (fungicidal or bactericidal) or seriously affect the growth (fungistatic or bacteriostatic) of the organism.*

Origin and manufacture of preservatives

Preservatives are usually present in nature in such small quantities as to make them difficult to obtain. Therefore, they are produced as synthetic copies of the natural products. Other preservatives are manufactured in chemical reactions using a variety of substances as starting blocks.

Many preservatives are:

- *present naturally in fruits and berries*
- *produced by microorganisms*
- *produced in natural reactions, such as fermentation*
- *present as minerals*
- *found in their pure state, such as the gas sulphur dioxide.*

The range of preservatives

There are over 80 substances which have permitted use as preservatives.

Sorbic acid and its salts (E200-203) are the most important food preservatives for the industrialised and wealthy countries.

Sorbic acid has two main advantages favouring its widespread use:

- it is effective over a wide range of foods and beverages
- it imparts no taste or flavour to products.

Sorbic acid is used in beverages, dairy products, fish and seafood, fat-based products, fruit and vegetable products, baked goods and confectionery products.

Sorbic acid and its salts
Sorbic acid is a naturally occurring substance and is metabolised safely in the human body.

Benzoic acid and its salts (E210-E213) is also a widely used preservative and its use is important in less well developed countries. It is only used in acidic situations which include non-alcoholic beverages, products prone to spoilage by bacteria and fruit-based products.

Benzoic acid and its salts
Benzoic acid is a naturally occurring substance.

Sulphur dioxide and sulphites (E220-E228) are multifunctional food ingredients which act as preservatives, antioxidants and stabilisers of colour. They have a much more pronounced antibacterial effect than other preservatives and are therefore used when control of bacterial growth is essential. They are used in a wide range of products including packet soup, dried bananas and apricots, tinned crabmeat, sausage meat, beer, wine, quick frozen chips and jams.

Sulphur dioxide and sulphites
The Romans, Ancient Greeks and Egyptians used the gas sulphur dioxide to preserve wine.

Potassium nitrite and sodium nitrite (E249 and E250 respectively) are not naturally occurring substances. They are multifunctional in the food industry having preservative, stabilising and flavouring properties. There are health concerns about their use. However, without their contribution there would undoubtedly be many more deaths from the disease botulism which is caused by the bacterium *Clostridium botulinum.*

Potassium nitrite and sodium nitrite
E249 + E250 are particularly important in the preservation of cured meat products.

Propionic acid and its salts, the propionates (E280-E283) are other examples of naturally occurring preservatives. They work better in the more alkaline conditions of bakery products and may be used, for example, to delay the green mould growth on bread.

Propionic acid and propionates

There are a few more specialised preservatives in use for limited applications. Nisin (E234) is a naturally occurring antibacterial substance used in some dairy products and another, natamycin (E235), is used on the rind of ripened cheeses or dried meats.

Specialised preservatives
Even caviar has its own specialised preservative, boric acid/sodium tetraborate (E284/E285), to protect it! It is a buffer solution.

'Jack Sprat could eat no fat,
His wife could eat no lean,
But both got fat, from eating sugar,
Strange as this may seem.'

Science has shown that the desire for sweet taste is inborn. Five month old foetuses have been reported to respond positively to sweet taste.

The use of honey dates back to 2000 BC but it is sugar which has been the sweetener of choice for centuries.

On cans of low calorie soft drinks, energy content is often referred to as Calorie, for example cans often state there is 'less than 1 Cal' in the can; where 1 Cal (with a capital 'C') is equivalent to 1 kcal or 4.2 kJ.

Some people like to sweeten otherwise tart fruits like grapefruit. Many like sweet tasting tea and coffee. Bitter tasting medicines may be helped down by 'a spoonful of sugar'. Most sweeteners share the interesting property of being able to modify other flavours.

Humectant: a substance added to another substance to keep its moist

Sweeteners are generally used in:

- *beverages (carbonated, non-carbonated, milk-based and alcoholic)*
- *breakfast cereals*
- *confectionery (including chewing gum)*
- *desserts, fillings and toppings (ice-cream, sweet whipped cream)*
- *processed fruit and vegetable products (jams, jellies, baked beans, canned fruit)*
- *medicines*
- *syrups*
- *salad dressings and condiments*
- *baked goods.*

Sugar is a most important flavouring substance. It conveys the sensation of sweetness and provides a source of energy. However, sugar is associated with a number of health problems, including tooth decay, weight gain and it causes difficulties for diabetics.

Sugar has been used for centuries for its sweetness. More recently, alternatives to sugar, which provide the sweetness without the calories, have become common in commercial use. The **artificial sweetner**, *saccharin* was discovered in 1878 but its potential was not developed until much later. The World Wars made rationing of staple foods such as sugar necessary, thus the popularity of saccharin increased.

The *cyclamates* were discovered in 1937 but it was not until the 1950s that low **calorie** (energy is given in kcal or kJ) sweeteners came into significant use. At this time, food supplies were more secure and consumers were beginning to show interest in the concept of reduced calorie foods and drinks.

Functions

Obviously the function of sweeteners is to provide the sweet taste!

It is important to note that sugar has a number of different functions in food.

- it provides texture in baked goods
- it is a **humectant** in cakes
- it is a freezing point depressor in ice creams
- it acts as a preservative in jams
- it thickens liqueurs
- it strengthens mouthfeel in soft drinks
- it adds bulk to baked goods.

Artificial sweeteners cannot provide all of these properties.

Technological need

Applications

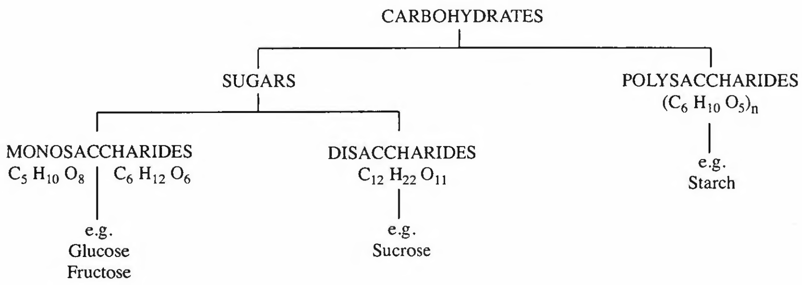
Sweetners are used in a wide variety of foods and beverages (see margin).

Sugar is still one of the cornerstones of the food industry. Today, in Western society, the nature of work has changed from active, often highly physical work to a far more sedentary lifestyle. In consequence, there has been a dramatic rise in obesity.

In an attempt to limit energy intake, a great demand has arisen for foods and drinks which have fewer calories (kcal or kJ) than their traditional counterparts. One way to accomplish this is to replace sugar with a sweet tasting, non-calorific sweetener.

Another reason for using sweeteners is to provide appropriate foods and drinks for *diabetics*. **Diabetes** results from a failure of the pancreas to produce a hormone called *insulin* which regulates the amount of glucose in the blood. Eating a sugary meal can be dangerous, even fatal, to a diabetic. Sweeteners allow diabetics to have sugar free, sweet tasting foods.

The chemistry and range of sweeteners



Sugars are one type of **carbohydrates**. Carbohydrates are ubiquitous in the plant and animal kingdoms.

Sweeteners can be:
sugars and sugar syrups

Household sugar is the carbohydrate called *sucrose*. This is a *disaccharide*, being a combination of the monosacharides, *glucose* and *fructose*.

Bulk sweeteners or sugar alcohols are significantly less sweet than sugar. They are based on sugar chemistry but are modified for various reasons of functionality or energy value. They do not contribute as many calories as sugar. They can add body and bulk to a product.

Xylitol has proven anti-cariogenic properties, that is, it can prevent tooth decay, and is often used in chewing gum.

Bulk sweeteners can act as a laxative if consumed in excessive amounts.
A warning to this effect is printed on appropriate packaging.

Bulk sweeteners or sugar alcohols

- *sorbitol*
- *mannitol*
- *xylitol*
- *maltitol and maltitol syrup*
- *isomalt*
- *isomaltulose*

The ***intense sweeteners*** are not able to be grouped chemically since there origins and structure are diverse. They are very much sweeter than bulk sweeteners and sugar. Intense sweeteners are generally used in products in which added sugars are undesirable. This may be for reducing calories (kcal/kJ), making tooth friendly confections or, in a few cases, for cost.

- *Aspartame* is a *dipeptide*, that is, a compound of two *amino acids* joined together. These are *aspartic acid* and *phenylalanine*. These are naturally present in living things. Aspartame has a sweetness value of about 200 times that of sugar. This means that only a very small amount is used for sweetening purposes.
- *Acesulfame-K* (the 'K' signifies that it is the potassium salt of acesulfame) is a synthetic compound. It is also about 200 times sweeter than sugar. Its taste is not as good as aspartame but it can act as a *synergist* with other sweeteners. This means that a mixture of two sweeteners can be sweeter than an equal quantity of either sweetener alone.
- *Saccharin* is about 300 times sweeter than sugar. It is a synthetic compound. The taste of saccharin is not ideal when used alone or at high concentrations. It synergises well with acesulfame-K and is more economical when used in this way.
- *Cyclamates* are not as sweet as most of the other intense sweeteners (30 times that of sugar). Again their taste is not ideal at higher concentrations but well suited for blends.

Intense sweeteners

- *aspartame*
- *acesulfame-K*
- *saccharin*
- *cyclamates*
- *thaumatin*
- *neohesperidine dihydrochalcone (NHDC) and soon to be approved*
- *alitame*
- *sucralose*

It is becoming more common to see blends of sweeteners used in foods and drinks. This is a good thing as sweeteners used in combination can be chosen to provide functionality far superior to that of any single sweetener. The concept of synergy will result in the use of less of any one sweetener and the exposure of the consumer to any single sweetener is reduced. The more safe sweeteners that can be found and approved, the more this trend will be realised.

Introduction

The legal blueprint for the establishment of a common, harmonised list of permitted additives across the EU was set out in the 1989 'framework directive' on additives (89/107/EC).

The EU was established under the Maastricht Treaty. However the European Community (EC) still exists and is the legal entity under which European law is made. Hence EC directives (e.g. 89/107/EC) are not EU directives.

Food additives are regulated and controlled on a European Union (EU) wide basis. The relevant directive clearly states that food additives are allowed only if:

- they present no hazard to health at the level proposed;
- a reasonable technological need can be demonstrated;
- they do not mislead the consumer.

The directive also states that all food additives must be re-evaluated wherever necessary in the light of changing conditions of use and new scientific observation.

The following sections describe briefly how additives are checked for safety and the procedures under which their use in food is controlled and regulated.

Safety

The SCF represents a broad cross section of expertise. Its members are appointed in their own right, as independent experts, not as representatives of national governments. The results of SCF evaluations are published by the European Commission. They are also accessible via the Internet.

http://europa.eu.int/comm/dg24/health/sc/scf1/index_en.html

The EU body responsible for evaluating the safety of food additives is the Scientific Committee on Food (SCF) which is a group of experts composed mainly of toxicologists.

The SCF has issued guidelines setting out the tests that must be carried out on food additives in order to demonstrate their safety. The guidelines require an extensive range of animal and other tests to assess every conceivable risk to the consumer:

- metabolic/pharmacokinetic studies (to understand how the body absorbs, distributes, metabolises and eliminates the substance);
- genetic toxicity (the potential for gene and chromosome damage);
- reproduction and teratogenicity studies (life-time studies, including the potential for fertility and birth defects);
- chronic and carcinogenicity studies (the potential for causing cancer).

Paracelsus: "All things are poisons; nothing is without poison; only the dose determines whether there is a harmful effect".

In assessing risk, toxicologists use a principle first stated by the 16th century physician, Paracelsus (see margin). Everything is toxic if consumed at a high enough dose, and everything is safe, with a few exceptions, if taken at a low enough dose. To put it another way, a threshold level exists above which consumption is unsafe and below which consumption is safe.

The ADI is defined as the amount of the additive that can safely be ingested daily, over a lifetime, without risk. It is expressed as mg of the additive per kg of body weight.

The aim of testing is the identification of an adverse effect caused by the additive. The aim is to test at three different dosages: the top dose should show an effect and both mid- and low doses show no effect. This being the case, the mid-dose becomes the no observable effect level (NOEL). This is considered to be a safe level for humans since there were no effects in animals. The toxicologist takes this level and applies a safety factor which recognises, amongst other things, that humans are not just big rats. The safety factor is usually, but not always, 100. The value then obtained by dividing the NOEL by 100 is called the **Allowable/Acceptable Daily Intake (ADI)**. So, for example, a NOEL of 5000 mg/kg gives an ADI of 50 mg/kg for humans.

The costs of the required safety testing for a food additive must, of course, be borne by the additive manufacturer, who invariably contracts out the work to an independent test house. The cost can be as high as several million pounds. Nevertheless, the SCF cannot afford to be anything other than scrupulously thorough and its reviews are rarely straightforward. The SCF usually asks the additive manufacturer for additional data and can insist on further testing. Eventually, when the SCF is satisfied with the data, it reports its findings to the European Commission.

Regulation and control

The adoption of an EC specification is necessary, in order to ensure that the product eventually sold has the same composition and purity as the product that was tested and evaluated. The regulatory procedure is quite straightforward, involving discussions among member state experts, under the Chairmanship of the Commission.

The procedure for final EC *approval* for the additive, involving agreement on the foods in which it will be allowed and maximum levels of use in each of those foods, is more complex. Three principal institutions are involved:

- the European Commission (appointed officials)
- the European Parliament (directly elected MEPs) which provides the political dimension
- the Council of Ministers (representatives of national governments) where differing national interests are resolved.

The Commission's proposals are issued after discussions with the member states, and input from consumer groups and the food industry. These proposals are, however, invariably amended further by the European Parliament and the Council. This, too, can take a great deal of time as agreement among the political groups in the Parliament and among member state representatives in the Council can be difficult. Final agreement of a joint text between the Council and the Parliament is also required. Consequently, the approval procedure is, unfortunately but necessarily, both long and arduous.

Armed with the SCF evaluation, the Commission can initiate the necessary legislation for EC directives on:

- *an EC specification for the additive*
- *an EC approval for its use in food.*

From start to finish, it can take 10 years to obtain an approval for a new food additive: 5 years to carry out safety testing; 1-2 years for the SCF to evaluate it; perhaps a further 12 months before the Commission is able to deal with it; 2 years to obtain EC approval; and at least 12 months before the directive is implemented by member states.

There are three directives on food additives, one on colours, a second on sweeteners and a third on remaining categories of additives, e.g. preservatives, stabilisers, emulsifiers, the so-called 'miscellaneous additives'. All have now been implemented into the national laws in each member state, which means the same additives are now allowed in the same foods in every country in the Union. A total of 297 additives are now approved for use in food across the Union (43 colours, 12 sweeteners and 242 'miscellaneous additives').

The directive on colours (94/36/EC) and sweeteners (94/35/EC) were both adopted in 1994. The directive on the miscellaneous additives (95/2/EC) was adopted in 1995. Each directive contains a list of permitted additives, the foods in which each of the additives may be used, and permitted levels of use.

"One man's meat is another man's poison" Lucretius 96-55BC

The fact that certain susceptible people suffer unpleasant reactions to foods which everyone else is able to enjoy without the slightest ill-effects has been known for a very long time. Lucretius recognised it, and famously paraphrased it, over 2000 years ago.

'Food allergy' describes an abnormal response triggered by the immune system.

'Food intolerance' describes an abnormal response that is not immunological in nature, for example, an enzyme deficiency.

These days, the terms 'food allergy' and 'food intolerance' are sometimes used interchangeably to describe the phenomenon - but these terms have a precise medical meaning.

Food allergy

The foods most likely to cause allergy are eggs, cow's milk, shellfish, wheat, fish, soya, peanuts (which is one of the main foods associated with severe anaphylactic reactions) and treenuts such as walnuts, but reactions can also occur to spices such as sesame or to vegetables such as tomato.

Food allergy is essentially 'immunity gone wrong', where a normally harmless, natural protein is perceived as a threat and attacked by the body's immunological defences. The resulting release of chemicals such as histamine in the body causes a variety of symptoms:

- gastrointestinal (e.g. nausea, colic, diarrhoea)
- respiratory (e.g. sneezing, wheezing),
- dermatological (e.g. eczema).

The most serious reaction is *anaphylaxis*, a life threatening shock that can occur within minutes of ingestion.

Food intolerance

Food intolerance can be caused by a number of mechanisms.

- *Alactasia* is a common form of intolerance to cows milk found in people who have a deficiency of the enzyme lactase, which digests the milk sugar lactose.
- Naturally occurring (so-called biogenic) *amines* such as histamine and tyramine, which reach high levels in cheese, some wines, tuna and mackerel, can also cause adverse reactions in susceptible individuals.
- Food additives, for example, certain colours, preservatives and anti-oxidants, can also cause adverse reactions. There is as yet little insight as to the mechanism, but it is not thought to be immunologically based.

'Double blind' because neither patient nor doctor knows what is being tested.

'Placebo controlled' because the patient is exposed to a placebo as well as well as the substance under test.

The literature on intolerance to food additives is confusing because many early studies reporting adverse affects from additives were unable to be replicated in later, more carefully conducted *double-blind, placebo* controlled studies - which today is the "gold standard" of allergy/intolerance testing. Nevertheless, adverse reactions to additives certainly exist, though not to the extent first thought. Where they have an effect, they are thought to exacerbate an existing condition, rather than cause it.

- *Sulphites* in high concentrations can affect a small sub-group of people with severe asthma. Steroid-dependent asthmatics are most at risk and anaphalactic type reactions, e.g. severe broncospasm, are reported to have occured on occasions.
- *Benzoates* can affect asthmatics and aggravate dermatitis.
- Azo dyes have been linked to a variety of symptoms, e.g. nettle rash, asthma and dermatitis. It is well established that tartrazine and other azo dyes can occassionally provoke nettle rash. Tartrazine is also known to have affected patients with dermatitis, but the link between tartrazine and asthmatics remains speculative at present.

- *Chinese Restaurant Syndrome* has been associated with monosodium glutamate (MSG), present in Chinese meals (see page 18). However, double-blind challenge has failed to confirm MSG as the provocative agent. There is evidence that the Syndrome is most likely caused by other components, e.g. histamine from fermented food ingredients, known to be present in this type of food.

There have been numerous studies of a possible link between colours and childhood 'hyperactivity', more correctly called 'attention deficit syndrome'. Results have, however, been equivocal - childhood behaviour is a complex phenomenon and psychological factors are known to play a part. There is evidence to suggest that diet can have an effect on children affected by the syndrome, but that does not mean that particular foods or food additives are the cause of the problems. In fact, only children with milder behavioural changes seem to benefit from an elimination diet, whilst more severe alterations of behaviour require other means of treatment.

How prevalent is it?

Adverse reactions to everyday foods such as milk, eggs, wheat and fish are believed to affect between 1% and 2% of the population. Adverse reactions to food additives turn out to affect a much smaller proportion of the population.

An extensive survey carried out by the High Wycombe Health Authority in the 1980s estimated prevalence to be 1.4% using strict criteria and 1.8% using less stringent criteria. As part of the High Wycombe study, a questionnaire was sent out to 11 000 households to find out how many of those questioned believed they were intolerant to food additives. A total of 18 562 individuals responded, 7.4% of whom claimed an adverse reaction to food additives. However, only three people showed adverse reactions that could be confirmed. It was estimated from this that the prevalence of food additive intolerance in the general population is in the range of 0.01% (using stringent criteria) to 0.23% (using less stringent criteria). This finding is similar to an earlier estimate by experts of the European Commission. Food additive intolerance therefore appears to be rare.

Intolerance is more common in children who, however, have usually grown out of it by the age of five. Trials at the Brompton Hospital suggest that food additive intolerance is a genuine problem in some children but is likely to be transient. These findings parallel the situation with allergies to food such as eggs and milk which are usually transient, but which may persist into adult life.

In summary, adverse reactions to food additives are rare; reactions to foods more common. There are, in any case, many causes of food related illness and it is important to consult a qualified professional to determine whether symptoms are related to allergy/intolerance, or other medical disorders.

Allowable/ Acceptable Daily Intake, ADI	the level of a substance such as a food additive that can be ingested daily over a lifetime without health risk; determined from toxicology tests, a dose is found which gives no observable effect, this is then divided by 100
acidulant	a food additive used to impart a tart, acidic taste to a food; may also assist in the setting of gels or to act as preservatives
amino acid	an organic compound containing both an amino group ($-NH_2$) and a carboxyl group (-COOH); essential component of proteins
amylopectin	is one of the components of starch; amylopectin consists of long chains of glucose units which are branched and linked to one another
amylose	is one of the components of starch; it is a smaller molecule than amylopectin and consists of straight chains of glucose units
anion	see ion
antioxidant	a substance which retards oxidation
anti-caking agent	a substance which enables a powder to flow freely
artificial sweeteners	substances which are not carbohydrates but which have the ability to impart the sensation of sweetness
bactericidal	having the ability to kill bacteria
bacteriostatic	having the ability to slow down the growth/multiplication of bacteria
bread/flour improvers	gluten obtained from 'old' flour is stronger and more elastic than the gluten from flour that has just been milled and hence will produce better loaf; this ageing process can be copied by the addition of tiny quantities of agents that are called improvers
buffers	substances which are capable of 'mopping up' excess acidity or alkalinity (excess hydrogen ions or hydroxyl ions) to maintain a constant pH
bulking aids	additives which add to the bulk of a particular food; often used in slimming products but may also be used to replace more expensive ingredients
Calories, kilocalories/ kilojoules	units of energy; 1 Calorie = 1 kcal = 4.2 kJ
carbohydrates	compounds which contain the elements carbon, hydrogen and oxygen; there is always twice as much hydrogen as there is oxygen, made up of sub units called simple sugars; carbohydrates are one of the major classes of nutrients; one function in the body is as an energy source
chelators	substances capable of combining with free metal ions; they are important in preventing the oxidation of food
COT	Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment
diabetes	a disorder of carbohydrate metabolism caused by a deficiency of insulin
diglycerides	see glycerol
emulsifier	a substance which allows an emulsion to stay in a stable state
emulsion	tiny drops of one liquid spread evenly through a second liquid
enzymes	biological catalysts, protein in nature, which control the rate of all biological reactions; some have uses in the production of food
ester	formed by the combination of an alcohol with an organic acid; fats and oils are examples of esters

esterification	the process which produces fats through a combination of glycerol and three fatty acids. Generally, the reaction between an alcohol and a carboxylic acid.
Food Advisory Committee, FAC	advises MAFF on the composition, labelling and advertising of food products
fatty acids	unbranched hydrocarbon chains having about 14-24 carbon atoms with an acidic group (see saturated/unsaturated fatty acids)
fats	compounds which contain the elements carbon, hydrogen and oxygen; made up of sub units called glycerol and fatty acids; fats are one of the major classes of nutrients; one function in the body is to provide energy
fermentation	a process carried out on a carbohydrate source by some microorganisms, particularly yeasts, which produces alcohol and carbon dioxide. The alcohol can be oxidised to acetic acid.
firming agents	food additives used to prevent the loss of crispness to fruit and vegetables during processing
foam	the dispersal of a gas in a liquid
food additive	food additives are those substances deliberately added to food by the manufacturer to facilitate processing or to improve the appearance, texture, flavour, keeping quality or nutritional value of foods
free radicals	reactive species which usually have an unpaired, or free, electron
fungicidal	having the ability to kill fungi and moulds
fungistatic	having the ability to slow down the rate of growth of fungi and moulds
gel/gelation	gels are systems where large volumes of liquids can be held stationary by small amounts of solids; gelation can be caused by polysaccharides such as starch or proteins such as gelatin
glazing agents	food additives used to produce a glaze which gives a shine and protection to a final product
glucose	a simple sugar; a monosaccharide; the most common substrate for respiration
gluten	a protein found in flour; it has stretching and elastic properties which allow it to provide a network within dough which can trap carbon dioxide
glycerol	is a sweet, sticky liquid containing three alcohol groups; it can combine with one, two or three fatty acid molecules to give a mono-, di- or tri-glycerides
humectants	substances capable of keeping other substances moist; added to food to prevent it from drying out
hydrophilic	hydro = water, philic = loving; substances that are hydrophilic will dissolve in water
hydrophobic	hydro = water, phobic = hating; substances which are hydrophobic will not dissolve in water
hygroscopic	capable of absorbing water from the air
ions	particles which carry a positive (cations) or negative (anions) electrical charge
immiscible/miscible	liquids which will not mix to form a homogeneous substance when combined are said to be immiscible, e.g. oil and water; liquids that completely mix on combining are miscible, e.g. water and alcohol
interfacial tension	the surface tension between two immiscible liquids, when the two are mixed, is called the interfacial tension

lipid	a fat or fat-like material
lipophilic	lipo = fat or lipid, philic = loving; substances which are lipophilic will dissolve in fat
MAFF	Ministry of Agriculture, Fisheries and Food; a government body, responsible for labelling of food and regulation of food additives. However, these will come under the responsibilities of a new Food Standards Agency.
microorganisms	microscopically small organisms such as viruses, bacteria, protozoa and fungi; bacteria and fungi are principally responsible for decay in food
monoglycerides	see glycerol
monomer	a small molecule which forms the building block to make a polymer
organic compounds	compounds that contain chains of atoms of the element carbon, i.e. carbon based compounds, e.g. proteins, fats and carbohydrates
organoleptic	able to stimulate a sensory organ particularly the nose and the tongue
oxidation	a chemical reaction which involves at least one of the following: loss of electrons, the gain of oxygen or the loss of hydrogen. (Rust is the result of the oxidation of iron; the oxidation of fats in foods results in rancidity.)
pectin	(E440) a plant polysaccharide capable of producing a gel and hence has important setting properties, particularly, in the production of jams
pH	is a mathematical expression of the acidity of a system
phospholipid	a lipid containing 2 fatty acid residues and 1 phosphate group attached to the glycerol molecules; these are polar molecules
polar	some molecules, such as water, have areas of both positive charge and negative charge; such molecules are said to be polar; this is due to an unequal distribution of electrons
polymer	a long chain molecule built up from small units called monomers
polymorphic	poly = many, morphic = shape or form; substances that are polymorphic exist in a number of different forms
polysaccharide	poly = many, saccharide = sugar; polysaccharides are the carbohydrates made up of many sugar sub units
polyunsaturated fatty acids	the occurrence of *two* or *more* carbon to carbon double bonds in a fatty acid chain will result in a polyunsaturated fatty acid (see saturated fatty acids).
preservatives	substances capable of slowing down or preventing the reactions of decay
proteins	compounds which contain the elements carbon, hydrogen, oxygen, nitrogen and sometimes, but not always, phosphorus and sulphur; consist of sub units called amino acids; one of the major classes of nutrients having a wide range of biological functions
rancidity	process in which fats exposed to the air undergo oxidation and liquefy; other reactions, such as hydrolysis, take place which result in the release of foul smelling free acids
receptors	cells capable of detecting changes or stimuli in the internal or external environment of an organism; in humans the receptors for sight, taste and smell are of particular importance to food manufacturers
releasing agents	substances used to coat the inside of baking tins, mixing equipment, etc. to prevent food from sticking

respiration	process which takes place in the living cells of all plants and animals which releases energy
retrogradation	when starch is mixed with water it swells and forms a gel; with time, the starch components will re-crystallise and squeeze the water out of the gel; this phenomenon is known as retrogradation and is responsible for the staling process in bread
resistance	a phenomenon where the use of chemicals, such as antibiotics, has led to the selection of individuals in a population which are not affected by the chemical; chemical preservatives have not been known to cause this.
saturated/unsaturated fatty acids	fats are the result of the reaction between an alcohol such as glycerol and, typically, three fatty acid molecules. When carbon atoms are joined to each other by single carbon to carbon bonds, the resulting fatty acid is said to be *saturated*; as each carbon atom has a full complement of hydrogen atoms. Fats formed from this type of fatty acid will tend to be hard. When there is *one* carbon to carbon *double* bond within the fatty acid chain, the fatty acid is described as being *monounsaturated*; the occurrence of *two* or *more* carbon to carbon double bonds in the fatty acid chain will result in a *polyunsaturated* fatty acid. The double bonds mean that the carbon atoms have fewer hydrogen atoms attached to them. Fats formed from this type of fatty acid will be softer. The greater the degree of unsaturation, the softer the fat and, indeed, an oil may be produced. Food manufacturers must take into consideration, the fact that softer fats are naturally more susceptible to oxidation.
stabilisers	those food additives which help to retain the physical and textural properties of food particularly emulsions and low fat systems
starch	the storage polysaccharide in plants; has important thickening properties
surface tension	a property of liquids where forces between the molecules near the surface leads to the apparent presence of a film
suspension	the dispersion of small particles of a solid in a liquid
syneresis	the loss of water from a gel is called syneresis; it is also an important mechanism in the production of curds in cheese manufacture
synergist	a substance that is used in conjunction with another substance which results in their performance being enhanced by each other; their performance together is better than their total effect if they were used separately
tenderisers	substances or processes which alter the fibrous structure of meat to make it less tough
triglyceride	see glycerol
unsaturated fatty acids	see saturated fatty acids
volatile	a liquid which will easily change into a gas is said to be volatile
viscosity	is a measure of the 'runniness' or 'flow' of a liquid; water is less viscous or more runny than treacle

Before an additive is given an 'E' number, it must first be cleared for safety by the EC's Scientific Committee on Food (SCF - see page 22) and shown to be safe in the foods in which it is allowed. An 'E' number is only given to those substances which have passed all the safety checks.

'E' numbers are allocated, in blocks, by function:

e.g.
- E100 series: colours, e.g. E160a (carotene)
- E200 series: preservatives, e.g. E234 (nisin)
- E300 series: antioxidants, e.g. E307 (alpha-tocopherol)
- E400+ : miscellaneous additives, including stabilisers, emulsifiers, raising agents, etc. e.g. E440 (pectin), E501 (sodium bicarbonate)

'E' numbers are intended as a shorthand notation for purposes of food labelling. The Food Labelling Directive (79/112/EC) allows food manufacturers to use either the name of the additive and/or its 'E' number on their labels.

*An exception has been made for the modified starches, E1404 - E1450, any one of which may be labelled as **modified starch**.*

Complete lists of EC-approved additives, firstly in numerical order and then in alphabetical order, are given in the following pages.

'E' numbers in numerical order

colours

E100	curcumin
E101	(i) riboflavin
	(ii) riboflavin-5'-phosphate
E102	tartrazine
E104	quinoline yellow
E110	sunset yellow FCF, orange yellow S
E120	cochineal, carminic acid, carmines
E122	azorubine, carmoisine
E123	amaranth
E124	ponceau 4R, cochineal red A
E127	erythrosine
E128	red 2G
E129	allura red AC
E131	patent blue V
E132	indigotine, indigo carmine
E133	brilliant blue FCF
E140	chlorophylls and chlorophyllins
	(i) chlorophylls
	(ii) chlorophyllins
E141	copper complexes of chlorophylls and chlorophyllins
	(i) copper complexes of chlorophylls
	(ii) copper complexes of chlorophyllins
E142	green S
E150a	plain caramel
E150b	caustic sulphite caramel
E150c	ammonia caramel
E150d	sulphite ammonia caramel
E151	brilliant black BN, black PN
E153	vegetable carbon
E154	brown FK
E155	brown HT
E160a	carotenes
	(i) mixed carotenes
	(ii) beta-carotene
E160b	annatto, bixin, norbixin
E160c	paprika extract, capsanthin, capsorubin
E160d	lycopene
E160e	beta-apo-8'-carotenal (C30)
E160f	ethyl ester of beta-apo-8'-carotenic acid (C30)
E161b	lutein
E161g	canthaxanthin
E162	beetroot red, betanin
E163	anthocyanins
E170	calcium carbonates
	(i) calcium carbonate
	(ii) calcium hydrogen carbonate
E171	titanium dioxide
E172	iron oxides and hydroxides
E173	aluminium
E174	silver
E175	gold
E180	litholrubine BK

preservatives

E200	sorbic acid
E202	potassium sorbate
E203	calcium sorbate
E210	benzoic acid
E211	sodium benzoate
E212	potassium benzoate
E213	calcium benzoate
E214	ethyl p-hydroxybenzoate
E215	sodium ethyl p-hydroxybenzoate
E216	propyl p-hydroxybenzoate
E217	sodium propyl p-hydroxybenzoate
E218	methyl p-hydroxybenzoate
E219	sodium methyl p-hydroxybenzoate
E220	sulphur dioxide
E221	sodium sulphite
E222	sodium hydrogen sulphite

E223 sodium metabisulphite
E224 potassium metabisulphite
E226 calcium sulphite
E227 calcium hydrogen sulphite
E228 potassium hydrogen sulphite
E230 biphenyl, diphenyl
E231 orthophenyl phenol
E232 sodium orthophenyl phenol
E233 thiabendazole
E234 nisin
E235 natamycin
E239 hexamethylene tetramine
E242 dimethyl dicarbonate
E249 potassium nitrite
E250 sodium nitrite
E251 sodium nitrate
E252 potassium nitrate
E260 acetic acid
E261 potassium acetate
E262 sodium acetates
(i) sodium acetate
(ii) sodium hydrogen acetate
E263 calcium acetate
E270 lactic acid
E280 propionic acid
E281 sodium propionate
E282 calcium propionate
E283 potassium propionate
E284 boric acid
E285 sodium tetraborate (borax)
E290 carbon dioxide
E296 malic acid
E297 fumaric acid

antioxidants

E300 ascorbic acid (Vitamin C)
E301 sodium ascorbate
E302 calcium ascorbate
E304 fatty acid esters of ascorbic acid
(i) ascorbyl palmitate
(ii) ascorbyl stearate
E306 tocopherol-rich extract
E307 alpha-tocopherol (Vitamin E)
E308 gamma-tocopherol
E309 delta-tocopherol
E310 propyl gallate
E311 octyl gallate
E312 dodecyl gallate
E315 erythorbic acid
E316 sodium erythorbate
E320 butylated hydroxyanisole (BHA)
E321 butylated hydroxytoluene(BHT)
E322 lecithins
E325 sodium lactate
E326 potassium lactate
E327 calcium lactate
E330 citric acid
E331 sodium citrates
(i) monosodium citrate
(ii) disodium citrate
(iii) trisodium citrate
E332 potassium citrates
(i) monopotassium citrate
(ii) tripotassium citrate
E333 calcium citrates
(i) monocalcium citrate
(ii) dicalcium citrate
(iii) tricalcium citrate
E334 tartaric acid (L(+)-)
E335 sodium tartrates
(i) monosodium tartrate
(ii) disodium tartrate
E336 potassium tartrates
(i) monopotassium tartrate
(ii) dipotassium tartrate
E337 sodium potassium tartrate
E338 phosphoric acid
E339 sodium phosphates
(i) monosodium phosphate
(ii) disodium phosphate
(iii) trisodium phosphate
E340 potassium phosphates
(i) monopotassium phosphate
(ii) dipotassium phosphate
(iii) tripotassium phosphate
E341 calcium phosphates
(i) monocalcium phosphate
(ii) dicalcium phosphate
(iii) tricalcium phosphate
E350 sodium malates
(i) sodium malate
(ii) sodium hydrogen malate
E351 potassium malate
E352 calcium malates
(i) calcium malate
(ii) calcium hydrogen malate
E353 metatartaric acid
E354 calcium tartrate
E355 adipic acid
E356 sodium adipate
E357 potassium adipate
E363 succinic acid
E380 triammonium citrate
E385 calcium disodium ethylene diamine tetra-acetate (calcium disodium EDTA)

miscellaneous

E400 alginic acid
E401 sodium alginate
E402 potassium alginate
E403 ammonium alginate
E404 calcium alginate
E405 propane-1,2-diol alginate
E406 agar
E407 carrageenan
E410 locust bean gum
E412 guar gum
E413 tragacanth
E414 acacia gum (gum arabic)
E415 xanthan gum
E416 karaya gum
E417 tara gum

miscellaneous (continued)

E418 gellan gum
E420 sorbitol
(i) sorbitol
(ii) sorbitol syrup
E421 mannitol
E422 glycerol
E431 polyoxyethylene (40) stearate
E432 polyoxyethylene sorbitan monolaurate (polysorbate 20)
E433 polyoxyethylene sorbitan monooleate (polysorbate 80)
E434 polyoxyethylene sorbitan monopalmitate (polysorbate 40)
E435 polyoxyethylene sorbitan monostearate (polysorbate 60)
E436 polyoxyethylene sorbitan tristearate (polysorbate 65)
E440 pectins
(i) pectin
(ii) amidated pectin
E442 ammonium phosphatides
E444 sucrose acetate isobutyrate
E445 glycerol esters of wood rosins
E450 diphosphates
(i) disodium diphosphate
(ii) trisodium diphosphate
(iii) tetrasodium diphosphate
(iv) dipotassium diphosphate
(v) tetrapotassium diphosphate
(vi) dicalcium diphosphate
(vii) calcium dihydrogen diphosphate
E451 triphosphates
(i) pentasodium triphosphate
(ii) pentapotassium triphosphate
E452 polyphosphates
(i) sodium polyphosphate
(ii) potassium polyphosphate
(iii) sodium calcium polyphosphate
(iv) calcium polyphosphate
E460 cellulose
(i) microcrystalline cellulose
(ii) powdered cellulose
E461 methyl cellulose
E463 hydroxypropyl cellulose
E464 hydroxypropyl methyl cellulose
E465 ethyl methyl cellulose
E466 carboxy methyl cellulose
sodium carboxy methyl cellulose
E470a sodium, potassium and calcium salts of fatty acids
E470b magnesium salts of fatty acids
E471 mono- and diglycerides of fatty acids
E472a acetic acid esters of mono- and diglycerides of fatty acids
E472b lactic acid esters of mono- and diglycerides of fatty acids
E472c citric acid esters of mono- and diglycerides of fatty acids
E472d tartaric acid esters of mono- and diglycerides of fatty acids
E472e mono- and diacetyl tartaric esters of mono- and diglycerides of fatty acids
E472f mixed acetic and tartaric acid esters of mono- and diglycerides of fatty acids
E473 sucrose esters of fatty acids
E474 sucroglycerides
E475 polyglycerol esters of fatty acids
E476 polyglycerol polyricinoleate
E477 propane-1,2-diol esters of fatty acids
E479b thermally oxidised soya bean oil interacted with mono- and diglycerides of fatty acids
E481 sodium stearoyl-2-lactylate
E482 calcium stearoyl-2-lactylate
E483 stearyl tartrate
E491 sorbitan monostearate
E492 sorbitan tristearate
E493 sorbitan monolaurate
E494 sorbitan monooleate
E495 sorbitan monopalmitate
E500 sodium carbonates
(i) sodium carbonate
(ii) sodium hydrogencarbonate
(iii) sodium sesquicarbonate
E501 potassium carbonates
(i) potassium carbonate
(ii) potassium hydrogencarbonate
E503 ammonium carbonates
(i) ammonium carbonate
(ii) ammonium hydrogencarbonate
E504 magnesium carbonates
(i) magnesium carbonate
(ii) magnesium hydroxide carbonate (syn. magnesium hydrogen carbonate)
E507 hydrochloric acid
E508 potassium chloride
E509 calcium chloride
E511 magnesium chloride
E512 stannous chloride
E513 sulphuric acid
E514 sodium sulphates
(i) sodium sulphate
(ii) sodium hydrogensulphate
E515 potassium sulphates
(i) potassium sulphate
(ii) potassium hydrogensulphate
E516 calcium sulphate
E517 ammonium sulphate
E520 aluminium sulphate
E521 aluminium sodium sulphate
E522 aluminium potassium sulphate
E523 aluminium ammonium sulphate
E524 sodium hydroxide
E525 potassium hydroxide
E526 calcium hydroxide
E527 ammonium hydroxide
E528 magnesium hydroxide
E529 calcium oxide
E530 magnesium oxide
E535 sodium ferrocyanide
E536 potassium ferrocyanide
E538 calcium ferrocyanide
E541 sodium aluminium phosphate, acidic

miscellaneous (continued)

E551	silicon dioxide
E552	calcium silicate
E553a	(i) magnesium silicate
	(ii) magnesium trisilicate
E553b	talc
E554	sodium aluminium silicate
E555	potassium aluminium silicate
E556	calcium aluminium silicate
E558	bentonite
E559	aluminium silicate (kaolin)
E570	fatty acids
E574	gluconic acid
E575	glucono-delta-lactone
E576	sodium gluconate
E577	potassium gluconate
E578	calcium gluconate
E579	ferrous gluconate
E585	ferrous lactate
E620	glutamic acid
E621	monosodium glutamate
E622	monopotassium glutamate
E623	calcium diglutamate
E624	monoammonium glutamate
E625	magnesium diglutamate
E626	guanylic acid
E627	disodium guanylate
E628	dipotassium guanylate
E629	calcium guanylate
E630	inosinic acid
E631	disodium inosinate
E632	dipotassium inosinate
E633	calcium inosinate
E634	calcium 5'-ribonucleotides
E635	disodium 5'-ribonucleotides
E640	glycine and its sodium salt
E900	dimethyl polysiloxane
E901	beeswax, white and yellow
E902	candelilla wax
E903	carnauba wax
E904	shellac
E912	montan acid esters
E914	oxidised polyethylene wax
E927b	carbamide
E938	argon
E939	helium
E941	nitrogen
E942	nitrous oxide
E948	oxygen
E950	acesulphame K
E951	aspartame
E952	cyclamic acid and its sodium and calcium salts
E953	isomalt
E954	saccharin and its sodium, potassium and calcium salts
E957	thaumatin
E959	neohesperidine DC
E965	maltitol
	(i) maltito
	(ii) maltitol syrup
E966	lactitol
E967	xylitol
E999	quillaia extract
E1105	lysozyme
E1200	polydextrose
E1201	polyvinylpyrrolidone
E1202	polyvinylpolypyrrolidone
E1404	oxidised starch
E1410	monostarch phosphate
E1412	distarch phosphate
E1413	phosphated distarch phosphate
E1414	acetylated distarch phosphate
E1420	acetylated starch
E1422	acetylated distarch adipate
E1440	hydroxy propyl starch
E1442	hydroxy propyl distarch phosphate
E1450	starch sodium octenyl succinate
E1505	triethyl citrate
E1518	glyceryl triacetate (triacetin)

'E' numbers in alphabetical order

E414 acacia gum (gum arabic)
E950 acesulphame K
E260 acetic acid
E472a acetic acid esters of mono- and diglycerides of fatty acids
E1422 acetylated distarch adipate
E1414 acetylated distarch phosphate
E1420 acetylated starch
E355 adipic acid
E406 agar
E400 alginic acid
E129 allura red AC
E307 alpha-tocopherol
E173 aluminium
E523 aluminium ammonium sulphate
E522 aluminium potassium sulphate
E559 aluminium silicate (kaolin)
E521 aluminium sodium sulphate
E520 aluminium sulphate
E123 amaranth
E150c ammonia caramel
E403 ammonium alginate
E503 ammonium carbonates
(i) ammonium carbonate
(ii) ammonium hydrogencarbonate
E527 ammonium hydroxide
E442 ammonium phosphatides
E517 ammonium sulphate
E160b annatto, bixin, norbixin
E163 anthocyanins
E938 argon
E300 ascorbic acid
E951 aspartame
E122 azorubine, carmoisine
E901 beeswax, white and yellow
E162 beetroot red, betanin
E558 bentonite
E210 benzoic acid
E160e beta-apo-8'-carotenal (C30)
E230 biphenyl, diphenyl
E284 boric acid
E151 brilliant black BN, black PN
E133 brilliant blue FCF
E154 brown FK
E155 brown HT
E320 butylated hydroxyanisole
E321 butylated hydroxytoluene
E263 calcium acetate
E404 calcium alginate
E556 calcium aluminium silicate
E302 calcium ascorbate
E213 calcium benzoate
E170 calcium carbonates
(i) calcium carbonate
(ii) calcium hydrogencarbonate
E509 calcium chloride
E333 calcium citrates
(i) monocalcium citrate
(ii) dicalcium citrate
(iii) tricalcium citrate
E623 calcium diglutamate
E385 calcium disodium ethylene diamine tetra-acetate (calcium disodium EDTA)
E538 calcium ferrocyanide
E578 calcium gluconate
E629 calcium guanylate
E227 calcium hydrogensulphite
E526 calcium hydroxide
E633 calcium inosinate
E327 calcium lactate
E352 calcium malates
(i) calcium malate
(ii) calcium hydrogenmalate
E529 calcium oxide
E341 calcium phosphates
(i) monocalcium phosphate
(ii) dicalcium phosphate
(iii) tricalcium phosphate
E282 calcium propionate
E634 calcium 5'-ribonucleotides
E552 calcium silicate
E203 calcium sorbate
E482 calcium stearoyl-2-lactylate
E516 calcium sulphate
E226 calcium sulphite
E354 calcium tartrate
E902 candelilla wax
E161g canthaxanthin
E927b carbamide
E290 carbon dioxide
E466 carboxy methyl cellulose
sodium carboxy methyl cellulose
E903 carnauba wax
E160a carotenes
(i) mixed carotenes
(ii) beta-carotene
E407 carrageenan
E150b caustic sulphite caramel
E460 cellulose
(i) microcrystalline cellulose
(ii) powdered cellulose
E140 chlorophylls and chlorophyllins
(i) chlorophylls
(ii) chlorophyllins
E330 citric acid
E472c citric acid esters of mono- and diglycerides of fatty acids
E120 cochineal, carminic acid, carmines
E141 copper complexes of chlorophylls and chlorophyllins
(i) copper complexes of chlorophylls
(ii) copper complexes of chlorophyllins
E100 curcumin
E952 cyclamic acid and its sodium and calcium salts
E309 delta-tocopherol
E242 dimethyl dicarbonate
E900 dimethyl polysiloxane
E450 diphosphates
(i) disodium diphosphate
(ii) trisodium diphosphate
(iii) tetrasodium diphosphate
(iv) dipotassium diphosphate
(v) tetrapotassium diphosphate
(vi) dicalcium diphosphate
(vii) calcium dihydrogen diphosphate
E628 dipotassium guanylate
E632 dipotassium inosinate
E627 disodium guanylate

E631	disodium inosinate
E635	disodium 5'-ribonucleotides
E1412	distarch phosphate
E312	dodecyl gallate
E315	erythorbic acid
E127	erythrosine
E160f	ethyl ester of beta-apo-8'-carotenic acid (C30)
E465	ethyl methyl cellulose
E214	ethyl p-hydroxybenzoate
E304	fatty acid esters of ascorbic acid (i) ascorbyl palmitate (ii) ascorbyl stearate
E570	fatty acids
E579	ferrous gluconate
E585	ferrous lactate
E297	fumaric acid
E308	gamma-tocopherol
E418	gellan gum
E574	gluconic acid
E575	glucono-delta-lactone
E620	glutamic acid
E422	glycerol
E445	glycerol esters of wood rosins
E1518	glyceryl triacetate (triacetin)
E640	glycine and its sodium salt
E175	gold
E142	green S
E626	guanylic acid
E412	guar gum
E939	helium
E239	hexamethylene tetramine
E507	hydrochloric acid
E463	hydroxypropyl cellulose
E1442	hydroxypropyl distarch phosphate
E464	hydroxypropyl methyl cellulose
E1440	hydroxypropyl starch
E132	indigotine, indigo carmine
E630	inosinic acid
E172	iron oxides and hydroxides
E953	isomalt
E416	karaya gum
E270	lactic acid
E472b	lactic acid esters of mono- and diglycerides of fatty acids
E966	lactitol
E322	lecithins
E180	litholrubine BK
E410	locust bean gum
E161b	lutein
E160d	lycopene
E1105	lysozyme
E504	magnesium carbonates (i) magnesium carbonate (ii) magnesium hydrogencarbonate
E511	magnesium chloride
E625	magnesium diglutamate
E528	magnesium hydroxide
E530	magnesium oxide
E470b	magnesium salts of fatty acids
E553a	(i) magnesium silicate (ii) magnesium trisilicate
E296	malic acid
E965	maltitol (i) maltitol (ii) maltitol syrup
E421	mannitol
E353	metatartaric acid
E461	methyl cellulose
E218	methyl p-hydroxybenzoate
E472f	mixed acetic and tartaric acid esters of mono- and diglycerides of fatty acids
E624	monoammonium glutamate
E472e	mono- and diacetyl tartaric esters of mono- and diglycerides of fatty acids
E471	mono- and diglycerides of fatty acids
E622	monopotassium glutamate
E621	monosodium glutamate
E1410	monostarch phosphate
E912	montan acid esters
E235	natamycin
E959	neohesperidine DC
E234	nisin
E941	nitrogen
E942	nitrous oxide
E311	octyl gallate
E231	orthophenyl phenol
E914	oxidised polyethylene wax
E1404	oxidised starch
E948	oxygen
E160c	paprika extract, capsanthin, capsorubin
E131	patent blue V
E440	pectins (i) pectin (ii) amidated pectin
E1413	phosphated distarch phosphate
E338	phosphoric acid
E150a	plain caramel
E1200	polydextrose
E475	polyglycerol esters of fatty acids
E476	polyglycerol polyricinoleate
E432	polyoxyethylene sorbitan monolaurate (polysorbate 20)
E431	polyoxyethylene (40) stearate
E433	polyoxyethylene sorbitan monooleate (polysorbate 80)
E434	polyoxyethylene sorbitan monopalmitate (polysorbate 40)
E435	polyoxyethylene sorbitan monostearate (polysorbate 60)
E436	polyoxyethylene sorbitan tristearate (polysorbate 65)
E452	polyphosphates (i) sodium polyphosphate (ii) potassium polyphosphate (iii) sodium calcium polyphosphate (iv) calcium polyphosphate
E1202	polyvinylpolypyrrolidone
E1201	polyvinylpyrrolidone
E124	ponceau 4R, cochineal red A
E261	potassium acetate
E357	potassium adipate
E402	potassium alginate
E555	potassium aluminium silicate
E212	potassium benzoate
E501	potassium carbonates (i) potassium carbonate (ii) potassium hydrogencarbonate
E508	potassium chloride
E332	potassium citrates (i) monopotassium citrate (ii) tripotassium citrate

E536	potassium ferrocyanide
E577	potassium gluconate
E228	potassium hydrogensulphite
E525	potassium hydroxide
E326	potassium lactate
E351	potassium malate
E224	potassium metabisulphite
E252	potassium nitrate
E249	potassium nitrite
E340	potassium phosphates
	(i) monopotassium phosphate
	(ii) dipotassium phosphate
	(iii) tripotassium phosphate
E283	potassium propionate
E202	potassium sorbate
E515	potassium sulphates
	(i) potassium sulphate
	(ii) potassium hydrogensulphate
E336	potassium tartrates
	(i) monopotassium tartrate
	(ii) dipotassium tartrate
E405	propane-1,2-diol alginate
E477	propane-1,2-diol esters of fatty acids
E280	propionic acid
E310	propyl gallate
E216	propyl p-hydroxybenzoate
E999	quillaia extract
E104	quinoline yellow
E128	red 2G
E101	(i) riboflavin
	(ii) riboflavin-5'-phosphate
E954	saccharin and its sodium, potassium and calcium salts
E904	shellac
E551	silicon dioxide
E174	silver
E262	sodium acetates
	(i) sodium acetate
	(ii) sodium hydrogen acetate
E356	sodium adipate
E401	sodium alginate
E541	sodium aluminium phosphate, acidic
E554	sodium aluminium silicate
E301	sodium ascorbate
E211	sodium benzoate
E500	sodium carbonates
	(i) sodium carbonate
	(ii) sodium hydrogencarbonate
	(iii) sodium sesquicarbonate
E331	sodium citrates
	(i) monosodium citrate
	(ii) disodium citrate
	(iii) trisodium citrate
E316	sodium erythorbate
E215	sodium ethyl p-hydroxybenzoate
E535	sodium ferrocyanide
E576	sodium gluconate
E222	sodium hydrogensulphite
E524	sodium hydroxide
E325	sodium lactate
E350	sodium malates
	(i) sodium malate
	(ii) sodium hydrogenmalate
E223	sodium metabisulphite
E219	sodium methyl p-hydroxybenzoate
E251	sodium nitrate
E250	sodium nitrite
E232	sodium orthophenyl phenol
E339	sodium phosphates
	(i) monosodium phosphate
	(ii) disodium phosphate
	(iii) trisodium phosphate
E470a	sodium, potassium and calcium salts of fatty acids
E337	sodium potassium tartrate
E281	sodium propionate
E217	sodium propyl p-hydroxybenzoate
E481	sodium stearoyl-2-lactylate
E514	sodium sulphates
	(i) sodium sulphate
	(ii) sodium hydrogensulphate
E221	sodium sulphite
E335	sodium tartrates
	(i) monosodium tartrate
	(ii) disodium tartrate
E285	sodium tetraborate (borax)
E200	sorbic acid
E493	sorbitan monolaurate
E494	sorbitan monooleate
E495	sorbitan monopalmitate
E491	sorbitan monostearate
E492	sorbitan tristearate
E420	sorbitol
	(i) sorbitol
	(ii) sorbitol syrup
E512	stannous chloride
E1450	starch sodium octenyl succinate
E483	stearyl tartrate
E363	succinic acid
E474	sucroglycerides
E444	sucrose acetate isobutyrate
E473	sucrose esters of fatty acids
E150d	sulphite ammonia caramel
E220	sulphur dioxide
E513	sulphuric acid
E110	sunset yellow FCF, orange yellow S
E553b	talc
E417	tara gum
E334	tartaric acid (L(+)-)
E472d	tartaric acid esters of mono- and diglycerides of fatty acids
E102	tartrazine
E957	thaumatin
E479b	thermally oxidised soya bean oil interacted with mono- and diglycerides of fatty acids
E233	thiabendazole
E171	titanium dioxide
E306	tocopherol-rich extract
E413	tragacanth
E380	triammonium citrate
E1505	triethyl citrate
E451	triphosphates
	(i) pentasodium triphosphate
	(ii) pentapotassium triphosphate
E153	vegetable carbon
E415	xanthan gum
E967	xylitol

Pre-planning

For almost all of the activities, it would be very useful if pupils collected labels from as large a variety of food packets as is possible.

Introductory activities

KS3 and upwards
science and food technology

Timing - various

The aim of the card games is to enable pupils to learn to compare the amounts of protein, fat, calcium, vitamin C, etc and energy content present in a fixed mass of a variety of foodstuffs. The other activities in this section involve the use of information on food labels.

I1. Food ingredient card games

Eight I1 master sheets for the playing cards accompany these activities. They should be photocopied onto card. The corresponding food name should be stuck or written onto the reverse side and then the cards cut out. There are blank cards, should you wish to add other foods.

There are 52 playing cards which have information on them about a variety of foods. On one side (the face side), the cards show the amounts of energy, **protein**, **fat**, **carbohydrate**, calcium, iron and vitamin C contained in 100g of the foodstuff. The back of the card merely has the name of the food.

Since the information given is for the same mass of food, fair comparisons can be made. It is important to remember, however, that 100g may not represent a 'normal' portion of that particular food.

The information on the cards is adapted from the **MAFF** *Manual of Nutrition (HMSO publication ISBN 011 2411126).*

Strictly: 1 kcal = 4.2 KJ

Please note *- the values for energy have been rounded up or down to make them easier to compare. Conversion from kcal and kJ has been simplified to a factor of 4.*

In some games, having the name of the food on the back of the card will give players, with knowledge of that food, an advantage over their opponents. Hopefully, this will motivate pupils to acquire useful and relevant information.

The rules for some of the many games that can be played are given below. It is likely that you, or your students, will devise more games and variations as the cards are used.

Energy pontoon

Energy pontoon

Aim: with 2 - 5 cards gain an energy score as close to the limit of 1000 kcal/4000 kJ as possible without going 'bust'. The player is allowed a maximum of 5 cards.

Game 1a.

Game 1a.
2 - 4 players
simplest version

The dealer shuffles the cards and deals alternately two cards *face down* to a player/players and two to the dealer.

The first player to be dealt the cards goes first. (S)he adds up openly the kcal or kJ for the two cards and then decides whether to 'twist'.

Twist: player takes another card
Stick: player takes no more cards
Bust: score is more than 1000kcal/4200kJ and the player is out.

The player should look at the *back* of the next card in the pile so that an *educated guess* can be made as to whether or not taking the next card would keep the score below the limit.

If the player decides to twist, the next card is dealt *face upwards* for all the players to see.

The player keeps 'twisting' until:

- the player thinks that the next card would take them over the limit . . . and then sticks.
- or, until they unintentionally go over the limit, . . . when the player is 'bust' and out of the game.

The winner is the person who is not 'bust' and whose total is the nearest to 1000kcal/4000kJ.
A '5-card trick' beats any other hand.
If anyone ties with the dealer, the dealer wins.
The winner becomes the dealer.

The next player(s) then take a turn.

The dealer is the last person to go. *All* of the dealers' cards are placed face upwards and the dealer then plays in the same way as other players.

Game 1b. A 'blind' version

The dealer deals two cards *face down* to each player .

Player 1 has to *estimate* the energy value from *the back of the cards only.*

Player 1 is allowed to see the *back* of the next card on the pile and must decide whether to twist or not from the name of the next food and the information on the *back* of the original two cards. If the player decides to twist, the next card is dealt but still only with the back facing. The player sticks when they feel their limit is reached.

Players *do not* look at the value of the cards yet. Player 2 then has a turn in a similar way. When each player has stuck, the value of the cards is added up. The winner is decided as described before.

Food whist

Game 2a.
for 2 - 6 players
simplest version

The person winning the greatest number of tricks is the winner.

Game 2a.

Only *one* of the categories of information on the cards is used. If the players use the 'fat' category then the winner has the *lowest* value. If the other categories have been chosen, the winner has the *highest* value. The aim is to win *tricks.*

For example, using the *protein* category; imagine there are 2 players.

Shuffle the cards.

7 cards are dealt *face down* to each player. The players pick up their cards to look at protein values.

The first player chooses a card from his/her hand and places it *face down* on the desk.

If the second player does not think that they have a card to beat the original card, they can throw away a low value card.

The second player looks at the name of the food and then at their own hand. They choose a card to play, making an *educated guess* as to which of their cards may beat the protein value of the card that was played initially.

Two cards played which happen to have the same value for the category results in a void trick and the trick is discarded.

The second card is placed with the original card and then both cards are examined.

The winner of the trick is the person who played the card with the highest protein value.

These cards are removed, ready to play the next trick. The winner of the trick leads the next card. The game continues until all 7 tricks have been played.

Game 2b
for 2 - 4 players

Game 2b. A 'knock-out' version

The rules to win a trick are the same as above, but the game is played with the following modifications:

First round: *energy values* are compared.

The player to the left of the dealer goes first and places a card *face down* in front of the players.

The next player plays a card which they think may beat the energy value of the original card (or they 'throw away' a card) by placing the card *face down* next to the original card.

Other players play cards in a similar way.

When each player has played, the cards are turned over to find the card with the greatest energy value.

The player of this card is the winner of that trick and begins the next trick in the same way as the first.

If two people win the same number of tricks, they cut the cards. The person with the greatest energy value on their card is the winner. This is the procedure for any round that ends in a tie.

Tricks are played for all 7 cards.

The person who wins the greatest number of tricks in this round becomes the dealer.

Second round: the winner of the first round deals *6* cards to the players.

The winner looks at his/her hand and decides which category (s)he wants as the category for comparison and declares this.

Remember - the category for the first round is energy; subsequent categories are chosen by the dealer; the category ***cannot*** *be changed in the middle of a round.*

The game continues as before till all six cards have been played.

The person who wins the greatest number of tricks becomes the dealer.

The game continues with *5* then *4* then *3, 2, 1* cards being dealt in subsequent rounds. In each case, the person who wins the greatest number of tricks in the previous round becomes the dealer and choses the category for comparison.

Game 2c.

Game 2c.
2 players

requires thought!

The game is as above, but with only one 7 card round played as follows:

first trick - energy values
second - protein
third - fat (*lowest* value wins)
fourth - carbohydrate
fifth - calcium
sixth - iron
the seventh - vitamin C.

A 'thinking' period after the cards are dealt, for players to decide which card to play for each trick, will be helpful. Decisions may be altered in the light of the outcomes of previous tricks.

The player who wins the most tricks is the winner.

Game 3. "My card can beat yours" *(similar to 'Top trumps')*

Game 3.
2 players

The cards are shuffled.

All of the cards are dealt equally to the two players.

Each player holds all of their cards in a pile with the information on the first card only facing them.

The player who was *not* the dealer goes first. (S)he looks at the information on the first card and decides which of the categories has a possible 'winning' value.

Example, if they are looking at the 'Chips' card they might decide that an energy value of 250 kcal (1000 kJ) has a good chance of beating many other cards in this category.

The player declares *'energy'* and the *name* of the food at which (s)he is looking.

The second player looks at the *energy* category on their first card and reads out the value.

The person who has the card with the greatest value wins both cards and puts them on a pile in front of them.

Whoever wins the cards looks at their next card to choose the category, and the game continues until all cards have been compared.

The cards can also be used as a source of information in any situation where the nutritional value of common, everyday foods is needed.

The cards in the winning piles for each player are counted. The person with the greatest number of cards is the winner.

KS3 and upwards
science and food technology

Timing - 10 - 15 minutes

Pupil activity sheet I2 accompanies this activity.

I2. Guess the foods from these labels

Pupils are given copies of labels from food packaging which list the ingredients in the foods. Pupils use this information to identify the foods concerned.

If you wish to make this easier, the pupils could be given a list of foods including the correct names from which to choose their answers, or you may like to use pictures or the parts of the labels with names on them.

Answers to Pupil activity sheet I2:

A - baked beans (in tomato sauce)
B - barbecue flavour 'Hoops' (snacks)
C - cornflakes
D - egg custard tarts
E - ice cream
F - malted milk biscuits
G - naan bread (peshwari)
H - mayonnaise (and mustard) dressing
I - polo mints

KS3 and upwards
science and food technology

Timing - 10 minutes

Pupil activity sheet I3 accompanies this activity.

I3. Would you eat these for breakfast?

The purpose of this exercise is to illustrate that *all* foods are chemicals; it is not intended as a test of a pupil's chemical knowledge.

The mention of the word 'breakfast' gives a clue to the identity of the foods. You may like to provide pictures or a list of possible correct answers to make the task easier.

Answers to Pupil activity sheet I3:

Food 1 - tomato
Food 2 - bacon
Food 3 - eggs
Food 4 - buttered toast
Food 5 - coffee

KS3
science and food technology

Timing - 15 - 20 minutes

Three pupil activity sheets I4 accompany this activity.

I4. What can be added to the food you buy?

This is a simple outline for pupils of the main functions of the major classes of food additives. Pupils read the information and answer the questions.

Answers to Pupil activity sheet I4:

1. Any suitable suggestions such as to improve the flavour, improve the texture, to colour the food, to preserve the food.

2. Answers will depend on the foods used.

KS3
science and food technology

Timing - 15 - 20 minutes

Two pupil activity sheets I5 accompany this activity.

I5. Reading the label

Pupils read the information and answer the questions.

Answers to Pupil activity sheet I5:

1. wheatflour
2. pepper
3. emulsifier E471, emulsifier E451, antioxidant E301, preservative E250, preservative E251, colour E160(b)

   (There are 10 different modified starches (E1404 - E1450) any one of which may be legally labelled just as 'modified starch'.)

4. Since they are present in small amounts they will be found near the end of the list; mustard, pepper.
5. 20.7 - 1.7 = 19.0g.
6. starch (of some description), non-starch polysaccharide (NSP)
7. in the storage information; suitable for home freezing
8. recyclable packaging

I6. Finding the additives

KS3
science and food technology

Timing - 15 - 20 minutes

Pupil activity sheet I6 accompanies this activity.

Pupils read the information and answer the questions.

To answer Q9, pupils may need access to some information about food additives. You may wish to supply the pupils' sheet I4 *What can be added to the food you buy?* and the E number lists, page 30.

Answers to Pupil activity sheet I6

1. water
2. flavourings
3. 12 substances are present in smaller quantities than salt; 3 of garlic, basil, oregano, green peppers, modified starch, tartaric acid, colours (caramel and copper chlorophyll), lemon juice, stabiliser (xanthan gum), antioxidant (BHA), flavourings.
4. At first glance, there don't appear to be any because the letter 'E' and numbers are not present. Some pupils are likely to be 'suspicious' about some of the ingredients.
   All the additives appear after salt.
5. They must be present in very small quantities.
6. 2 months after purchase, assuming it has not been opened.
7. Not very long! A few days only and certainly not 2 months.
8. Xanthan gum is an effective stabiliser and suspending agent for water based foods such as salad dressings.

You may like to ask pupils to think about why the bought dressing will stay fresh for 2 months.

Answer: The packaging prevents the entry of microorganisms. The antioxidant delays the oil from going rancid.

INTRODUCTORY CARD GAMES MASTER

Coca Cola	*White Bread*	*Lettuce*	*Chips*
White Sugar	*Cottage Cheese*	*Cauliflower*	*Bananas*
Fresh Peaches	*Apple Pie*	*Tomato Soup*	*Blackcurrants*
Carrots	*Cheddar Cheese*	*White Fish*	*Cooking Oil*
Raw Cabbage	*Chocolate Biscuits*	*Cornflakes*	*Sweetcorn*
Boiled Frozen Peas	*Milk Chocolate*	*Roasted Peanuts*	*Madeira Cake*
Low Fat Spread	*Jam*	*Honey*	*Fresh Tomatoes*
Fried Cod in Batter	*Rice*	*Pork Sausage*	*Oranges*
Cooked Bacon	*Milk*	*Butter*	*Rich Fruit Cake*
Baked Beans	*Wholemeal Bread*	*Cream Crackers*	*Boiled Sprouts*
Fresh Eggs	*Apples*	*Boiled Potatoes*	*Roast Chicken*
Spaghetti	*Fried Liver*	*Strawberries*	*Onions*
Potato Crisps	*Roast Potatoes*	*Cooked Stewing Beef*	*Vanilla Ice Cream*

100g of Chips

energy (kcal)	250
energy (kJ)	1000
protein (g)	3.8
fat (g)	10.9
carbohydrate (g)	37.3
calcium (mg)	14
iron (mg)	0.9
vitamin C (mg)	15

100g of Lettuce

energy (kcal)	10
energy (kJ)	40
protein (g)	1
fat (g)	0
carbohydrate (g)	1.2
calcium (mg)	23
iron (mg)	0.9
vitamin C (mg)	15

100g of White Bread

energy (kcal)	225
energy (kJ)	900
protein (g)	7.8
fat (g)	1.7
carbohydrate (g)	49.7
calcium (mg)	100
iron (mg)	1.7
vitamin C (mg)	15

100g of Coca Cola

energy (kcal)	40
energy (kJ)	160
protein (g)	0
fat (g)	0
carbohydrate (g)	10.5
calcium (mg)	4
iron (mg)	0
vitamin C (mg)	0

100g of White Sugar

energy (kcal)	400
energy (kJ)	1600
protein (g)	0
fat (g)	0
carbohydrate (g)	105
calcium (mg)	2
iron (mg)	0
vitamin C (mg)	0

100g of Fresh Peaches

energy (kcal)	40
energy (kJ)	160
protein (g)	0.6
fat (g)	0
carbohydrate (g)	9.1
calcium (mg)	5
iron (mg)	0.4
vitamin C (mg)	8

100g of Carrots

energy (kcal)	20
energy (kJ)	80
protein (g)	0.7
fat (g)	0
carbohydrate (g)	5.4
calcium (mg)	48
iron (mg)	0.6
vitamin C (mg)	6

100g of Boiled Frozen Peas

energy (kcal)	40
energy (kJ)	160
protein (g)	5.4
fat (g)	7.7
carbohydrate (g)	4.3
calcium (mg)	31
iron (mg)	1.4
vitamin C (mg)	13

100g of Low Fat Spread	
energy (kcal)	350
energy (kJ)	1400
protein (g)	0
fat (g)	40.7
carbohydrate (g)	0
calcium (mg)	0
iron (mg)	0
vitamin C (mg)	0

100g of Fried Cod in Batter	
energy (kcal)	200
energy (kJ)	800
protein (g)	19.6
fat (g)	10.3
carbohydrate (g)	7.5
calcium (mg)	80
iron (mg)	0.5
vitamin C (mg)	0

100g of Cottage Cheese	
energy (kcal)	100
energy (kJ)	400
protein (g)	13.6
fat (g)	4
carbohydrate (g)	1.4
calcium (mg)	60
iron (mg)	0.1
vitamin C (mg)	0

100g of Apple Pie	
energy (kcal)	300
energy (kJ)	1200
protein (g)	3.2
fat (g)	14.4
carbohydrate (g)	40.4
calcium (mg)	42
iron (mg)	0.8
vitamin C (mg)	2

100g of Cheddar Cheese	
energy (kcal)	400
energy (kJ)	1600
protein (g)	26
fat (g)	33.5
carbohydrate (g)	0
calcium (mg)	800
iron (mg)	0.4
vitamin C (mg)	0

100g of Milk Chocolate	
energy (kcal)	525
energy (kJ)	2100
protein (g)	8.4
fat (g)	30.3
carbohydrate (g)	59.4
calcium (mg)	220
iron (mg)	1.6
vitamin C (mg)	0

100g of Jam	
energy (kcal)	250
energy (kJ)	1000
protein (g)	0.5
fat (g)	0
carbohydrate (g)	69.2
calcium (mg)	18
iron (mg)	1.2
vitamin C (mg)	10

100g of Rice	
energy (kcal)	375
energy (kJ)	1500
protein (g)	6.5
fat (g)	1
carbohydrate (g)	86.8
calcium (mg)	4
iron (mg)	0.5
vitamin C (mg)	0

100g of Cauliflower

energy (kcal)	15
energy (kJ)	60
protein (g)	1.9
fat (g)	0
carbohydrate (g)	1.5
calcium (mg)	21
iron (mg)	0.5
vitamin C (mg)	64

100g of Raw Cabbage

energy (kcal)	20
energy (kJ)	80
protein (g)	2.8
fat (g)	0
carbohydrate (g)	2.8
calcium (mg)	57
iron (mg)	0.6
vitamin C (mg)	53

100g of Cooked Bacon

energy (kcal)	450
energy (kJ)	1800
protein (g)	24.5
fat (g)	38.8
carbohydrate (g)	0
calcium (mg)	12
iron (mg)	1.4
vitamin C (mg)	0

100g of Chocolate Biscuits

energy (kcal)	550
energy (kJ)	2200
protein (g)	5.7
fat (g)	27.6
carbohydrate (g)	67.4
calcium (mg)	110
iron (mg)	1.7
vitamin C (mg)	0

100g of Milk

energy (kcal)	60
energy (kJ)	240
protein (g)	3.3
fat (g)	3.8
carbohydrate (g)	4.7
calcium (mg)	120
iron (mg)	0.1
vitamin C (mg)	2

100g of Cornflakes

energy (kcal)	375
energy (kJ)	1500
protein (g)	8.6
fat (g)	1.6
carbohydrate (g)	85.1
calcium (mg)	3
iron (mg)	0.6
vitamin C (mg)	0

100g of White Fish

energy (kcal)	80
energy (kJ)	320
protein (g)	17.4
fat (g)	0.7
carbohydrate (g)	0
calcium (mg)	16
iron (mg)	0.3
vitamin C (mg)	0

100g of Tomato Soup

energy (kcal)	50
energy (kJ)	200
protein (g)	0.8
fat (g)	3.3
carbohydrate (g)	5.9
calcium (mg)	17
iron (mg)	0.4
vitamin C (mg)	0

100g of Blackcurrants	
energy (kcal)	30
energy (kJ)	120
protein (g)	0.9
fat (g)	0
carbohydrate (g)	6.6
calcium (mg)	60
iron (mg)	1.3
vitamin C (mg)	200

100g of Cooking Oil	
energy (kcal)	900
energy (kJ)	3600
protein (g)	0
fat (g)	99.9
carbohydrate (g)	0
calcium (mg)	0
iron (mg)	0
vitamin C (mg)	0

100g of Madeira Cake	
energy (kcal)	450
energy (kJ)	1800
protein (g)	7.1
fat (g)	24
carbohydrate (g)	49.7
calcium (mg)	67
iron (mg)	1.4
vitamin C (mg)	0

100g of Fresh Tomatoes	
energy (kcal)	15
energy (kJ)	60
protein (g)	0.9
fat (g)	0
carbohydrate (g)	2.8
calcium (mg)	13
iron (mg)	0.4
vitamin C (mg)	20

100g of Oranges	
energy (kcal)	35
energy (kJ)	140
protein (g)	0
fat (g)	0
carbohydrate (g)	8.5
calcium (mg)	41
iron (mg)	0.3
vitamin C (mg)	50

100g of Butter	
energy (kcal)	750
energy (kJ)	3000
protein (g)	0.4
fat (g)	82
carbohydrate (g)	0
calcium (mg)	15
iron (mg)	0.2
vitamin C (mg)	0

100g of Sweetcorn	
energy (kcal)	75
energy (kJ)	300
protein (g)	2.9
fat (g)	0.5
carbohydrate (g)	16.1
calcium (mg)	3
iron (mg)	0.6
vitamin C (mg)	15

100g of Rich Fruit Cake	
energy (kcal)	350
energy (kJ)	1400
protein (g)	3.7
fat (g)	11
carbohydrate (g)	58.3
calcium (mg)	75
iron (mg)	1.8
vitamin C (mg)	0

100g of Baked Beans	
energy (kcal)	60
energy (kJ)	240
protein (g)	5.1
fat (g)	0.5
carbohydrate (g)	10.3
calcium (mg)	45
iron (mg)	1.4
vitamin C (mg)	0

100g of Strawberries	
energy (kcal)	30
energy (kJ)	120
protein (g)	0.6
fat (g)	0
carbohydrate (g)	6.2
calcium (mg)	22
iron (mg)	0.7
vitamin C (mg)	60

100g of Boiled Potatoes	
energy (kcal)	80
energy (kJ)	320
protein (g)	1.4
fat (g)	0
carbohydrate (g)	19.7
calcium (mg)	4
iron (mg)	0.3
vitamin C (mg)	10

100g of Cream Crackers	
energy (kcal)	450
energy (kJ)	1800
protein (g)	9.5
fat (g)	16.3
carbohydrate (g)	68.3
calcium (mg)	110
iron (mg)	1.7
vitamin C (mg)	0

100g of Fresh Eggs	
energy (kcal)	150
energy (kJ)	600
protein (g)	12.3
fat (g)	10.9
carbohydrate (g)	0
calcium (mg)	52
iron (mg)	2
vitamin C (mg)	0

100g of Spaghetti	
energy (kcal)	375
energy (kJ)	1500
protein (g)	13.6
fat (g)	1
carbohydrate (g)	84
calcium (mg)	23
iron (mg)	1.2
vitamin C (mg)	0

100g of Cooked Stewing Beef	
energy (kcal)	220
energy (kJ)	880
protein (g)	30.9
fat (g)	11
carbohydrate (g)	0
calcium (mg)	15
iron (mg)	3
vitamin C (mg)	0

100g of Potato Crisps	
energy (kcal)	525
energy (kJ)	2100
protein (g)	6.3
fat (g)	35.9
carbohydrate (g)	49.3
calcium (mg)	37
iron (mg)	2.1
vitamin C (mg)	17

100g of Wholemeal Bread

energy (kcal)	225
energy (kJ)	900
protein (g)	8.8
fat (g)	2.7
carbohydrate (g)	41.8
calcium (mg)	23
iron (mg)	2.5
vitamin C (mg)	0

100g of Onions

energy (kcal)	25
energy (kJ)	100
protein (g)	0.9
fat (g)	0
carbohydrate (g)	5.2
calcium (mg)	31
iron (mg)	0.3
vitamin C (mg)	10

100g of Roast Chicken

energy (kcal)	140
energy (kJ)	560
protein (g)	26.5
fat (g)	4
carbohydrate (g)	0
calcium (mg)	9
iron (mg)	0.5
vitamin C (mg)	0

100g of Boiled Sprouts

energy (kcal)	20
energy (kJ)	80
protein (g)	2.8
fat (g)	0
carbohydrate (g)	1.7
calcium (mg)	25
iron (mg)	0.5
vitamin C (mg)	41

100g of Apples

energy (kcal)	50
energy (kJ)	200
protein (g)	0.3
fat (g)	0
carbohydrate (g)	11.9
calcium (mg)	4
iron (mg)	0.3
vitamin C (mg)	5

100g of Fried Liver

energy (kcal)	250
energy (kJ)	1000
protein (g)	24.9
fat (g)	13.6
carbohydrate (g)	5.6
calcium (mg)	14
iron (mg)	8.8
vitamin C (mg)	12

100g of Vanilla Ice Cream

energy (kcal)	175
energy (kJ)	700
protein (g)	3.5
fat (g)	7.4
carbohydrate (g)	22.8
calcium (mg)	130
iron (mg)	0.3
vitamin C (mg)	1

100g of Roast Potatoes

energy (kcal)	150
energy (kJ)	600
protein (g)	2.8
fat (g)	4.8
carbohydrate (g)	27.3
calcium (mg)	10
iron (mg)	0.7
vitamin C (mg)	15

100g of Honey

energy (kcal)	300
energy (kJ)	1200
protein (g)	0.4
fat (g)	0
carbohydrate (g)	76.4
calcium (mg)	5
iron (mg)	0.4
vitamin C (mg)	0

100g of Roasted Peanuts

energy (kcal)	575
energy (kJ)	2300
protein (g)	24.3
fat (g)	49
carbohydrate (g)	8.6
calcium (mg)	61
iron (mg)	2
vitamin C (mg)	0

100g of

energy (kcal)	
energy (kJ)	
protein (g)	
fat (g)	
carbohydrate (g)	
calcium (mg)	
iron (mg)	
vitamin C (mg)	

100g of

energy (kcal)	
energy (kJ)	
protein (g)	
fat (g)	
carbohydrate (g)	
calcium (mg)	
iron (mg)	
vitamin C (mg)	

100g of Bananas

energy (kcal)	80
energy (kJ)	320
protein (g)	1.1
fat (g)	0
carbohydrate (g)	19.2
calcium (mg)	7
iron (mg)	0.4
vitamin C (mg)	10

100g of Pork Sausage

energy (kcal)	375
energy (kJ)	1500
protein (g)	10.6
fat (g)	32.1
carbohydrate (g)	9.5
calcium (mg)	41
iron (mg)	1.1
vitamin C (mg)	0

100g of

energy (kcal)	
energy (kJ)	
protein (g)	
fat (g)	
carbohydrate (g)	
calcium (mg)	
iron (mg)	
vitamin C (mg)	

100g of

energy (kcal)	
energy (kJ)	
protein (g)	
fat (g)	
carbohydrate (g)	
calcium (mg)	
iron (mg)	
vitamin C (mg)	

GUESS THE FOODS FROM THESE LABELS

Read the labels and see if you can guess the foods described.

INGREDIENTS A

haricot beans, water, tomato puree, sugar, modified starch, salt, spices

INGREDIENTS B

dried potato, vegetable oil, potato starch, barbecue beef flavour (flavourings, flavour enhancer: E621, E635), salt

INGREDIENTS C

maize, sugar, salt, niacin, iron, vitamin B_6, riboflavin (B_2), thiamin (B_1), folic acid, vitamin D, vitamin B_{12}

INGREDIENTS D

whole milk, wheat flour, egg (14%), sugar, vegetable oil and hydrogenated vegetable oil, vegetable margarine, dextrose, salt, nutmeg, flavourings, colours (beta-carotene, caramel)

INGREDIENTS E

fresh whole milk, double cream, sugar, skimmed milk powder, glycerine, eggs, emulsifiers (mono- and di-glycerides of fatty acids), stabilisers (sodium alginate and guar gum)

INGREDIENTS F

wheat flour, vegetable oil, sugar, malt extract, whole milk powder, salt, raising agents (sodium bicarbonate, ammonium bicarbonate), flavourings

INGREDIENTS G

wheat flour, water, sugar, desiccated coconut, apple puree, oil, cinnamon, salt, clarified butter, skimmed milk powder, sesame seeds, spices, raising agents (disodium dihydrogen phosphate, sodium bicarbonate), preservative (calcium propionate), black onion seed, yeast

INGREDIENTS H

water, vegetable oil, spirit vinegar, mustard seed, salt, modified starch, egg & egg yolk, sugar, flavourings, cream, stabilisers (xanthan gum, guar gum), spices, lemon juice, preservative (potassium sorbate), colour (beta-carotene), white wine, mustard flour, citric acid, tartaric acid, antioxidant (BHA)

INGREDIENTS I

sugar, glucose syrup, modified starch, stearic acid, mint oils

WOULD YOU EAT THESE FOR BREAKFAST?

The following lists show the ingredients in five foods. What do you think these foods are? Would you eat them for breakfast?

FOOD 1:

WATER, SUGAR, CELLULOSE, MONOSODIUM GLUTAMATE (E621), CAROTENE (E160A), LYCOPENE (E160D), RIBOFLAVIN (E101), ASCORBIC ACID (E300), CITRIC ACID (E330), MALIC ACID (E296), OXALIC ACID, FLAVOURINGS

FOOD 2:

MYOSIN, ACTOMYOSIN, MYOGLOBIN, COLLAGEN, ELASTIN, AMINO ACIDS, CREATINE, LIPIDS, LINOLEIC ACID, OLEIC ACID, LECITHIN (E322), CHOLESTEROL, SUCROSE, GLUCOSE, PYROLIGNEOUS ACID, PHOSPHORUS, THIAMIN, RIBOFLAVIN (E101), NIACIN (E375), CYNAOCOBALAMIN, PYRIDOXINE, SODIUM CHLORIDE, IRON, MAGNESIUM, POTASSIUM

FOOD 3:

LECITHINS (E322), CEPHALINS, LYSOPHOSPHATIDYL CHOLINES, SPHINGOMYELLINS, CHOLESTEROL, AMINO ACIDS, AVIDIN, LUTEIN (E161B), ZEAXANTHIN, PYRIDOXINE, COBALAMIN, BIOTIN, CHOLECALCIFEROL

FOOD 4:

GLUTEN, AMINO ACIDS, AMYLOSE, STARCHES, DEXTRIN, SUCROSE, PENTOSANS, HEXOSANS, MONO-, DI- AND TRI-GLYCERIDES, SODIUM CHLORIDE, PHOSPHORUS, CALCIUM, IRON, THIAMIN, RIBOFLAVIN (E101), NIACIN (E375), PANTOTHENIC ACID, VITAMIN D, METHYL ETHYL KETONE, ACETIC ACID (E260), PROPIONIC ACID (E280), BUTYRIC ACID, VALERIC ACID, CAPROIC ACID, ACETONE, MALTOL (E636), ETHYL ACETATE, ETHYL LACTATE

FOOD 5:

WATER, CAFFEINE, METHANOL, ETHANOL, BUTANOL, METHYLBUTANOL, ACETALDEHYDE, METHYL FORMATE, DIMETHYL SULPHIDE, PROPIONALDEHYDE, PYRIDINE, ACETIC ACID (E260), FURFURAL, FURFURYL ALCOHOL, ACETONE, METHYL ACETATE, FURAL, METHYLFURAN, DIACTYL ISOPRENE

Food manufacturers often use **food additives**. These substances are added to food we eat to:

- improve flavour or colour
- improve the texture
- **preserve**, that is slow down the speed at which food goes off.

Important groups of additives are **acidulants**, **anti-caking agents**, **antioxidants**, **colours**, **emulsifiers** and **stabilisers**, **flavourings**, **preservatives** and **sweeteners**.

Food manufacturers must:

- test all food additives to show that they are safe to eat
- show that an additive is really needed in a product before the additive is allowed on the list of permitted additives.

Certain additives, like certain foods, can cause a small number of people to react badly to them. Such people need to avoid the food or food additive to which they are sensitive. To do this they must learn how to read the labels on food packages.

Food additives must be named on the food label; they are shown as:

E-numbers, e.g. E440. or they may be shown as their chemical name, e.g. **pectin**, or both, e.g. E440 - pectin.

The label must also say what sort of additive it is, e.g. gelling agent E440 - pectin. You will then know why the additive has been used.

Colours are found in the **E100** series.

Preservatives are found in the **E200** series.

Antioxidants are found in the **E300** series.

Miscellaneous additives such as **emulsifiers**, **gelling agents** and **stabilisers** are found in the **E400** series.

Some products would not exist at all if additives were not used, e.g. processed cheese, low fat products, sugar-free products.

An overview of the main classes of food additives follows.

Acidulants

Many foods we eat are **acidic**, so they have a sharp, sour taste. Fruit such as lemons contain a lot of citric acid. Cheese and yoghurt contain lactic acid. **Acidulants** are added to food, such as soft drinks, desserts, jams, sweets, soups and sauces to give a better taste. They also act as a preservative.

Anti-caking agents

These are particularly important in the manufacture of powdered foods. The small particles present in powdered food tend to stick together or cake. This causes problems when manufacturers are trying to put powders into containers such as jars. The powders tend to get stuck in the machinery and the packing process can be delayed. The addition of an anti-caking agent allows powders to flow more easily.

Anti-caking agents are also important in vending machines which make tea, coffee, etc. from powdered ingredients.

Another common place to find an anti-caking agent is in table salt. The anti-caking agent prevents the salt from clogging up the salt cellar.

Antioxidants

The oxygen that we breathe is essential for life. However, it can also be destructive, for example, it makes iron rusty! Our food will also react with oxygen and will be very unpleasant to eat if it does so. Substances called **antioxidants** are used to stop our food reacting with oxygen in the air.

Foods that contain **fats** and **oils** are particularly affected by oxygen. When this happens the fats and oils go **rancid**. Rancid foods taste and smell horrible. They can also be harmful.

Colours

We are more likely to eat food which looks good. Some processed foods lose their natural colour as they are being made, so colours are added to make them look appetising again. Some sweets would be colourless if the manufacturer did not add colour.

However, some people do believe colour additives are not needed.

Flavourings

If food does not taste very nice, you will not want to eat it. The substances that give food a recognisable flavour are often a complicated mixture of chemicals. Food manufacturers try to copy the taste of natural flavours so that the food tastes good. If you are making a dish at home you often add substances such as herbs and spices to give the dish a good flavour. Flavours are added to manufactured foods in very small quantities.

Emulsifiers and stabilisers

What happens if you try to add oil (such as cooking oil) to water? You will find that they do not mix together. They form two separate layers.

Some of the foods we eat, like ice cream and margarine, are mixtures of oil and water. However, they are not in two separate layers. Substances called **emulsifiers** are used to make the oil and water in these products mix together evenly.

Stabilisers are also used to give products like yoghurt a smooth, even texture.

Preservatives

The food we eat can also be 'eaten' by tiny organisms (microbes or microorganisms) such as bacteria and fungi. These microbes can make poisons (toxins) which can harm us. You have probably heard of food poisoning caused by a bacterium called salmonella.

Many different sorts of food contain preservatives. Preservatives are used to destroy bacteria and fungi or to slow down their growth. Some preservatives are simple substances such as vinegar (E260 - acetic acid). This is a natural substance. You may add it to chips!

Other preservatives such as nitrates and nitrites (E249 - E252) have a slight chance of causing some people health problems. People may choose not to eat products containing these substances. However, if they were not used, more people would certainly die from food poisoning. The nitrates and nitrites are used in meat products to prevent the growth of very dangerous bacteria.

Sweeteners

We only have 4 tastes. These are sweet (like sugar), sour (like lemons), bitter (like strong coffee or tonic water) and salt. Most of us like to eat sweet tasting foods. Food manufacturers can add different sorts of sugars or sweeteners to their products to make them sweeter. Sugar may be bad for your teeth and if you eat too much your body can change it into fat and you will put on weight.

Scientists have tried to find or make substances which will make your food sweeter but which do not affect teeth or make people fat. These are called **artificial sweeteners**. A substance like this would also be very useful for foods made for people who have **diabetes**. Artificial sweeteners can be added to many different products such as chocolate, jam and chewing gum.

Questions

1. Give two reasons why food manufacturers use food additives.
2. Complete the table below using information from food labels. Try to find four different foods. You may need to use a list of E numbers with names.

Name of food	Contains	E number	Chemical name
	a colour		
	a preservative		
	an antioxidant		
	any miscellaneous additive		

By law, food manufacturers must list, on the packet, the ingredients in a food.

Usually, the ingredients are listed in descending order by weight (mass). This means that the ingredient that is in the largest amount must be listed first. The ingredient that is in the smallest amount will be last.

There is a lot of other information on packets, for example:

- storage instructions
- a date telling you when you should eat the food
- cooking instructions
- nutritional information, which shows how much of the major nutrients such as **protein**, **carbohydrate** and **fat** are present in the food.

The following is the information found on a packet of -

CHEESE AND HAM PASTIES

INGREDIENTS

WHEATFLOUR; WATER; VEGETABLE MARGARINE (WITH EMULSIFIER - E471); CHEESE (WITH COLOUR - E160(b)); HAM (WITH EMULSIFIER - E451, ANTIOXIDANT - E301, PRESERVATIVE - E250, E251); MILK; ONION; POTATO; CREAM; MODIFIED STARCH; EGG; SALT; MUSTARD; PEPPER.

LESS THAN 10% MEAT/NO ARTIFICIAL FLAVOUR

COOKING

HEATING IN A CONVENTIONAL OVEN- *PREHEAT OVEN TO* ***180 °C, 350 °F, GAS MARK 4.*** *REMOVE PRODUCT FROM PACKAGING. PLACE ON PREHEATED BAKING TRAY IN OVEN FOR 15 MINUTES.*

FOR FAN ASSISTED OVENS HEATING TIME SHOULD BE REDUCED BY APPROXIMATELY 2 MINUTES. ***DO NOT REHEAT.***

NUTRITION (*AVERAGE VALUES PER 100g*)

ENERGY	*1290kJ 310kcal*		
PROTEIN	*7.7g*		
CARBOHYDRATE	*20.7g*	*OF WHICH SUGARS*	*1.7g*
FAT	*21.7g*	*OF WHICH SATURATES*	*11.5g*
FIBRE	*1.3g*		
SODIUM	*0.6g*		

STORAGE

SUITABLE FOR HOME FREEZING, FREEZE ON DAY OF PURCHASE.
USE WITHIN 1 MONTH. DEFROST THOROUGHLY BEFORE USE.

Look at the **INGREDIENTS** list.

1. What is the ingredient which is present in the largest amount?

2. What is the ingredient which is present in the smallest amount?

3. Find the additives in this food. (These appear as an E - number and, on this packet, the name of the type of additive is given, e.g. EMULSIFIER - E471.)

4. The packet says that there is "no artificial flavour" in this food. Find 2 natural flavours that have been added to the food (clue - they are present in very small amounts).

Look at the **NUTRITION** information.

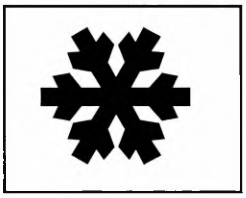
This information tells you that for every 100 g of this food there will be 20.7 g of **carbohydrate**. 1.7 g of this is present as sugars.

5. How much 'other' carbohydrate is present in 100 g of this food?

6. What might this 'other' carbohydrate be?

There were two symbols on this packet.

7. Where do you think you would have found this one?



What does it mean?

8. This one was found somewhere else on the packet:

What do you think it means?

FINDING THE ADDITIVES

This is the label from the packet of a vinaigrette salad dressing.

VINAIGRETTE SALAD DRESSING
INGREDIENTS
WATER, SOYA OIL, VINEGAR, MUSTARD, SUGAR, PARSLEY, CORIANDER, WHITE WINE, SALT, GARLIC, BASIL, OREGANO, GREEN PEPPERS, MODIFIED STARCH, TARTARIC ACID, COLOURS (CARAMEL AND COPPER CHLOROPHYLL), LEMON JUICE, STABILISER (XANTHAN GUM), ANTIOXIDANT (BHA), FLAVOURINGS
STORAGE
BEST BEFORE - 2 MONTHS AFTER PURCHASE. *DO NOT FREEZE; KEEP REFRIGERATED AFTER OPENING.*

1. What is the ingredient present in the largest amount?

2. What is the ingredient present in the smallest amount?

3. How many ingredients are present in smaller quantities than salt? Write down 3 of them.

4. Are there any additives in this food? At first glance, there are no E-numbers, but the following additives are present:

   tartaric acid E334
   copper chlorophyll E141
   BHA-Butylated hydroxyanisole E320
   caramel E150
   xanthan gum E415

   Flavourings: do not have to be listed individually

   Modified starch: modified starches are food additives but they do not have to be listed individually

   Find these again on the table. Do they appear before or after salt?

5. What does this tell you about them?

6. How long after buying this food would it still be safe to eat?

7. Imagine you made a similar dressing at home using only ingredients that you can buy easily. How long, approximately, would you expect it to stay fresh?

8. Find out what job/function xanthan gum (E415) has in this food.

A1. Some reactions between acids and alkalis

Looking at sodium hydrogencarbonate and citric acid

Pupils investigate solubility, acidity and neutralisation.

Task 1

Citric acid is far more soluble than sodium hydrogencarbonate. It is likely that all of the citric acid will dissolve in the water. About 6g of sodium hydrogencarbonate can be expected to dissolve.

Task 2

Citric acid has a **pH** of <5.

Sodium hydrogencarbonate has a pH of >7.

When the two are mixed effervescence occurs. Pupils may suggest that this could be because a gas/carbon dioxide (because a carbonate has been used) is being produced. This can be tested for using limewater which goes from clear to cloudy.

By mixing the volumes suggested on the pupil sheet, it should be possible to see that neutralisation occurs when acids are added to alkalis.

The equation for this reaction is:

citric acid + sodium hydrogencarbonate → carbon dioxide + sodium citrate + water

How much acid is present in drinks?

Pupils investigate acidity and carry out a titration.

Task 1

All of the suggested foods are acidic to some extent except for water. The inclusion of the juice from fresh fruit is to show that many natural foods are highly acidic. Fresh milk may not give an acidic pH; but with time the production of lactic acid by bacteria causes milk to 'sour' resulting in a solution with pH <7.

Task 2

Pupils carry out a titration to determine accurately the concentration of an acid in a fizzy drink.

SAFTEY NOTE: DO NOT ALLOW PIPETTING BY MOUTH

Hints for the teacher:

- Some of the soft drinks which the students will wish to test contain a range of acidulants, companies such as Britvic will often quote on labels total acidity, as an expression of citric acid.
- Make sure the drinks supplied do contain mainly citric acid rather than other acids such as malic acid, which is found in apple drinks.
- The correct use of burettes is quite a difficult skill and pupils will need guidance if this is the first time that they carry out a titration. If this is the case they should be allowed to practice using the equipment. How to read the burette correctly with respect to the meniscus and the scale must also be explained.
- The end point is taken when the pink colour just remains in the solution.

The standard citric acid solution should take between 7 and 8 cm^3 to be neutralised by the sodium hydroxide. Other results will depend on the drinks tested.

KS4
science
- some prior knowledge about acids and alkalis is desirable.

Timing - 2 or 3 sessions of 40 - 50 minutes to cover all the activities

Two pupil activity sheets A1 accompany this activity

Requirements
Task 1 (per group)

- *30 g citric acid powder*
- *30 g sodium hydrogencarbonate powder*
- *2x50 cm^3 water in small beakers*
- *stirring rods (or access to magnetic stirrer)*

Task 2

- *equal concentrations (4.0 g in 100 cm^3) of citric acid solution & sodium hydrogencarbonate solution*
- *Universal indicator & chart*
- *measuring cylinders*
- *small beakers*
- *apparatus for testing for gases such as carbon dioxide and oxygen*

Task 1

- *Universal indicator & chart*
- *samples of water, cola, fizzy lemonade, blackcurrant juice, orange squash, milk, freshly squeezed juice from oranges/lemons/other fruits*

Task 2

- *250 cm^3 conical flasks*
- *10 cm^3 measuring cylinders/pipettes*
- *distilled water*
- *phenolphthalein indicator solution*
- *burettes*
- *funnels to assist filling of burette*
- *various small beakers*
- *0.1M sodium hydroxide solution*
- *Solution 1: citric acid solution of 7 g/dm^3*
  samples of fizzy drinks; Tango, lemonade, 7Up and limeade all work well; coloured solutions can be used

See A3 Acids and Alkalis in food.

Dentists are very concerned about the effects that acids from *all food* sources, including drinks, could be having on our teeth. The best advice to anyone would be to consume these drinks in moderation; this should be stressed to pupils. It could be recommended that any action which reduces the amount of contact time between the acidic drink/food and the teeth, such as *not* constantly sipping small volumes, may be of benefit. Caution should be applied to suggestions since scientific studies have yet to analyse the situation conclusively.

Two pupil activity sheets A2 accompany this activity.

Requirements per group

- *safety goggles*
- *200 g plain flour*
- *<2 g finely ground sodium hydrogencarbonate (e.g. commercial baking powder)*
- *<2 g finely ground monocalcium phosphate* (acid calcium phosphate) (*supplied with book)*

- *2 or more 1 dm^3 beakers*
- *bunsen burner, heat resistant mat, gauze*
- *stopclock*
- *Universal indicator & chart*
- *ink and sponge (optional)*

** Further supplies are available from the Chemical Industry Education Centre, University of York, Heslington, York, YO10 5DD, (tel 01904 432523)*

A2. Boiling dumplings

Pupils do practical activities investigating raising agents.

Hints for the teacher

- The first task is to get the water to boiling point in order to cook the dumplings. A kettle could be used to bring the water to the boil more quickly.
- The pupils will have to wait 15 minutes for the dumplings to cook and so can do other tasks during this time. The order of the tasks in this section could be altered to accommodate this.
- If the cut surfaces of the cooked dumplings are brushed over with an ink-soaked piece of sponge, a texture print can be made.

Typical results (see table)

pH

- The pH of the final dumplings shows that flour alone is acidic.
- Sodium hydrogencarbonate alone makes the dumpling alkaline (and would give it a soapy taste).
- The monocalcium phosphate alone makes the dumpling acidic.
- A combination of the two results in a typical acid-alkali (carbonate) reaction and results in the dumpling being approximately neutral.

Raising properties

- A combination of an acid and alkali is needed to produce an acceptably risen product as this reaction produces carbon dioxide which is responsible for making the dumpling rise.
- Sodium hydrogencarbonate alone will make the dumpling rise a little as the compound decomposes thermally to produce carbon dioxide. Thermal decomposition is completed at higher temperatures than boiling.

The taste of sodium hydrogencarbonate used as the sole raising agent is soapy and thus its use is limited to baked products which have strong flavours such as gingerbread and parkin so that the unpleasant taste is masked.

flour + water dumpling plus	volume	colour	texture/ colour	+ Universal indicator
nothing (Recipe A)	2/1	off white	closed	orange; pH 5 - 6
$NaHCO_3$ (Recipe B)	3	yellow	medium	blue/green; pH 8 - 9
monocalcium phosphate (Recipe C)	2/1	off white	closed	red; pH 4 -5
$NaHCO_3$ and monocalcium phosphate (Recipe D)	4	white	open	green; pH 7

Pupils may wonder why the acid and alkali are not present in equal amounts. They could make a dumpling where this is the case (use 0.60 g of each). This will produce a slightly alkaline, pale yellow dumpling which has a softer texture.
In commercial situations the proportions of acid (and acid type) to alkali vary according to the product, taking into account factors such as added flavours, waiting time between mixing and baking. Most usually the proportion of monocalcium phosphate to sodium hydrogencarbonate is 1.2 : 1.0.

A3. Acids and alkalis in food

Pupils make sherbet and look at food labels for presence of acids. (Some of the information on the pupil activity sheet repeats the work done on A1, a science activity)

KS3/4
food technology

Timing - 2 sessions may be needed to cover all the activities; 50 - 60 minutes will be needed for the scones activity.

Pupil activity sheet A3 accompanies this activity.

Requirements per group
9 teaspoons of icing sugar
2 teaspoons of citric acid
1 teaspoon of sodium hydrogencarbonate

Making sherbet

Hints for the teacher

- Use citric acid and sodium hydrogencarbonate (bicarbonate of soda) suitable for consumption (citric acid suitable for eating can easily be obtained from a pharmacist).
- Pupils may like to have lollipops/liquorice if some of the sherbet is to be eaten straight away.
- It may be desirable to sieve the ingredients together to ensure thorough mixing.

A simple experiment, such as mixing each substance alone with water and then combinations of the substances with water, will show that the icing sugar is not essential to the fizzing reaction whereas the other two ingredients are. The sherbet must be kept in a sealed container until consumed so that it does not react with moisture in the air.

Find the acid

Answers to questions on Pupil activity sheet A3

2. The results will depend on the labels which are used.
3. To impart a characteristic, tart taste (e.g. citric acid for lemons; malic acid for apples).

Do we drink acids?

See *How much acid is present in fizzy drinks?*, page 43.

A4. Baking scones

Pupils investigate raising agents used in baking scones.

Two pupil activity sheets A4 accompany this activity.

Requirements for baking scones activity
plain flour
self-raising flour
Universal indicator & chart
Apparatus (per batch)

- *300 g plain flour*
- *62.5 g margarine*
- *62.5 g sugar; (it is possible to make the scones without sugar in order to save money)*
- *120 cm^3 milk*
- *balance accurate to 0.1 g*
- *<10 g commercial bicarbonate of soda*
- *<10 g monocalcium phosphate* (acid calcium phosphate) - supplied with this resource*
- *various mixing bowls, knives, etc.*
- *pastry cutters*
- *greased baking trays*
- *oven at 230^{o}C*
- *Universal indicator & chart*
- *ink and sponge (optional)*

* *Further supplies are available from the Chemical Industry Education Centre, University of York, Heslington, York, YO10 5DD, (tel 01904 432523)*

Flour - acid or alkali?

Pupils test small quantities of plain flour, and self raising flour in suitable dishes, with the Universal indicator.

Results

mixture	colour	pH	comment
self raising flour	uniform orange with red specks red specks appear; this goes greener with time	red specks 4 - 5	the red specks are picking out the acid part of the raising agent present in the flour
plain flour	even orange	5 - 6	plain flour is an acidic substance on its own

What makes scones rise?

Hints for the teacher

- To save time it might be more convenient to have the flour plus the raising agent mixtures already weighed out and prepared.
- It is important to roll the scones out to the same thickness. The use of roller guides would help this process.
- If the cut surfaces of the cooked scones are brushed over with an ink-soaked piece of sponge, a texture print can then be made. Alternatively, the cut surface of the scones can be photocopied.

Results for scones

scone mixture plus	volume	colour	texture/ structure	Universal indicator
nothing (recipe A)	2/1	off white	closed	orange; pH 5 - 6
sodium hydrogen carbonate (recipe B)	3	yellow	medium	blue/green; pH 8 - 9
monocalcium phosphate (recipe C)	2/1	off white	closed	red; pH 4 - 5
sodium hydrogen carbonate and monocalcium phosphate (recipe D)	4	white	open	green; pH 7

The taste of sodium hydrogencarbonate used as the sole raising agent is soapy and thus its use is limited to baked products which have strong flavours, such as gingerbread and parkin so that the unpleasant taste is masked.

The pupils' sheet does not specifically ask pupils to smell or taste the scones but this is permissable. The scones with just the sodium hydrogencarbonate may smell and taste 'soapy'. Obviously, the fourth batch of scones should be the most acceptable.

Discussion of results:

pH

- The pH of the final scones shows that flour alone is acidic.
- Sodium hydrogencarbonate alone makes the scones alkaline (and would give them a soapy taste).
- The monocalcium phosphate alone makes the scones acidic.
- A combination of the two results in a typical acid-alkali (carbonate) reaction and results in the scones being approximately neutral.

raising properties

- A combination of an acid and alkali is needed to produce an acceptably risen product as this reaction produces carbon dioxide which is responsible for making the scones rise.
- The sodium hydrogencarbonate alone will make the scones rise a little as the compound decomposes thermally to produce carbon dioxide.

colour

- The use of sodium hydrogencarbonate alone produces a yellow colour. This is desirable in some industrially produced cakes such as some chocolate cakes.

Pupils may wonder why the acid and alkali are not present in equal amounts. They could make scones where this is the case (use 3.61g of each). This will produce a slightly alkaline, pale yellow scone which has a softer texture. In commercial situations the proportions of acid (and acid type) to alkali vary according to the product taking into account factors such as added flavours, waiting time between mixing and baking and others. Most usually the proportion of monocalcium phosphate to sodium hydrogencarbonate is 1.2 : 1.0.

Tests on the unbaked flours

mixture	colour	pH	comment
plain flour	even orange	~ 5	plain flour is an acidic substance on its own
plain flour + sodium hydrogen carbonate	even yellow/green the colour becomes darker with time	6 - 7.5	sodium hydrogen carbonate is an alkali
plain flour + monocalcium phosphate	even orange/red	4 - 5	monocalcium phosphate is an acidic substance
plain flour, sodium hydrogen carbonate + monocalcium phosphate	even orange with red specks; goes greener with time	4 - 5	similar to self raising flour

A5. Citric acid

This is a text based activity concerning citric acid.

Answers for questions on Pupil activity sheet A5:

1. To calculate the angles required to produce a pie chart

   for soft drinks 48/100 x 360 = 172.8°
   for health salts 8/100 x 360 = 28.8° and so on.

2. A table seems the most appropriate form of presentation; its content will vary depending on the labels.

3.

Type of food product	Function in this product
beverages and soft drinks	taste; buffering properties; increase effectiveness of preservatives
jams and jellies	sour taste; acidic pH needed to make products set
frozen food	chelating agent; prevents colour and flavour deterioration
fats and oils	prevent oxidation
processed cheeses	emulsifying salt
whipping cream	stabiliser
vegetable based dairy substitutes	stabiliser
seafood	increase effectiveness of preservatives and antioxidants
cured meat products	increase effectiveness of preservatives and antioxidants; modifies texture

KS3/4
science and food technology; possibly a homework written exercise

Timing - 20 - 30 minutes

Two pupil activity sheets A5 accompany this activity.

chelating *agent - removes trace metals which enhances the performance of antioxidants*

substances are given pH values between 1 -14; acids have values<7, alkalis have values >7; pH 7 indicates neutrality.

4. a. **pH** - measurement of acidity or alkalinity of a system.

   b. **Buffer** - substances which are capable of reducing excess acidity/alkalinity so that the final pH remains the same.

   c. **Emulsions** - formed when tiny drops of one liquid are spread evenly through a second liquid; there are many examples of foods which are emulsions, such as ice cream, margarine and mayonnaise.

5. Foods containing **preservatives**; some examples:
   pizza (pepperoni with cured pork and beef sausage), sodium nitrite E250

   mayonnaise, potassium sorbate E202

   chocolate Swiss roll, potassium sorbate E202

   Belgian buns, sodium propionate E281, sodium benzoate E211

   naan bread, calcium propionate E282

6. Foods containing **antioxidants**; some examples:

   cheese and ham pasties (the ham), sodium ascorbate E301

   pizza (as above), sodium ascorbate E301

   vinaigrette, butylated hydroxyanisole (BHA) E320

SOME REACTIONS BETWEEN ACIDS AND ALKALIS

The reactions between acids and alkalis are very important reactions in everyday life as well as in both food technology and science lessons.

acid + alkali ⟶ a salt + water

Sometimes other substances are produced depending on the nature of the acids and alkalis which take part in the reaction.

Looking at sodium hydrogencarbonate and citric acid

Sodium hydrogencarbonate (an alkali) and citric acid are often found in food products.

Task 1

You are given 30 g each of citric acid and sodium hydrogencarbonate.

You are given 2 beakers each containing 50 cm^3 of water.

Find out how much of each substance you can dissolve in the water. This will compare the *solubility* of the two substances. Do **not** heat the water.

Comment on your findings.

Task 2

You are given solutions of citric acid and sodium hydrogencarbonate. Use Universal indicator to find the **pH** of each solution.

Mix 10 cm^3 of the citric acid solution with 20 cm^3 of the sodium hydrogencarbonate solution. What happens? Use Universal indicator to find the pH of the resulting solution.

What gas do you think might be produced when the two are mixed? Devise how you could test for this gas. Write a *word equation* for the reaction between these two substances.

Present your results in a suitable way.

Explain your findings.

How much acid is present in drinks?

The use of artificial sweeteners in soft drinks has helped to reduce the amount of sugar we eat. This has also reduced the amount of tooth decay. Tooth decay is caused by the production of *acids* by *bacteria* in *plaque*.

Tooth decay should not be confused with *tooth erosion*. The acids found in many of the foods and drinks we eat can cause the loss of tooth enamel. This is known as *erosion*. The frequent exposure of teeth to any *acidic* food or drink may cause this chemical erosion.

Task 1

Use Universal indicator to find out the pH of a range of drinks. Make sure you test tap water, cola, fizzy lemonade, blackcurrant juice, orange squash, milk and freshly squeezed orange or lemon juice.

Present your results in a suitable way.

Task 2

The acid that is used in most fizzy drinks is citric acid. It is quite easy to determine the acidity of drinks using a technique called **titration**.

You are given a number of solutions. Find how much citric acid is in each.

SAFETY - REMEMBER TO WEAR GOGGLES
PHENOLPHTHALEIN SOLUTION IS FLAMMABLE AND HARMFUL
SODIUM HYDROXIDE SOLUTION IS AN IRRITANT

Method

1. Measure accurately 10 cm^3 of solution 1 into a conical flask.
2. Add *about* 15 cm^3 of distilled water to the flask.
3. Add 5 drops of *phenolphthalein* to the flask. Swirl the flask carefully to mix the contents of the flask.
4. Fill the burette to a convenient point with *sodium hydroxide* solution. Sodium hydroxide solution is an alkali. (Your teacher will show you how to use a burette properly.)
5. *Slowly* and *carefully* add the sodium hydroxide solution to the flask. Swirl the flask carefully after each addition.
6. Keep adding the sodium hydroxide until the pink colour *just remains* after swirling. Carefully read from the burette how much alkali you added.
7. Repeat the titration (steps 1 - 6) another 2 times.

   You will then be able to work out, from the three* readings, an average volume of sodium hydroxide added.
8. You can find out the total acidity of the solution using the following equation. The amount of acidity will be expressed as the amount of citric acid:

   amount of citric acid = 0.64 x volume of sodium hydroxide g per dm^3.
9. If there is time, repeat the titration using another drink in place of solution 1.
10. Write up your investigation.

    Present your results in a suitable way.

    Comment on your results.
11. If your teeth are in contact with acidic foods, not just fizzy drinks, tooth erosion may occur. Think of any advice you could give to individuals who like to drink acidic drinks so that the effects of the acid are minimised.

Phenolphthalein is an indicator. It is colourless in acids. It will change to pink in alkalis.

You will notice that a pink colour appears when the sodium hydroxide is first added to the flask. This disappears when you swirl the flask as the alkali reacts with the acid.

**Do not include the reading from the first titration if this was much larger than the second two.*

BOILING DUMPLINGS

Many foods, particularly those made from a dough, rise when they are cooked. There are a number of *raising agents* which are used in cooking and some of them involve the reaction between an acid and an alkali.

The following investigation considers the effect of components in some raising agents. To do this, you are going to make 4 dumplings using different recipes.

Recipe A

50 g plain flour only

Recipe B

50 g plain flour
0.60 g sodium hydrogencarbonate

Recipe C

50 g plain flour
0.72 g monocalcium phosphate (acid calcium phosphate)

Recipe D

50 g plain flour
0.60 g sodium hydrogencarbonate
0.72 g monocalcium phosphate (acid calcium phosphate)

Method

1. Put about 500 cm^3 of water into two, 1 dm^3 beakers and heat to boiling. This will be used to cook the dumplings.
2. Meanwhile, mix each of the dumpling mixtures with sufficient water to give a stiff ball of dough.
3. Place two of the dough balls into each of the beakers of boiling water for 15 minutes. Make sure you know which dumpling is which.
4. Remove the dumplings from the water and allow them to cool for a few minutes after cooking.
5. Cut each dumpling in half so that you can see inside. Compare the dumplings in the following ways:

- Which has the greatest volume? Give the greatest one the value 4, the next 3, the next 2 and the smallest 1.
- Describe the colour as white, off-white, pale yellow or yellow.
- Describe the texture/structure as closed, medium or open.
- Place three drops of universal indicator on a cut surface of each dumpling. Wait one minute. Describe what happens in terms of colour and pH number.

6. Put your results in a suitable table.

Try to explain the differences in the results.

What reaction is taking place in recipe D which makes the dumplings rise?

The reactions between acids and alkalis are very important in everyday life as well as in both food technology and science lessons.

Making sherbet

Sherbet fizzes when it comes into contact with moisture on your tongue. Sherbet can be made from icing sugar, citric acid and sodium hydrogencarbonate (an alkali; it is sometimes called sodium bicarbonate or bicarbonate of soda).

Can each of these chemicals make the fizz on their own? Or is a combination of 2 or all 3 of them needed? Plan a simple experiment to find out.

You can then make your own sherbet by using the following recipe:

9 teaspoons of icing sugar
2 teaspoons of citric acid
1 teaspoon of sodium hydrogencarbonate

Mix all the ingredients very thoroughly. Keep the sherbet in a sealed container until you want to eat it. Why do you think this is important?

Find the acid

1. Find the labels from at least 10 items of food and drink that contain *acids*.
2. Make a table into which you can put the *name* of the food or drink and the *acid* it contains.
3. Why do food manufacturers add acids to foods?

Do we drink acids?

The use of artificial sweeteners in soft drinks has helped to reduce the amount of sugar we eat. This has also reduced the amount of tooth decay. Tooth decay is caused by the production of *acids* by *bacteria* in *plaque*. Tooth decay should not be confused with *tooth erosion*. The acids found in many of the foods and drinks we consume can cause the loss of tooth enamel. This is known as *erosion*.

The frequent exposure of teeth to *any* acidic food or drink may cause this chemical erosion.

Use Universal indicator to find out the pH of a range of drinks. Make sure you test tap water, cola, fizzy lemonade, blackcurrant juice, orange squash, milk and freshly squeezed orange or lemon juice.

Present your results in a suitable way.

If your teeth are in contact with acidic foods, not just fizzy drinks, tooth erosion may occur. Think of any advice you could give to individuals who like to drink acidic drinks so that the effects of the acid are as reduced as is possible.

BAKING SCONES

Before being eaten, any product which contains flour must be cooked. This alters the starch in the flour so that it becomes digestible. Flour is used in many savoury and sweet dishes, particularly in foods that consist of a *dough*.

Cakes, bread and other similar dishes often contain a *raising agent*. A raising agent consists of an acid and an *alkali*. The acid present can vary but the alkali used is usually sodium hydrogencarbonate. Raising agents are classed as food additives; the two most important ones being E341 - the acid calcium phosphates and E500 - sodium carbonate.

You are going to investigate what makes scones rise.

Flour - acid or alkali?

1. Place a small sample of ordinary *self raising flour* into a suitable dish.
2. Add some Universal indicator solution. Leave for two minutes. Describe and explain what happens.
3. Repeat this using ordinary *plain flour*. Describe and explain what happens.

What makes scones rise?

You are going to produce and compare *four* different batches of scones. It may be better to work in 4 groups and share results.

Recipe A

1. Sift 250 g of *plain flour* into a mixing bowl.
2. Rub 62.5 g of *margarine* into the flour.
3. Add 62.5 g of *sugar* into the mixture.
4. Gradually add approximately 120 cm^3 of milk and mix to give a good dough. The amount of milk you will need to add may vary.
5. Roll out the dough on a lightly floured surface or board. It must be 1cm thick.
6. Cut the dough into scones using a pastry cutter.
7. Place the scones onto a lightly greased baking tray and bake for 12 to 15 minutes in an oven at 230 °C.

Recipe B

1. Weigh out 300 g of *plain flour*.
2. Add to this 3.61 g of *sodium hydrogencarbonate*.
3. Mix these dry ingredients very thoroughly.
4. Take 250 g of this mixture and sift it into a mixing bowl. Keep the rest of the mixture for a later test.

Carry out steps 2-7 of recipe A.

Recipe C

1. Weigh out 300 g of *plain flour*.
2. Add to this 4.33 g of *monocalcium phosphate* (acid calcium phosphate).
3. Mix these dry ingredients very thoroughly.
4. Take 250 g of this mixture and sift it into a mixing bowl. Keep the rest of the mixture for a later test.

Carry out steps 2-7of recipe A.

Recipe D

1. Weigh out 300 g of *plain flour*.
2. Add to this 3.61 g of *sodium hydrogencarbonate* and 4.33 g of *monocalcium phosphate* (acid calcium phosphate).
3. Mix these dry ingredients very thoroughly.
4. Take 250 g of this mixture and sift it into a mixing bowl. Keep the rest of the mixture for a later test.

Carry out steps 2 - 7 of recipe A.

When the scones are ready and cool, cut each of the scones in half so that you can see inside. Compare them in the following ways:

- Describe the colour; white, off-white, pale yellow or yellow.
- Which scone has risen the most? Give 4 to the highest scone, 3 to the next, 2 to the next and 1 to the smallest.
- Describe the texture/structure; closed, medium or open.
- Add three drops of Universal indicator to each cut surface. Wait for one minute. Describe what happens in terms of colour and pH number.

You should have samples of unused mixtures from recipes B, C and D and some plain flour as used in recipe A. Add 3 drops of Universal indicator to each of these mixtures and comment on what you observe.

Present your results in tables similar to those below. Try to explain the differences in the results.

Comparison of scones from the four recipes

scone mixture plus	volume	colour	texture/ structure	Universal indicator
nothing (Recipe A)				
sodium hydrogen carbonate (Recipe B)				
monocalcium phosphate (Recipe C)				
sodium hydrogen carbonate and monocalcium phosphate (Recipe D)				

Comparison of flour mixtures prior to baking

flour mixture sample	colour/pH	comments
from recipe A		
from recipe B		
from recipe C		
from recipe D		

Many of the foods we eat are *acidic*, that is they contain acids. This explains their sharp taste. Natural foods like oranges, lemons, apples, tomatoes, cheese and yoghurt are all strongly acidic. Citrus fruits contain citric acid, apples and pears contain malic acid, cheese and yoghurt are rich in lactic acid.

Citric acid was first extracted from lemon juice about 200 years ago. It is the most versatile and widely used **acidulant**. It is found abundantly in nature. It is used extensively in foods, beverages and the pharmaceutical industry.

Tasks

Citric acid is economically very important. It is manufactured in 20 countries with world wide production, in 1997, in the region of 750 000 tonnes. Just over 35% of citric acid is manufactured in Europe, where about 250 000 tonnes of citric acid is used each year.

The table below shows the % use of citric acid in the UK.

PRODUCT	% USE
soft drinks	48
health salts	8
other foods	12
confectionery	9
detergents	16
other uses	7

1. Construct a *pie chart* to illustrate these figures.
2. Collect food labels and non-food product labels, like some medicines, where citric acid, E330, or its salts, E331, E332, E333, are present. Display your findings in a suitable way.

   Answer the following questions after you have read the information about citric acid (on next page).
3. Make a table which summarises the functions of citric acid and its salts in food. The first column should show the type of food product. The second should show the function of citric acid.
4. What is meant by:
   a. **pH**?
   b. a **buffer**?
   c. an **emulsion**?
5. From food labels, find the names of two food products which contain a **preservative**. Write down the name of the food, the name of the preservative and the E-number.
6. From food labels, find the names of two food products which contain an **antioxidant**. Write down the name of the food, the name of the preservative and the E-number.

CITRIC ACID

"Citric acid is used extensively in food and industrial applications because it has many important chemical properties.

Citric acid (E330), sodium citrate (E331) and potassium citrate (E332) are widely used in beverages and soft drinks. A combination of these three substances is used to give flavour, provide buffering properties and increase the effectiveness of preservatives.

In jams, jellies and preserves, citric acid is used to give a sour taste. An acidic pH (<7) is also needed for these products to set properly, i.e. to produce a gel.

Citric acid is able to combine with free metals in foods that are frozen. This is described as being a **chelating** agent. This is important since it enhances the actions of antioxidants. Citric acid also prevents colour and flavour deterioration in frozen food.

The oxidation of fats and oils in food products can be prevented by the addition of citric acid. It acts, again, by removing trace metals.

Sodium citrate acts as an emulsifying salt in processed cheeses. It modifies the protein in the cheese enabling it to form an emulsion between the water and fat. This prevents the separation of these components and improves the body and texture of the cheese. Sodium citrate is also an important stabiliser in whipping cream and vegetable based dairy substitutes.

Citric acid is used in seafood and cured meat products to increase the effectiveness of colours, flavourings, preservatives and antioxidants. It also modifies the texture of meat products.

Citric acid and citrate salts have a number of medical uses. They are used as buffers in a wide range of pharmaceutical products. Effervescent formulations (such as Alka Seltzer) contain a mixture of citric acid and sodium bicarbonate to assist dissolving and to improve taste. Sodium citrate is added to human blood to prevent coagulation before it is used in transfusions, etc.

Citric acid has many industrial uses, such as a laundry detergent, and a number of agricultural uses. Other uses include the production of concrete and mortar, a blowing agent in plastic production and an important component of many cosmetics and toiletries.

It is a truly versatile compound!"

AC1. The action of an anti-caking agent

Pupils are asked to design and carry out an investigation for a cocoa manufacturer who wishes to know whether the addition of an anti-caking agent to the cocoa will help the powder to flow more freely through the machinery. An additional question asks whether leaving the cocoa to stand further with the anti-caking agent added, affects the flow.

Hints

It should be noted that, without care, this has the potential to be a very messy investigation! The cocoa is most easily mixed with the anti-caking agent by putting the two together into a plastic bag or lidded container and shaking them. Make sure the bags are tied at the top or that the lids fit well! When transferring the cocoa from any container into another, there is a tendency for it to fly around.

Using either 100 g or 50 g of cocoa (the smaller of the two suggested funnels will not hold 100 g) it is possible to count the number of taps on the side of the funnel needed to make the cocoa pass through the funnel.

The process must be repeated a number of times to find a mean.

The maximum amount of anti-caking agent that can be used in food legally is 1% by mass in the final product. Pupils may design an experiment which covers a range of concentrations from 0.1 to 1%.

The addition of the anti-caking agent makes a significant difference to the flow of the cocoa above a certain concentration.

Leaving the mixture to stand *for any length of time* also makes a considerable difference. This is one factor which may not be immediately apparent. Making up all the concentrations together, but leaving them standing while testing one of them, may affect the results. However, it is advisable to leave the two powders together *for a short and standard period of time* before carrying out the test.

Factors to keep constant include:

- how 'strong' the tap is on the side of the funnel
- how the anti-caking agent and cocoa are mixed before use
- size of funnel
- the length of time the anti-caking agent is left mixed with cocoa before use.

KS3 and 4 science

Timing - various

Pupil activity sheet AC1 accompanies this activity.

Requirements
- *balance accurate to 0.1 g*
- *clamps and stands*
- *powder funnels [Ordinary filter funnels are not suitable since the opening to the stem is too narrow; suitable funnels may be purchased from Philip Harris, Lynn Lane, Shenstone, Lichfield, Staffs, WS14 0EE; two sizes are appropriate and have code numbers R86432/6 and R86433/8]*
- *plastic bags approximately 25x25cm [It is essential that the bags do not have holes in them! The bags are used to mix the cocoa with the anti-caking agent; you could also use plastic containers with lids]*
- *cocoa [This must be 100% cocoa and not have an anti-caking agent already present (check the label!)]*
- *anti-caking agent* This is supplied with the resource. Store this in a dry place; this additive is silicon dioxide, E551*
- *other simple equipment such as beakers, spatulas, spoons*

* *Further supplies are available from the Chemical Industry Education Centre, University of York, Heslington, York, YO10 5DD, (tel 01904 432523)*

AC2. The function of anti-caking agents - a case study

The effect of Neosyl GP (silicon dioxide, E551) on the ability of Sainsbury's cocoa to flow is investigated.

Two pupil activity sheets AC2 accompany this case study.

The case study, on pupils sheet AC2, gives the procedures and results for an example investigation. You may prefer to replace the actual experiment AC1 with a discussion of AC2.

Neosyl GP (GP = general purpose) is an anti-caking agent. It is capable of improving the flow of many powders. Sainsbury's cocoa does not contain a free-flow agent. Other brands could be used as long as they too contained only cocoa.

Aim of the first part of the investigation: to determine the orifice size through which cocoa without Neosyl GP will not readily flow.

Aim of the remaining investigations: to determine the effect on the flow of cocoa with Neosyl GP added.

pupil activity AC1

TO INVESTIGATE THE ACTION OF AN ANTI-CAKING AGENT

The problem with powders is that the particles in the powder have a tendency to stick together or *cake*. This is commonly seen with table salt which sticks in the salt cellar and refuses to be sprinkled over your chips! This is really only a minor inconvenience and the problem can often be solved by adding a few grains of rice. It may be interesting to consider how this works.

Manufacturers of food powders may experience real problems if the powder sticks together to form big lumps and clogs up the machinery.

Many production systems will use an *anti-caking agent* at some point in the production process.

You receive the following letter from the manufacturers of a cocoa powder:

Memo to: ***Research Director***
from: ***Technical Manager***

Chris,
As you know, we manufacture a high quality powdered cocoa which is used in cooking and for hot drinks.

We have found that particles of cocoa stick together and stop flowing through various parts of the machinery. This causes us to stop production in order to clear the blockages, which wastes a lot of time and is costing us a lot of money. The time taken to fill the containers is double what it should be.

If this situation continues we will be forced to pass this extra expense on to the consumer.

We have available to us an anti-caking agent which claims to help the cocoa powder to flow more freely and enable us to overcome this problem. We understand, by law, that the maximum permitted level of anti-caking agent is 1% of the mass of the final food.

We would like you to carry out an investigation using our cocoa and the anti-caking agent to find out:

a. Does the anti-caking agent really make the cocoa flow more freely?

b. Sometimes the machines are left full of cocoa overnight and so the agent would remain mixed in with the cocoa. Will this make further difference to how quickly it flows?

Yours sincerely,

Jo

You are given the following:

- cocoa
- anti-caking agent
- clamps and stands
- a funnel - if cocoa is *carefully* placed in this funnel, the cocoa will *not* flow through the funnel unless the rim of the funnel is gently tapped
- a balance
- plastic bags or containers with lids in which you can mix cocoa with the anti-caking agent
- and other simple apparatus.

Task

Design and carry out an investigation which will attempt to answer the two questions asked in the letter.

Hints

- handle the powders **very carefully**; to avoid mess
- remember to carry out a **fair test**
- remember to write a **report** for the cocoa company.

Investigation into the effect of Neosyl GP (silicon dioxide, E551) on the ability of Sainsbury's cocoa to flow

Method 1

1. Different sized funnels were prepared by removing 'stems'.
2. 100 g of cocoa was placed in the funnels.
3. The sides of the funnels were tapped to allow cocoa to flow through.
4. The number of taps required to remove all the powder was counted.
5. Each test was done 6 times and an average calculated.

Results: Cocoa without Neosyl GP

Orifice size	Number of taps						
mm	1	2	3	4	5	6	Average
50	4	4	2	2	2	2	3
40	2	1	1	7	3	3	3
30	44	20	20	21	21	23	25

On the basis of these results, the funnel with the 30 mm orifice was chosen for subsequent experiments as cocoa would not readily flow through this size.

Method 2

1. 100 g of cocoa powder was mixed with varying amounts of Neosyl GP so that the Neosyl GP was present as 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 % by weight of the final mixture.
2. The mixing took place in a plastic bag. The two substances were placed in the bag and shaken vigorously.
3. Each mixture was placed in the funnel, as described before, and the number of taps needed to get all the powder through the funnel were counted. Each experiment was repeated 6 times.
4. One of the mixtures, the 0.3 %, was left for ~48 hours before carrying out the test.
5. A 0.6 % mixture was left for ~24 hours before being tested.

Results: Cocoa with Neosyl GP

Neosyl GP	Number of taps						
%	1	2	3	4	5	6	Average
0.1	23	25	25	19	19	20	22
0.2	27	23	20	16	17	19	20
0.3*	7	7	6	6	7	5	6
0.4	6	7	5	3	2	2	4
0.5	5	2	2	4	3	4	3
0.6	7	5	3	2	7	6	5
0.6**	3	2	2	2	2	4	3

* After an interval of ~48 hours

** After an interval of ~24 hours

Discussion: There appears to be a sudden improvement in flowability between the 0.2 and 0.3 % levels. It is not clear whether this is due to the increase in the level of the flow aid or to the fact that the mixture was allowed to stand for some time. Leaving the 0.6 % to stand seems to have improved its flowability. The experiment was repeated starting with the 0.4 % mixture.

Results: Cocoa with Neosyl GP, repeats

Neosyl GP	Number of taps						
%	1	2	3	4	5	6	Average
0	27	27	39	26	26	24	28
0.4	16	20	14	12	15	10	14.5
0.5	11	16	9	12	12	8	11
0.6	11	9	7	7	7	6	8
0.7	5	4	3	4	8	4	5
0.7*	1	2	2	1	2	1	1.5

* After ~48 hours

Discussion: These results show some variance with the previous results, some of which were supposed to be identical repeats. The results indicate that considerably more than the 0.3% Neosyl GP is needed to achieve good flowability. Leaving the mixture to stand for a while is again observed to result in improved flowability.

The experiment was repeated again with larger amounts of Neosyl GP.

Results: Cocoa with more Neosyl GP.

Neosyl GP	Number of taps						
%	1	2	3	4	5	6	Average
0	35	13	19	13	31	22	22
0.7	7	9	9	4	9	3	7
1.0	3	4	2	4	3	2	3

Discussion: It appears from the data that the maximum allowed dose of 1.0% Neosyl GP will almost make the cocoa entirely free flowing and that leaving the mixture to stand improves the flow.

The improvement in flow when left to stand may be due to the fact that the Neosyl GP is capable of absorbing fat. Cocoa has a fat content of ~20 %. The absorption of fat by the Neosyl GP may thus allow the particles of cocoa to flow more freely.

The action of an anti-caking agent can be demonstrated using ball bearings or something similar. If particles of the same size are within a container, they reach a point where they 'lock' together and become stationary. The addition of other spheres of *different sizes* has the effect of 'unlocking' the spheres so that they move again. Cocoa consists of small particles of similar size. The Neosyl GP consists of particles of a different size to the cocoa. Mixing of the two increases the mobility of the cocoa particles.

AO1. Oxygen - friend or foe?

Why has my apple gone brown?

Pupils carry out investigations into conditions for apple browning.

SAFETY NOTE: ***SOME ASTHMATICS ARE VERY SUSCEPTIBLE TO SULPHUR DIOXIDE VAPOURS*****; THE SODIUM METABISULPHITE SOLUTION MUST BE PREPARED BY A TEACHER OR TECHNICIAN.**

The results given are for Bramley cooking apples. The cut surface of a Bramley showed noticeable browning after 10 minutes.

The tasks on sheet AO1 show:

2. The cut surface browns more quickly than the broken surface. When an apple is broken it tends to break between the cells rather than through the cells as is caused by cutting. Breaking the apple causes less cell damage and less discolouration.
3. The pulped apple browns much quicker than the whole apple piece. Pulping produces extensive cell damage and allows for rapid diffusion of oxygen into the tissue. Intact cells have reducing characteristics which mean that oxygen is reduced in a controlled way in respiration rather than taking part in browning reactions.
4. The piece in the air should brown fastest; the one in water should be next; the piece in ascorbic acid takes longer to brown and the sulphur dioxide piece takes much longer to brown. The one in air has greater contact with oxygen than the one in water. Ascorbic acid is a reducing agent and hence will slow down the rate of **oxidation**. Sulphur dioxide is a common preservative; in this case it is acting as an **enzyme** inhibitor.
5. The piece in boiling water should take a long time, if at all, to brown. If this was a purely chemical reaction, the rate of browning should increase with temperature. The result suggests an enzyme controlled reaction. This is enhanced by the fact that the piece at 30 °C should brown more quickly than others at room temperature.
6. Bruising should have a similar effect to pulping since bruising also causes extensive cell damage. Pupils may wonder how the reaction occurs without the air/oxygen seemingly being in contact with the tissues. It is important for them to realise that very little oxygen is needed to initiate oxidation. Dissolved oxygen will be present in the tissues and this is taking part in the reaction.

Two important points come from these tasks. The browning reaction is:

- enzyme controlled;
- an oxidation reaction.

Hence, the reaction may be prevented or slowed down by using methods which restrict enzyme action or methods which employ an antioxidant or reducing agent.

Further investigations

The suggestions for further investigation may be suitable for assessment of Sc1. Since pulped apple browns more quickly and evenly than whole pieces, it is advisable to use pulp in further investigations.

a. There are many other natural **antioxidants** that could be investigated.

KS4
science and food technology

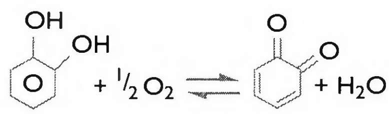
Timing - 40 - 60 minutes
Pupil activity sheet AO1 accompanies this activity.

Requirements
- *apples (see below)*
- *knives or scalpels*
- *white tiles to cut on*
- *a blender or pestle and mortars*
- *ascorbic acid (Viramin C) solution - 5%*
- *sodium metabisulphite - to give a dilute solution of sulphur dioxide use 2 g in 100 cm³ of water*
- *beaker of boiling water*
- *beaker of water at 30 °C*

Apple selection *- you need to choose a variety which browns in the shortest time possible; cooking apples and continental apples brown more quickly than English eating apples; it is recommended that you try a particular apple first since even different batches of the same apple type will show variations.*

Cooks and chefs add lemon juice to prevent browning.

For teacher information: *the browning reaction is really a series of reactions which result in the oxidation of compounds which contain the structure of 1,2-dihydroxybenzene. The first reaction in the sequence is catalysed by the enzyme polyphenoloxidase and this is the reaction that is important in the pupils' investigations. It is an oxidation reaction which produces a quinone.*



a quinone

There are many potential substrates for the reaction, but they are usually referred to as the 'tannins'. The final reactions are polymerisation reactions which produce the highly coloured pigments that can be detected as browning.

You could try a number of acids - malic acid (E296), this is the principal acid in apples; citric acid (E330), the principal acid in citrus fruits; acetic acid (E260) which is vinegar.

b. A set of **buffers** could be used to produce a variety of pHs. Alternatively, mixtures of 0.4M disodium hydrogen orthophosphate and 0.2M citric acid solutions can be used.

0.4M disodium hydrogenorthophosphate/cm^3	0.2M citric acid/cm^3	pH (approx.)
0.4	19.6	2.2
4.1	15.9	3.0
7.7	12.3	4.0
10.3	9.7	5.0
12.6	7.4	6.0
16.5	3.5	7.0
19.4	0.6	8.0

c. Since this is an enzyme controlled reaction, a range of temperatures can be chosen to reflect knowledge of the effect of temperature on enzymes.

d. A range of suitable concentrations could be from 0 to 10% acid.

e. Different types of apples, i.e. different substrates, do brown at different rates. Dessert apples tend to brown more slowly than cooking apples. This is due to lower levels of tannin in dessert apples which have been selected for this reason over many years.

In all of these investigations, one of the most difficult aspects is the ability to measure the extent of the brown colour accurately.

KS4
science and food technology

Timing - 30 minutes

possible homework exercises

Two pupil activity sheets AO2 accompany this activity, plus optional sheets A02M and A02F.

Requirements
- *graph paper*
- *compass for drawing circles*
- *protractor (angle measurer)*

See page 53 for graph showing height to weight distribution

AO2. Fats

This exercise revises information on the structure of fats and encourages pupils to improve their diet with respect to fats. Some pupils may be over concerned with their weight. Pupil sheets A02M and A02F show ranges of heights and weights for young people between the ages of 5-18. These could provide data for group or class discussions.

Answers to questions on Pupil sheets AO2:

1. A bar chart is the most suitable method of displaying the information.
2. To calculate the angles required to produce a pie chart, e.g. for beef fat:

   saturated fatty acids 55/100 x 360 = 198°

   monounsaturated fatty acids 40/100 x 360 = 144°

   polyunsaturated fatty acids 5/100 x 360 = 18°
3. Lard is pig fat.
4. Herring oil (from fish) has a relatively low % of saturated fatty acids.

   Coconut oil has a relatively high % of saturated fatty acids. (Pupils could give answers that referred to correspondingly low % of unsaturated fatty acids.)
5. Olive oil, maize (corn) oil and herring oil have the greatest % of total unsaturated fatty acids and would be expected to go rancid most quickly.

6. Answers will vary according to chosen foods. Antioxidants are used in these foods to prevent the fat in the food reacting with oxygen (prevent oxidation) to produce **rancidity**.

AO3. Further fat research

Cooking up trouble?

KS4
science and food technology

Timing; 2 possible homework exercises

Pupil activity sheet, AO3 accompanies these activities.

Unsaturated fatty acids become more saturated with use. This is an established fact but the consequences on our health are largely unknown. There is no legal requirement for caterers to change the fat used for frying after any particular amount of use. This is usually governed by subjective tests such as 'it doesn't look right any more'. This project allows pupils to find out common practice in various catering establishments.

What a lot of fat

The Department of Health has set a target to reduce the percentage of energy derived from fat from 40 % to a healthier 33 %. The levels of saturated fatty acids should be reduced from 15.4 % for men and 16.5 % for women to 10 % for both genders.

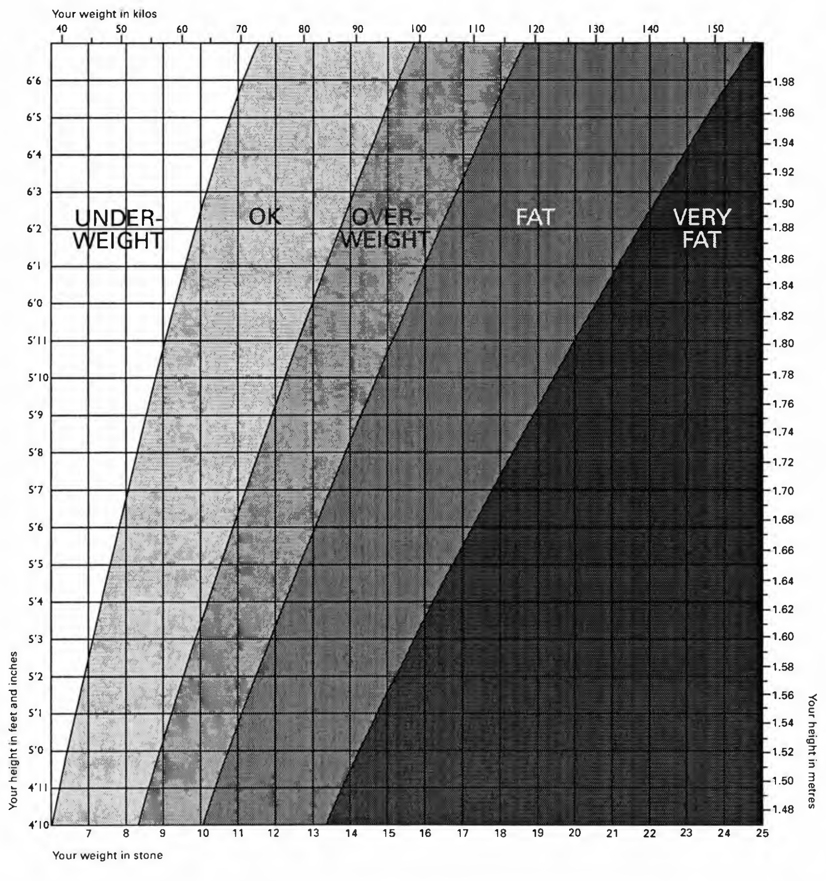
The Health of the Nation programme is also aiming to reduce obesity (see chart below) to 6 % in men and 8 % in women by the year 2005.

At the moment it seems unlikely that targets will be met. Indeed the current rates of obesity, of 13 % in men and 16 % in women, are actually predicted to rise!

This project asks pupils to find out about the fat content of common foods, simple ways of reducing fat intake and the contribution that 'light' versions of foods may make to our diets.

As a consequence of The Department of Health's 1992 White Paper "The Health of the Nation", the public was advised to reduce their total fat intake in an attempt to significantly reduce coronary heart disease in Britain by the year 2000.

Access to books, leaflets and/or computer databases/programs and food labels is needed. The booklet 'Enjoy healthy eating - the balance of good health' published by the Health Education Authority (ISBN 0 7521 0408X) is particularly useful.



Graph to show ideal Height :Weight ratio
Adapted from the Health Education Authority booklet: Changing what you eat.

All life needs oxygen. It is used in all plant and animal cells in the process of **respiration**. This process releases the *energy* contained in the food we eat so that we can do things. Reactions between oxygen and another substance are called **oxidation** reactions.

But is oxygen always useful? Foods can also be attacked by oxygen. Food additives called **antioxidants** are used to try and slow down the reaction between food and oxygen. Antioxidants are numbered from E220 - E330 (you may find that some of the preservatives are found within these numbers too).

Foods which contain **fats** and oils, in small or large quantities, are particularly susceptible to oxidation. The softer fats are described as being **unsaturated**. These fats may be less likely to cause harm to our health than the saturated fats but they are more likely to be attacked by oxygen. When fats become oxidised they produce unpleasant and sometimes dangerous substances; the fats become **rancid**.

It is hard to believe, but pure oxygen can be dangerous to our health. It seems that oxidation reactions inside our bodies could lead to increased risk from heart disease. Our bodies have natural antioxidants (vitamins C and E are examples) and consuming these, and other antioxidants, through our diets, could prove to be very important in combating heart disease.

Other effects of oxidation are less dangerous but also undesirable. You are going to investigate a very common oxidation reaction.

Why has my apple gone brown?

You may have noticed when peeling and slicing fruits such as apples, that the fruit starts to change colour and goes *brown* with time. This is not a problem when eating a raw apple as a snack but it is of great importance in the large scale production of many fruit products.

Cooks and chefs, perhaps by chance, found a simple way of slowing down this browning reaction. Do you know what they did?

Carry out the following investigation which will allow you to find out more about this browning reaction. There are a number of small tasks to do. You may like to divide the work up between a few groups and then pool results.

If you are the group using boiling water or water at 30°C, get this ready *before* you cut your apple.

SAFETY - USE SAFETY GOGGLES WHEN HEATING
BE CAREFUL USING KNIFE or SCALPEL BLADES
ASTHMATICS MAY BE SENSITIVE TO SULPHUR DIOXIDE

Method

1. You will need 11 pieces of apple for the entire investigation. Each piece needs to be about an eighth of a typical eating apple.
2. Take 2 pieces of apple. Leave them both to brown. When they are brown cut one of them in half using a knife/scalpel. Break the other into two pieces using your hands. What happens to the freshly cut surface and the freshly broken surface?
3. Take 2 pieces of apple. Turn one of them into a pulp (using a blender or a pestle and mortar. Compare the browning of the pulp with the unpulped piece.
4. Take 4 pieces of apple. Put one in water. Put one in ascorbic acid solution. Put one in dilute sulphur dioxide solution. Remember that apples will float so you will need to find a way to keep them below the liquid surface. Leave the fourth piece in the air. Leave them all for a few minutes and then compare.
5. Take 2 pieces of apple. Drop one piece into a beaker of already boiling water. Leave in the water for 2 minutes. Transfer the piece to cold water for 1 minute. Remove it and then leave it in the air.

   Drop the second piece into a beaker of water at 30°C for 2 minutes. Transfer the piece to cold water for 1 minute. Remove it and then leave it in the air.

   Compare the two pieces after a few minutes.
6. Take 1 piece of apple. It must still have the peel on. Bruise this piece, peel side down, by hitting it against a hard surface. Leave for a few minutes and then cut it open to see what has happened.

If different groups have done these tasks, you will have to get together to give each other the results. Using the results, write a few sentences about what each of the tasks tells you about the browning reaction in apples.

Further investigations

a. Investigate if other substances such as vanilla, other acids (instead of ascorbic acid), mustard, sesame seeds and rosemary can also slow down the browning reaction.

b. What effect does pH have on this reaction?

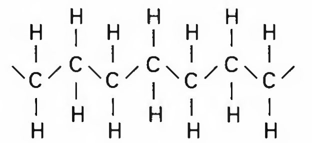
c. Investigate in greater detail the effect of temperature on this reaction.

d. What is the lowest concentration of ascorbic acid that can be used to significantly slow down the browning reaction?

e. Do different types of apples, e.g. Bramley, Golden Delicious, Cox, Granny Smith's, brown at different rates?

A great variety of **fats** are present in our foods, such as butter, lard, olive oil and suet. All fats have very similar structures. Each molecule of a fat is made from one molecule of a simple substance called **glycerol** joined to three molecules of substances called **fatty acids**. Fats may be described as **triglycerides**. Fats are also sometimes called *lipids*.

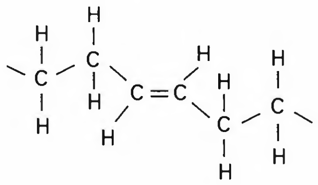
The fatty acid part of the fat molecule contains a long chain of *carbon* atoms to which *hydrogen* atoms are attached.



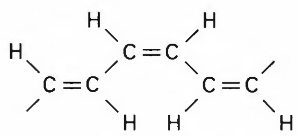
a saturated molecule

If each carbon atom is attached to its full amount of hydrogen atoms, the resulting molecule is said to be **saturated**. Molecules of saturated fat contain only carbon to carbon *single* bonds.

When one or more pairs of hydrogen atoms are missing from neighbouring carbon atoms, the resulting molecule is said to be **unsaturated**. Unsaturated molecules will have some *double* bonds between the carbon atoms. When one pair of hydrogen atoms is missing the fatty acid is said to be **monounsaturated**. When two or more pairs of hydrogen atoms are missing the fatty acid is said to be **polyunsaturated**.



Monounsaturated



Polyunsaturated

Whether or not fats contain saturated or unsaturated fatty acids is of considerable importance. The more saturated a fat is, the harder the fat tends to be. Fats which are from animal sources tend to be saturated and harder, though there are exceptions. The more unsaturated a fat is, the softer it is and oils may be formed. Fats from plant sources tend to be unsaturated and softer, though there are exceptions here as well.

Medical evidence suggests that the saturated fats are also associated with a higher risk of circulatory and heart problems. We are advised in general to cut down on the amount of fat we consume. When we do eat fats we are advised to use the monounsaturated or polyunsaturated fats.

Unfortunately, for the food industry and the home, the unsaturated fats are more susceptible to attack by oxygen. In other words they are more prone to **oxidation**. When fats undergo oxidation they produce unpleasant and sometimes harmful substances that make the fat **rancid**. There are many substances which are used as **antioxidants** in food processing to delay the process of oxidation.

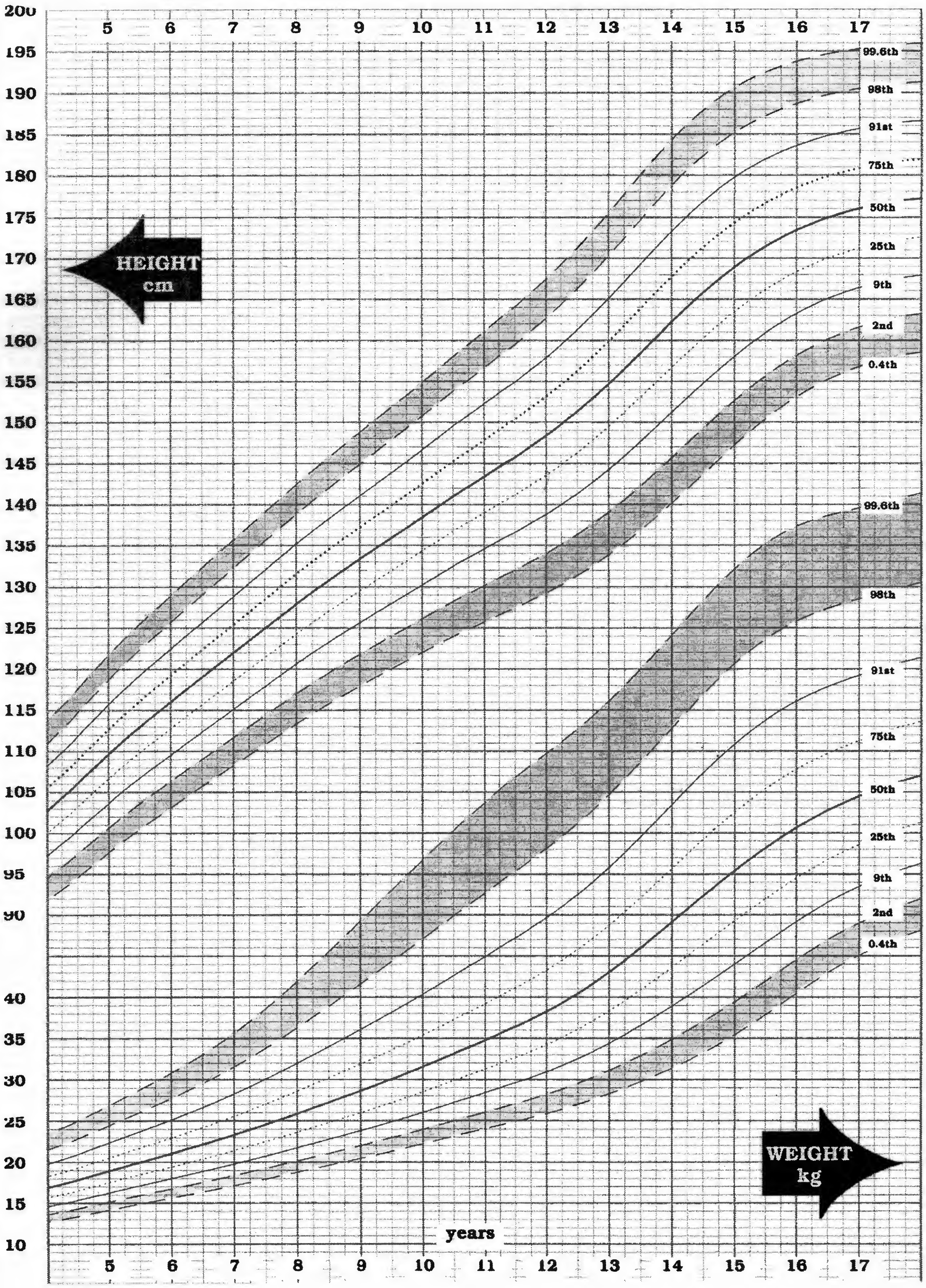
Oxidation reactions in the body, except those associated with the release of energy in respiration, can lead to heart and circulatory problems. The consumption of antioxidants in foods may help to reduce this.

The table shows the composition of some fats and oils with respect to saturated, monounsaturated and polyunsaturated fatty acids. These figures are typical, average figures. It must be remembered that the composition of fats, even from the same source, will vary considerably.

	% saturated fatty acids	% monounsaturated fatty acids	% polyunsaturated fatty acids
beef fat	55	40	5
lard	43	48	9
cow's milk fat	70	27	3
human milk fat	44	43	12
herring oil	21	65	14
maize (corn) oil	17	34	49
cocoa butter	65	32	3
coconut oil	94	5	1
palm oil	55	34	11
olive oil	14	79	6

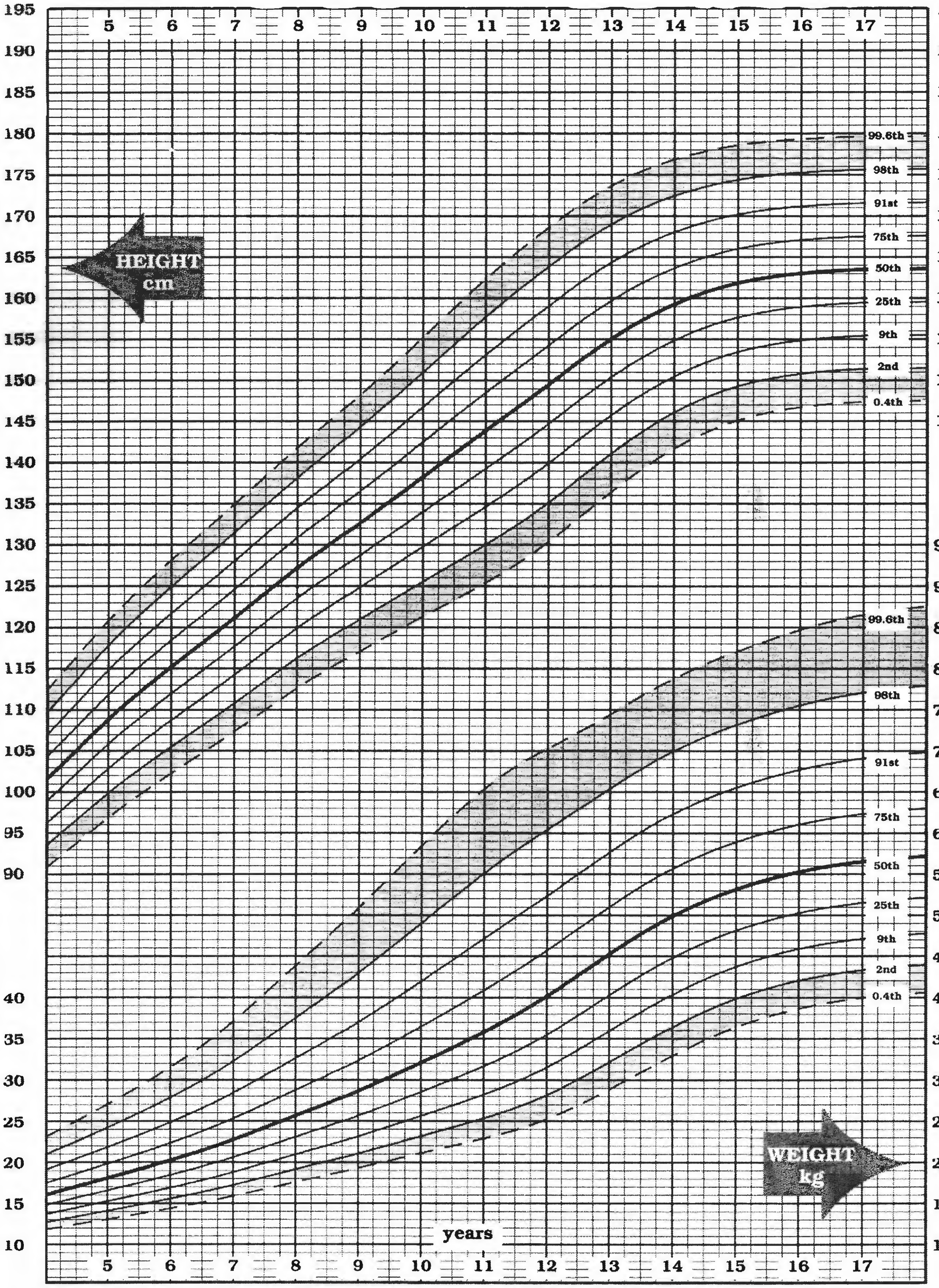
1. Present the figures in the table as a suitable graph.
2. Choose two of the fats from the table. Show the % of saturated, monounsaturated and polyunsaturated fatty acids present in each of these fats as two separate *pie charts*.
3. Where does lard come from?
4. Read the information from the third paragraph again. From the table, which animal fat seems to be an exception to the rule? Which plant fat seems to be an exception?
5. Name a fat from the table which you think would go rancid quickly. Explain why you have chosen this fat.
6. Using food labels, find the names of three foods which contain an **antioxidant**. Write down the names of the foods, the names of the antioxidants and their E-numbers. Explain why antioxidants are used in foods.

HEIGHT AND WEIGHT CHART (MALE)



Source: Adapted from Child Growth Foundation charts

HEIGHT AND WEIGHT CHART (FEMALE)



Source: Adapted from Child Growth Foundation charts

Cooking up trouble?

As fats get older they react with oxygen in the air and will eventually go rancid. This is an unpleasant and potentially dangerous condition. The monounsaturated and polyunsaturated fats become more saturated, i.e. the number of carbon to carbon double bonds *decreases* while the number of carbon to carbon single bonds correspondingly *increases*. There is no simple way of knowing that this is happening. The saturated fats are not as healthy as the unsaturated fats. The rate at which this happens will increase if the fat is heated.

This can have important consequences for food that is deep fried. Initially food may be being fried in an unsaturated fat but as time progresses this will change to a more saturated fat. This may not be good for your heart!

If food is deep fried in kitchens at your school, try and find out some information about how this is done. You could look at the following areas:

- What sort of fat is used for frying?
- What is the typical composition (% saturated, monounsaturated, polyunsaturated fatty acid content) of this fat?
- Is the same fryer and fat used for different foods?
- What temperature is the fat heated to when food is being cooked? Is a thermometer used to check this?
- How often is the fat changed? Is it changed completely or is it just 'topped up' as it is used up?
- Who decides when it is changed? How do they decide that this should happen?

Find out the answers to similar questions for the fat that is used at home. You may like to extend your research to local restaurants and cafes.

What a lot of fat

Many people are surprised by the amount of fat contained in common everyday foods such as peanuts and avocado pears. Using nutrition/science text books, computer resources and/or food labels, display information on the amount of fat in frequently eaten individual foods and complete dishes. Your display will be clearer if you can find out the percentage of saturated, monounsaturated and polyunsaturated fatty acids in the foods. Try to show people how much fat they eat on a regular basis.

We are advised to cut down on the total amount of fat we eat. Find out the meals that you and your friends regularly eat. For each meal suggest some ways in which the fat content could be reduced so that you are eating more healthily.

From magazines, etc. find some advertisements for foods that have 'light' varieties and critically analyse the claims that are made. You could devise taste panels to test acceptability to the consumer. From the labels of these products compare their composition with 'ordinary' equivalents. Discuss the ways in which you think these products may help people to reduce their total fat intake.

C1. "It looks good enough to eat!"

Pupils investigate whether the colours of a variety of foods and colourings are affected by the addition of acids and alkalis.

Additional hints

In addition to the foods suggested pupils could also try rosehips, black and green grapes, blackberries, blueberries, peppers (red/green/yellow/orange), turmeric (E100 curcumin).

It is not critical to measure exactly the masses or volumes.

The time for which you leave the mixtures is also not critical.

Answers to questions on pupil activity sheet C1:

(The optional results sheet (third C1 sheet) can be photocopied for pupils to use.)

The answers below assume that the foods mentioned in the requirements are used. You will need to alter the questions on sheet C1 if pupils use other samples.

1. beetroot and red cabbage only
2. beetroot, blue colouring, red cabbage, pink colouring
3. carrot, onion, probably green cabbage, onion skin
4. In alkali the green cabbage and onion become very brightly coloured. Bicarbonate of soda (sodium hydrogencarbonate) is an alkali. In the past, it was added during the cooking of green vegetables to make them look a bright colour. However, it destroys Vitamin C (present in the food) so its use is no longer recommended.
5. Orange squash is normally packed in transparent containers. The light might make an orange squash containing carotene fade whilst it was on the shelf or at home. This would probably be unacceptable to the consumer.
6. a. There would probably be no objections from the public about health safety; the marketing people would probably like it because they could make a big issue on the packet saying something like 'contains no artificial colours'; the company itself may think that using natural colours is preferable to artificial colours.

   b. If the food that the colour is to be used in is acidic or alkaline the colour may change to an unsuitable colour (whatever 'unsuitable' means in this case!); if the food changes in acidity or alkalinity before being consumed it may change colour; many of these natural colours seem to fade in the light - not suitable for a product in a clear container standing on a shelf for, maybe, weeks; some of these natural colours are expensive; adding other acid or alkali foods to them at home may change their colour.
7. This allows pupils to express an opinion. They may suggest to use names rather than E-numbers because E-numbers do not seem to be popular with the public and a product may be rejected merely because it contains them, regardless of the nutritional quality, or other qualities, of the product.

   They may repeat the marketing views.

Question 7 creates an opportunity for pupils to carry out some research into consumers' perceptions of E-numbers and chemical names. Pupils may like to devise some sort of questionnaire where lists of food ingredients are shown to

KS3
science and food technology

Timing - 30 - 40 minutes

Two pupil activity sheets C1 (plus optional results sheet) accompany this activity.

Requirements

- *balance accurate to 1 g*
- *knives or other appropriate cutting equipment*
- *white tiles or similar as a cutting surface*
- *petri dishes or watch glasses (3 containers are needed for each sample to be tested)*
- *distilled water*
- *any bench acid such as 2M hydrochloric acid, HCl or 2M nitric acid,* HNO_3
- *alkali such as 2M sodium hydroxide, NaOH*
- *teat pipette (those which have approximate volumes would be useful)*
- *samples of food (ca. 10 g) and food colourings [the following work very well: fresh beetroot, red cabbage, green cabbage, carrot, onion, - the brown outside onion skin (only 5g)]*
- *food colourings (the ones trialled were pink (E127), yellow (mixture of E102 and E110), orange (E110) and blue (E123)*
- *pieces of white paper on which to stand the dishes*
- *safety goggles*

consumers and the 'acceptance' or otherwise of E-numbers or chemical names is tested. For example, the same product could be shown with E-numbers only in one part of the test and with chemical names only in a different part, without the interviewee's knowledge. Is one more 'acceptable' to consumers than the other?

For example, the following lists are of the *same* product (which is an orange squash; both lists are legal):

water, glucose syrup, oranges, E330, flavourings, sweeteners (E951, E954), preservatives (E211, E223), stabilisers (E466, E414), antioxidant (E300), colours (E160(a), E160(e))	water, glucose syrup, oranges, citric acid, flavourings, sweeteners (aspartame, saccharin), preservatives (sodium benzoate, sodium metabisulphite), stabilisers (sodium carboxymethylcellulose, gum acacia), colours (beta-carotene, beta-apo-carotenal)

C2. How do you colour a jelly baby?

KS3
science or technology

Timing - 40 - 60 minutes

Pupil activity sheet C2 accompanies this activity.

Requirements
- *2 diced jelly babies, of the same colour (see footnote)*
- *50 cm^3 or 100 cm^3 beakers*
- *stirring rods*
- *distilled water*
- *small measuring cylinders*
- *2M hydrochloric acid*
- *teat pipettes*
- *watch glasses of a suitable size to act as a lid for the beakers*
- *50 cm lengths of* ***100% wool****, white or undyed*
- *hot plates for heating (if not enough of these are available, a water bath can be used; technology teachers may also be able to use a hob)*
- *card, sellotape, glue, etc. for making a display of the results*
- *safety goggles*

Pupils investigate the colours used in jelly babies by extracting the colour and using it to colour lengths of wool.

SAFETY NOTE: CARE IS NEEDED WHEN USING ACID AND HOT EQUIPMENT.

The volumes used are not critical. If you intend the pupils to also carry out investigation C3, it is advisable to use twice the quantity of wool in this investigation, that is, 2 x 50 cm lengths for each colour of jelly baby.

Answers to questions on Pupil activity sheet C2:

1. A coloured solution is produced.
2. The wool takes up (adsorbs) the colour from the solution. It is interesting to note what colours are left behind in the beaker. (For example, black jelly babies from Tesco make the wool turn a red/brown colour but leave a green colour in the beaker.)
3. The wool and sweets make a very colourful display which seems a suitable way of recording the results.

Their are a number of discussion points such as:

- why are colours necessary in this product?
- which manufacturers use the least number of colours?
- how do you get 6 different colours of jelly babies from only 3 added colours?
- why do different manufacturers use different colours?
- why do some manufacturers use natural rather than artificial colours?
- can you tell the flavour and colour of a jelly baby without seeing it?

As there are waiting times in this experiment, it is advisable to have other activities available to occupy pupils.

More able/older groups can go on to the next investigation which analyses the colours using chromatography.

Jelly babies: different brands do contain different colours; pupils may like to investigate these differences and discuss why some manufacturers use a minimum of 3 colours (and yet the packet contains 6 different colours) while other manufacturers use many more colours. It is also interesting to find out which manufacturers use natural rather than artificial colours.

C3. Using chromatography to analyse the colours in jelly babies

Pupils use chromatography to investigate the composition of the colours extracted from jelly babies in activity C2.

SAFETY NOTE AND TECHNICIANS NOTES:
TO PREPARE DILUTE AMMONIA SOLUTION; DILUTE ONE PART CONCENTRATED AMMONIUM HYDROXIDE R.D. 0.880 WITH 99 PARTS WATER.
THE CONCENTRATED AMMONIUM HYDROXIDE IS CORROSIVE WITH A HARMFUL VAPOUR; YOU MUST USE SAFETY GOGGLES; MIXING MUST BE DONE IN A FUME CUPBOARD.
ABOUT 20 CM^3 OF DILUTE AMMONIA SOLUTION IS NEEDED FOR EACH COLOUR REMOVAL.
USE THE DILUTE AMMONIA SOLUTION IN A WELL VENTILATED ROOM.

Safety notes and hints for pupils

Care must be taken when heating the coloured solution to evaporate the liquid. It is easy to heat the solution to dryness. Pupils must be aware that even when they stop heating the solution, evaporation continues to occur.

Heating ammonia solution may produce potentially dangerous fumes.

It is advisable to use the finest tubing as possible to spot the liquids onto the chromatography paper.

There are a number of waiting times in this experiment and it is advisable to have activities such as preparing the chromatography paper or others to occupy the pupils.

The results will obviously depend on the sweets used. Tesco's own brand give good results.

KS3 and 4
science *(possibly technology, but access to laboratory facilities is advised)*

Timing - 60 - 70 minutes

Two pupil activity sheets C3 accompany this activity.

Requirements

For removing the dye from the wool:
- *lengths of dyed wool made in C2*
- *dilute ammonia solution (see box)*
- *50 cm^3 or 100 cm^3 beakers*
- *stirring rods or tongs*
- *hot plates or water baths*
- *stopclocks*
- *safety goggles*

For chromatography:
- *chromatography or filter paper (if single chromatograms are to be run this needs to be about 12 cm x 3 cm; if you would like to test all the colours at the same time, then appropriately larger pieces are needed)*
- *solvent - dilute ammonia solution (see box) volume required will depend upon the containers you use as chromatography tanks (use the ammonia solution in a well ventilated room)*
- *melting point tubes or similar for spotting the coloured liquids*
- *beakers, or similar, of a suitable size to act as chromatography tanks*

"IT LOOKS GOOD ENOUGH TO EAT!"

We are all attracted by food that looks good. Dull, grey food appears extremely unappetising and is not what we have come to expect. Our world is full of colour and many of these coloured things are good to eat.

In this investigation you are going to have a look at some coloured substances. You are going to see if they are affected by adding *acids* and *alkalis* to them. You will be asked to think about some of the consequences of your observations on the food we eat.

Read the safety note before you begin.

SAFETY NOTE
BE CAREFUL WITH KNIVES OR BLADES.
DO NOT CUT TOWARDS YOURSELF.
DO NOT EAT OR TASTE ANYTHING IN THIS INVESTIGATION.
ACIDS AND ALKALIS CAN BURN YOU.
WASH OFF ANY SPLASHES STRAIGHT AWAY WITH PLENTY OF WATER.
TELL YOUR TEACHER WHAT HAS HAPPENED.

In each series of tests, the petri dishes should be placed on a piece of white paper so that differences in colour are easier to see.

Method

1. Weigh out three samples of *beetroot*. Each sample should be about 10 g.
2. Chop up each sample and place in a petri dish.
3. Add about 5 cm^3 of distilled water to the first sample.
4. Add the same amount of distilled water to the second sample. Also add about 1cm^3 of *acid* to this sample.
5. Add the same amount of distilled water to the third sample followed by 1 cm^3 of *alkali*.
6. Take 3 more petri dishes.
7. In each of them place *three* drops of *blue* food colouring. Repeat steps 3 - 5, adding the water, acid and alkali to the food colouring.
8. You will be given a variety of other things which you are going to test in the same way.

   If the substance is another vegetable, treat it in the same way as the beetroot.

   If the substance is a liquid, treat it in the same way as the blue food colouring.
9. Leave all of your samples for about 5 minutes then look at them carefully.

   If you tilt each dish you can see if any coloured liquid is present.

   Construct a table into which you can put all your observations.

Questions

1. Which foods produced a coloured liquid when only *distilled water* was added?

2. Which samples *changed colour*, (from their colour *in water*), when acid was added?

3. Which samples *only* produced coloured liquids when *alkali* was added?

4. Look at the results for the onion and green cabbage in the alkali. Cooks used to add a pinch of bicarbonate of soda (sodium bicarbonate) to vegetables such as sprouts and cabbage during cooking. Why do you think they did this? It is now understood that adding bicarbonate of soda is **not** a good thing to do. Find out why.

5. The yellow/orange colour from the carrots is called *carotene*. It is a colour that quickly fades in the light. Why might food manufacturers decide that this was an unsuitable colour to use in orange squashes?

6. The colourings from the beetroot, carrot, green cabbage and red cabbage are obviously all **natural substances**. All of them can be used as food colouring. Their names and E - numbers respectively are:

beetroot	E162	betanin
carrot	E160(a)	alpha, beta and gamma carotene
green cabbage	E140	chlorophyll
red cabbage	E163	anthocyanins

Think of reasons why food manufacturers:

a. might *want* to use these natural colours in food products instead of using artificial colours;

b. might think they are *unsuitable* for food use.

7. Imagine you are designing the label for a food which uses one or more of the natural colours named in question 6. In the list of ingredients would you advise the manufacturer to put just the names of the colours, just their E - numbers or both names and numbers? Why?

Some foods, like table jellies and boiled sweets, are colourless when they are first made. Manufacturers then add different colours so that these foods 'look' flavoured.

How natural food colours are affected by acids and alkalis

Substance	Colour in water	Colour in acid	Colour in alkali
beetroot			
blue colouring			
carrot			
onion			
red cabbage			
green cabbage			
onion skin (brown outside)			
orange colouring			
yellow colouring			
pink colouring			

HOW DO YOU COLOUR A JELLY BABY?

The manufacturers of jelly babies add colours to these sweets. Different manufacturers add different colours. Can you tell the flavour and colour of a jelly baby if you *don't look at* it before you eat it? Try this out!

In this investigation you are going to remove the colours from jelly babies and transfer the colours to long pieces of wool.

Read the safety note before you begin.

SAFETY NOTE
DO NOT EAT OR TASTE ANY OF THE SUBSTANCES USED IN THE INVESTIGATION.
BEWARE! YOU WILL BE USING HOT WATER!
YOU WILL BE USING DILUTE ACID. WASH OFF ANY SPLASHES WITH PLENTY OF WATER. TELL YOUR TEACHER WHAT HAS HAPPENED.
REMEMBER TO WEAR GOGGLES

Method

1. Place two *red* jelly babies in a small beaker. Add 10 cm^3 of distilled water.
2. Heat this and stir with a stirring rod until the jelly babies dissolve. This should only take a couple of minutes.
3. Add 1 cm^3 of dilute acid to the beaker and stir.
4. Add one length (about 50 cm) of pure white wool to the beaker. Cover the beaker with a watch glass.
5. Carry on heating the mixture for about three minutes.
6. Using your stirring rod, remove the wool and place it in an empty beaker. Wash the wool thoroughly using plenty of distilled water. Allow the wool to dry.
7. Repeat this method with the jelly babies of the other colours.

Questions

1. What happened to the water when you dissolved the jelly babies?
2. What happened to the wool when you put it in the jelly baby solution?
3. Make a display of your results.

Investigation: Using CHROMATOGRAPHY to separate the mixtures of colours in jelly babies

SAFETY NOTE
DO NOT EAT ANY OF THE SUBSTANCES USED IN THIS INVESTIGATION.
YOU WILL BE USING DILUTE ACIDS AND ALKALIS; WASH OFF ANY SPLASHES WITH PLENTY OF WATER.
TELL YOUR TEACHER WHAT HAS HAPPENED.
REMEMBER TO WEAR GOGGLES

Chromatography is an important method which is used to *separate* the different components in *mixtures*. *Paper chromatography* is one of the easiest techniques to carry out.

The substances that are used to colour food products are often mixtures of two or more chemicals. In this investigation you are going to find out the colours in the mixtures used to colour sweets.

Read the safety note before you begin.

Method to extract coloured liquid

1. You will need a 50 cm wool sample (from investigation C2), on which colours from jelly babies are 'stored'.
2. Place the sample of dyed wool in a *small* beaker. Add just enough dilute *ammonia solution* to cover the dyed wool.
3. Warm this mixture *carefully* for 5-10 minutes. You will notice that the ammonia solution becomes coloured. The wool will lose most of its colour.
4. Remove the wool so that you are left with just the coloured solution.
5. Continue to heat the solution so that most, but not all, of the liquid evaporates. *Be careful not to heat to complete dryness.* You must obtain a small amount of a very concentrated liquid. You will use this liquid for chromatography.
6. Repeat this process for as many colours as you can.

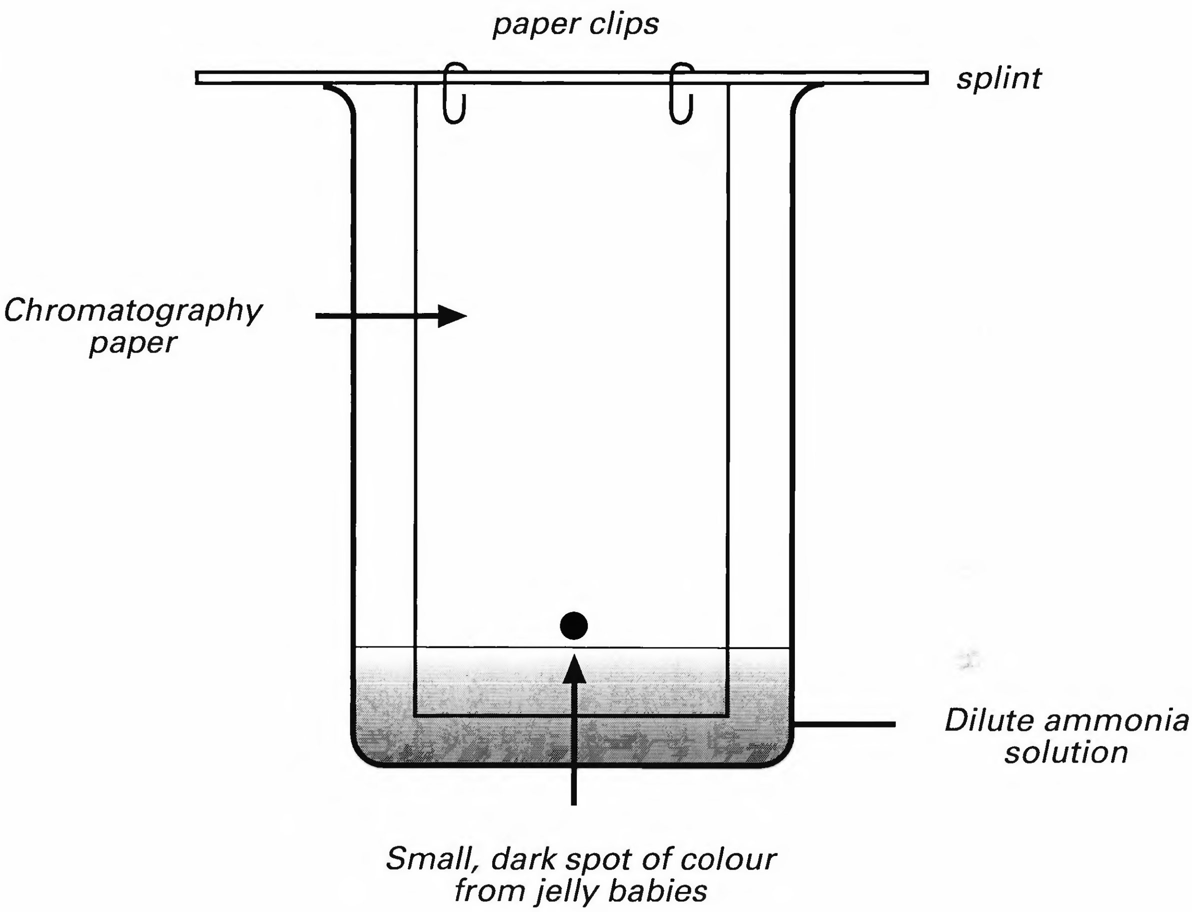
Chromatography of the coloured liquid

1. Cut the chromatography paper into strips of about 12 cm x 3 cm.
2. Dip a very fine piece of glass tubing into the concentrated coloured liquid.
3. Spot this liquid onto your piece of chromatography paper about 15 mm from the bottom of the paper.
4. Allow the spot to *dry*. Then apply another spot on top of the first. Do this at least 5 times so that a darkly coloured, but small, spot is left on the paper.
5. Pour the dilute ammonia solution into the container for the chromatogram to a depth of 3 mm. (The depth of solution must be such that it is *below* the level of the coloured spot on the chromatography paper.)

Handle the paper as little as possible.

Rest it on a clean surface. This piece of paper is big enough to investigate only one of the coloured liquids. You may decide to use a larger piece and investigate all of the colours at the same time.

6. Place your chromatography paper with the coloured spot into the solvent as shown in the diagram.
7. The solvent will rise up the paper and carry the different colours different distances. This will only take a few minutes.



E1. Making Salad Dressings

KS4
project in food technology

Timing - various

Pupil activity sheet E1 accompanies this activity.

Pupils research recipes, from cookery books, for coleslaw. They can conduct a survey of the ingredients of commercially produced coleslaw from the containers in supermarkets, etc.

Design a recipe

In this section pupils have to make up their own recipe for coleslaw. They have to choose the proportions of vegetables, etc. They may decide to add other ingredients, e.g. nuts, fruit or other vegetables.

They can use ready prepared dressings or one of their own (without the use of the stabiliser).

They must decide how to test their product for taste, appearance, etc. (not necessarily coating ability).

Design the label

Pupils have to design the packaging for their product including a label which conforms to legal requirements as to the ingredients in their product. Pupil activity sheet *I5 Reading the label* may help.

The label could also include any of the other information, such as storage, nutrition, etc. that is found on packaging.

E2. The function of emulsifiers and stabilisers

Pupil activity sheet E2 accompanies this activity.

Requirements (per group)
- *test tubes*
- *test tube rack*
- *5 cm³ tap water*
- *5 cm³ cooking oil*
- *1 cm³ whisked egg yolk.*

Pupils are asked why the food industry uses **emulsifiers** and **stabilisers**.
Pupils may suggest the following reasons for the food industry using stabilisers:

- the quantities produced are very much larger than for foods produced at home
- there needs to be greater consistency between batches produced for consumers
- foods are likely to be transported over large distances and stored for long periods of time before use
- some additives allow the production of food which it is not possible to produce at home
- there is a trend for more of this sort of product to be purchased ready made because:
    - there may be a lack of time due to work
    - these products are more convenient to use
    - there may be a lack of the necessary skills
    - ready made products may be cheaper.

Investigating the action of an emulsifier

Pupils carry out a simple practical activity to investigate the stabilising effect of egg yolks.

Following the introduction the pupils conduct a simple investigation which looks at emulsions and emulsifiers.

Pupils should find that before shaking, the liquids form separate layers in the tube with oil floating on top. The egg yolk may sink to the bottom. Immediately after shaking, the contents of the tubes appear to have mixed. However, on leaving to stand, the tube without the egg yolk will quickly revert back to two layers. The tube with the egg yolk should remain mixed.

Egg yolk contains the **phospholipid**, *lecithin*. Lecithins are used as food additives and have the E-number, E322. Lecithin acts an emulsifier because it enables the vinegar and oil to mix. Eventually, most emulsions will separate out into their components. The use of stabilisers prevents this for a considerable period of time.

Investigating using a stabiliser in a mayonnaise for coleslaw

Pupil activity sheet E2, accompanies this activity.

Requirements
- *kitchen blender with horizontal blade attachment*
- *balance or scales*
- *granulated sugar*
- *table salt*
- *white vinegar*
- *water*
- *vegetable oil*
- *fresh egg yolk*
- *chopped white cabbage*
- *grated carrot*
- *various bowls, spoons, etc*
- *'HAMULSION' - a commercial stabiliser* supplied with this resource; store this in a dry place*

** Further samples of the stabiliser are available from the Chemical Industry Education Centre, University of York, Heslington, York, YO10 5DD*

More able groups/older pupils will be able to make the mayonnaise for this investigation, otherwise you may like to carry out the investigation as a class exercise.

Stabilisers have been developed which are added to mayonnaise to give good viscosity and 'cling' properties in cold conditions. A mayonnaise suitable for the commercial market has to be able to thoroughly coat the pieces of vegetable and not 'run off'. The mayonnaise lubricates the vegetables and helps to prevent decay over the shelf life of the product (typically 16 days under refrigeration). During the shelf life the vegetables release water, which is mopped up by the mayonnaise while still maintaining its clinging properties.

In this investigation, a mayonnaise is produced with the use of an industrial stabiliser. It is compared to the same mayonnaise made without the stabiliser. The mayonnaise without the stabiliser has the consistency of water, separates into an oil layer and a lower aqueous layer and is not suitable as a coating mayonnaise.

The instructions for making the mayonnaise and carrying out the investigation are on the pupil activity sheets E2. You may have to increase the quantities of the ingredients in the mayonnaise to make sure that the horizontal blades are covered during mixing, otherwise a froth will be formed.

More able pupils may be able to calculate the cost of the two dressings (the cost of the stabiliser is negligible). They may also be able to compare the nutritional value of the dressings with respect to any, or all, of the following:

per 100g	energy (kcal/kJ)	fat (g)	carbohydrate (g)	protein (g)
vegetable oil	900/3780	100	0	0
egg yolk	350/1470	30	0	16
sugar	400/1680	0	100	0

There are many recipes for home-made dressings for salads. They are often made and added to dishes just before serving.

Home-made French dressing easily separates out into the two main ingredients. Home-made mayonnaise does not do this as easily if it is made carefully.

Home-made dressings and mayonnaise do not have very good keeping qualities.

Dressing = oil and vinegar mixture

Mayonnaise = oil and vinegar mixture, plus egg yolk, or similar, to stabilise

One property that dressings need to have when used in dishes, such as coleslaw, is that they should have good *coating* ability. This means that they will cling to the ingredients. The dressing should not become watery or 'run off' the ingredients.

Commercial dressings often contain **food additives** called **stabilisers** which help to give the dressing desirable properties.

Research

Find out, from recipe books, the main ingredients that are used in coleslaw salad. Try to find more than one recipe.

Compare these with some recipes for salad dressings.

From packaging, find the ingredients used in commercial coleslaw salads. The packaging may give you nutritional information as well. Include other information from the packaging such as storage instructions and the length of time the product will remain suitable for eating.

Investigation

The function of **emulsifiers and stabilisers** - see separate sheet, E2.

Design a recipe

Imagine that you are in charge of preparing all the salads for a restaurant. You have been given the task of producing a brand new coleslaw salad which will be on sale to the general public throughout the summer.

You have already researched into the sort of ingredients that go into such a salad. You now have to come up with an original recipe. You may decide to alter the *proportions* of the ingredients or *add* new ingredients.

You may make your own dressing for the salad or use a commercially available product (if you make your own dressing it must *not* contain a stabiliser).

Once you have designed your recipe and made some trial salads, you will have to *test* your product to make sure it is suitable for sale.

Two of the most important aspects are likely to be what the salad *tastes* like and what it *looks* like. You may decide to carry out some sort of testing on your friends and teachers.

Design a label and packaging

The label for your new coleslaw salad must conform to the present legal requirements for labels. The worksheet *I5, Reading the label* may help you.

You may like to work out the nutritional value (using appropriate tables of information) of your product. You should design an attractive style of packaging for your product.

THE FUNCTION OF EMULSIFIERS AND STABILISERS

Stabilisers and emulsifiers are *food additives*. They, and other similar additives, are numbered from *E331(c)* to *E495*. They are widely used in the food industry in products such as salad dressings, processed cheese, preserves, margarine, yoghurt, instant desserts, ice cream, low fat products and others.

Emulsifiers and stabilisers are used to help to retain the *physical* qualities of products. Emulsifiers make water and oil *mix together evenly*. Stabilisers give products good *texture* and *mouthfeel*.

When you make food at home, such as some of the items mentioned above, there is often no need to add extra emulsifiers or stabilisers to the recipe. So why does the food industry use emulsifiers and stabilisers so often? To answer this question you should think about the differences between producing food for the home and food for sale in shops and supermarkets.

Home-made foods such as salad dressings, yoghurt and ice cream are excellent and nutritious products. However, nowadays more of these products are bought from shops rather than made at home. Think of as many reasons as you can to explain this trend.

Investigating the action of an emulsifier

What are emulsifiers and emulsions? Carry out the following investigation to help you to answer this question.

Method

1. Pour about 2 cm depth of tap water into a test tube. Carefully add an equal depth of cooking oil to the same tube. Note down what the contents of the tube look like.
2. Pour about 2 cm depth of water into another test tube. Carefully add an equal depth of cooking oil to the same tube. Add 1 cm depth of egg yolk. Note down what the tube looks like.
3. Put a bung in each tube and then shake both of the tubes for 30 seconds.
4. Leave the tubes to stand in a test tube rack.
5. Look carefully at the tubes over the next few minutes and describe what is happening in each tube.

   Discuss with your group and with your teacher the explanation for your observations.

Investigating using a stabiliser in a mayonnaise for coleslaw

SAFETY NOTE
YOU MUST NOT EAT ANY OF THE MAYONNAISE MADE IN THIS INVESTIGATION
HORIZONTAL BLADES ARE EXTREMELY SHARP; BE VERY CAREFUL WHEN HANDLING AND WASHING THEM.

Ingredients for mayonnaise:

50 cm^3	vegetable oil
10 cm^3	egg yolk
20 g	sugar
9 g	salt
40 cm^3	white vinegar
70 cm^3	water
2 g	of a commercial stabiliser

Method

1. Secure the *horizontal blades* in a blender. Put the water, vinegar, sugar and salt into the blender. Mix on *slow speed* for 30 seconds.
2. Mix the stabiliser in about 5 cm^3 of the oil.
3. Add this to the mixture in the blender and blend on *slow speed* for 3 minutes.
4. Add the egg yolk and blend to mix this in.
5. *Very slowly* and *carefully* add the remaining oil.
6. When all the oil has been added continue to blend for at least 3 minutes until the final mayonnaise is white and homogeneous (evenly mixed).
7. Transfer the mixture to a bowl and wash the blender and blades thoroughly.
8. To show what the stabiliser does in the mayonnaise, make up exactly the same recipe but *do not* add any stabiliser.

What differences are there between the mayonnaise *with* the stabiliser and the mayonnaise *without* the stabiliser? Compare the two by looking at:

- the colour
- the consistency or thickness
- the homogeneity or how evenly mixed it is.

F1. What's in a flavour

Pupils make vanilla flavoured milky drinks, set up a tasting panel to judge their flavour and also consider relative costs, etc.

Setting up the tasting panel

Devising taste panels, which will give representative results, is quite a difficult process. It is obviously better to use as large a number of tasters as is possible.

Suggested questions include asking volunteers to award the smell, taste and colour of each drink using a scale of 1 - 5, (5 being 'very pleasant' and lower numbers being gradually less pleasant 0.

If each drink is sampled only once by each taster, the three drinks must be given to each taster in a different order; this compensates for palatability differences.

A basic rule of *taste panels* is that tasting must always be *blind*, e.g. samples are labelled A, B and C. This eliminates any possibility of bias on the part of the taster.

Hygiene must be taken into consideration. It would be preferable to supply the tasters with the drinks in small containers, such as those used for liquid medicines. This would also ensure that each taster received the same volume of drink.

Other considerations

For the purpose of the exercise, pupils may wish to know the relevant prices.
In 1998, the costs were as follows:

- vanilla pod, £1.77, for a single pod
- vanilla extract, £1.07, for 38ml
- vanilla flavouring, £0.37, for 38ml

On the basis of taste tests and cost, pupils will be able to make suggestions as to which product should be used to produce a milky drink which tastes of vanilla.

The ingredients labels on each product provide further discussion points.

- Vanilla pod - does not have a list of ingredients; it contains only the vanilla pod, which contains around 100 individual flavouring components.
- Vanilla extract - propylene glycol, water, vanilla extract. The extract contains the same flavouring components as the pod.
- Vanilla flavouring - water, isopropanol, propylene glycol, colour: caramel (E150), artificial flavouring substances, flavouring substances identical to natural substances. Vanilla flavouring contains the most important flavouring components (approximately 10 of the 100 in a vanilla pod) in terms of their contribution to flavour.

KS3/4
food technology

Timing - 40 - 60 minutes *depending on the way the drinks are tested. One week prior to the investigation, store 2 vanilla pods in 100g of ordinary sugar; seal and shake occasionally. This will produce 'vanilla sugar'.*

Pupil activity sheet F1 accompanies this activity.

Requirements

- *25 g of 'vanilla sugar'*
- *50 g of ordinary sugar*
- *1.5 dm^3 of milk*
- *vanilla pods (e.g. Schwartz)*
- *vanilla extract (e.g. Supercook*) - natural essence*
- *vanilla flavouring (e.g. Supercook)*
- *various containers in which to mix the drinks, etc.*
- *small containers to use for the tasting, e.g. those used for liquid medicines.*

* *Supercook are not the only producers of these products. However, it is essential that you obtain a natural extract and a flavouring.*

Propylene glycol is a permitted additive. It does not have an E-number, because it is only used as a solvent (carrier) for other food additives which are not water soluble e.g. some flavourings.

Isopropanol is also a permitted solvent. In this case, it is being used as an anti-mould agent.

WHATS IN A FLAVOUR?

Probably one of the most important sensations that we gain from the food we eat is taste. Our sense of taste is really a combination of the sense of taste and the sense of smell. Our noses, tongues and taste buds are sensitive to many thousands of different chemicals.

Imagine that you are in charge of the catering for a primary school tuck shop which looks after children between the ages of 4 -11 years. All of these children like to have milky drinks at certain times of the day. Some of the parents of the older children would like the milky drinks to taste of *vanilla*.

You can easily buy vanilla in 3 different forms:

- *vanilla pods* - the part of the plant which contains vanilla;
- *extract of vanilla* - this is a natural essence produced from vanilla pods;
- *vanilla flavouring* - this is a 'copy' of vanilla.

Which of these alternatives would be most suitable to be used at the shop?
The following investigation may help you to answer this problem.

Method

One week before the investigation, store 2 vanilla pods in 100 g of ordinary sugar. Put this into a container with a lid. Shake the container occasionally during the week. This will make 'vanilla sugar'.

1. Make up the samples of milky vanilla drinks as follows:

A. Dissolve 25 g of 'vanilla sugar' in 500 cm^3 of milk.

B. Add 4 drops of natural vanilla extract to 500 cm^3 of milk. Dissolve 25 g of ordinary sugar in this milk.

C. Add 2 drops of vanilla flavouring to 500 cm^3 of milk. Dissolve 25 g of ordinary sugar in this milk.

2. Devise a *tasting test* in which you will ask volunteers to compare the 3 drinks. You must make sure that this is a *fair test*. Think about what questions you will ask your volunteers.
3. Find out how much each of the forms of vanilla costs. Comment on this.
4. Look at the ingredients label on each of the products. Comment on this.
5. Think about other advantages and disadvantages of each product.
6. Write a report which details all of your findings and suggests the most suitable way of producing milky drinks that taste of vanilla.

G1. A jamming session

KS3/4
science and food technology

Timing - 30 - 40 minutes

Pupil activity sheet G1 accompanies this activity.

Requirements (per group)
- *safety goggles*
- *<25 cm^3 commercial* pectin solution*
- *7 g ordinary sugar (sucrose)*
- *5 test tubes/boiling tubes*
- *test tube racks*
- *2 stirring rods*
- *tiny amount of citric acid powder*
- *2 water baths (beakers); 1 boiling, 1 cold*
- *Bunsen burner, tripod, gauze, heat resistant board*
- *stopclock*

* *Certo produced by Citrus Colloids, can be purchased from supermarkets and is a type of pectin which would be used to produce jam and marmalade in the home.*

The initial investigation, which finds out which conditions are necessary for gel formation using liquid **pectin**, is suitable for both science and food technology. There are then further investigations; one for science and the other for food technology.

Hints for the teacher

- The quantities of substances and times specified are very important.
- The commercial pectin is, itself, quite a viscous liquid and this must be measured into the tubes by *mass* rather than volume. For the initial investigation it may be better to have the pectin already added to the tubes ready for pupils to use.
- A small amount of citric acid powder, no more than 0.2 g, is all that is needed. Collect a small amount on the end of a spatula, or similar, and tap into the appropriate tubes. The contents of the two tubes that contain sugar should be stirred when the sugar is added and every minute during heating. This helps the sugar to dissolve and therefore prevents its accumulation at the bottom of the tube. The stirring rods should be removed during the cooling period.

The method suggested for comparing the tubes after cooling is very simple and qualitative. At this point in the investigation it is all that is needed. The pupils compare viscosity of the liquids in the tubes by laying the tubes flat. 5 minutes is long enough to see an obvious difference between tubes C and E. The pupils will find:

- That the liquid in tube E is most viscous; a gel is produced in the given setting time. None of the others produce the same set.
- Tube C will be more viscous than A, B or D, which will all be very similar.

This investigation demonstrates to pupils that pectin, to be able to produce a set, requires:

- heating
- an acidic pH
- and sugar.

Further investigations

Allow 15 minutes - to perform a number of tests and repeats

Variables to investigate:
- *amount of pectin*
- *amount of sugar*
- *length of heating at a particular temperature*
- *different temperatures but same length of heating.*

In science - the conditions needed for gel formation can all be used as continuous variables for a Sc1 investigation. However, since the amount of citric acid required is so small, it would not be particularly easy to investigate this variable. The others are much easier to investigate, (see margin). Whichever variable is chosen there should then be evidence of fair testing by keeping the other variables constant. There is also the need for pupils to devise a quantitative method of comparing the results; for example, liquid flow could be carried out against a graduated scale and timed; the contents of the tubes could be poured into a suitable container and the area of 'spread', in a particular time, measured.

In food technology - here, there is opportunity for jam making investigations.

Groups could make small quantities of jam using different methods of producing a set and then compare the jams (see margin box).

Different groups produce jams using different methods and then devise methods of comparing the jams with respect to setting properties, taste, colour and keeping qualities.

Fruit such as strawberries, raspberries and cherries have low amounts of pectin and a high pH so that making jam from these fruits is more difficult.

There are two main ways of overcoming these problems:

- *often small quantities of other fruits which are high in pectin and acid are added to supplement that in the original fruit.*
- *alternatively, commercial pectin, and sometimes lemon juice, can be used.*

KS4
science and food technology

Timing *- an extension exercise with some revision points; suitable as a homework*

Two pupil activity sheets G2 accompany this activity.

This activity could include work on producing jams using artificial sweeteners, as yet another comparison, which would lead to a discussion of the preserving properties of sugar that artificial sweeteners fail to have. It is advised that jams produced using artificial sweeteners are stored in the refrigerator to slow down microbial, particularly fungal, growth. Pupils could compare the keeping qualities of ordinary jams and jams made using artificial sweeteners under normal usage, e.g. opening lids, removing jam, returning the lid, etc.

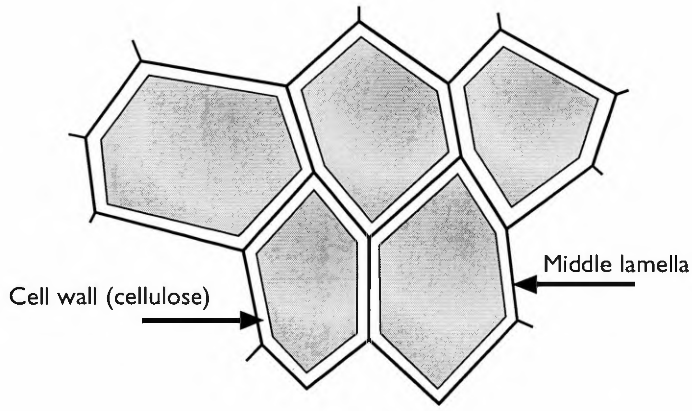
Additionally, the production of small quantities of jam at home could be compared to the commercial production of jam on a large scale (see G2 *An introduction to pectin*).

G2. An introduction to pectin

Answers to questions on Pupil activity sheet G2:
Some can be found in the text, others require research.

1. poly = many, saccharide = sugar units; a polysaccharide is a long chain carbohydrate, i.e. it consists of many sugar units joined together. Other well known plant polysaccharides are cellulose and starch.

2.



3. cellulose

4. As fruit ripens, enzymes begin to break down the pectin; less pectin will result in a poorer set to the jam. Jam made from very ripe fruit will be difficult to set.

5. This will vary; an example is included on a separate sheet.

6. *Filtration* - the separation of insoluble/suspended solids from a solvent/liquid/solution by means of some sort of 'sieve', e.g. filter paper, strainer.

   Evaporation - heating a solution/liquid to remove some or all of the solvent/water by turning it into a vapour/gas so as to leave a more concentrated solution or a solid.

   Distillation - a method of separating a mixture of liquids with different boiling points; liquids within boiling ranges are collected separately; the mixture is heated to a specific temperature so that one of the liquids boils and changes to a vapour/gas; the gas is then cooled so that it condenses, returns to a liquid and can be collected.

   Precipitation - exemplified by the mixing of two solutions so that a reaction takes place which produces an insoluble substance which will sink to the bottom of the reaction vessel.

7. 'commercially viable' - capable of producing an actual, useful, practicable product at a profit

8. Small quantities of other fruits, such as blackcurrants, can be added to supplement the pectin (and acid) present in the strawberries.

9. Powdered pectin is extremely difficult to dissolve in ordinary circumstances (last paragraph). If powdered pectin is available this could be demonstrated. It would be virtually impossible to successfully use the lumpy, very viscous mass that is produced. Pectin is very **hydrophilic** and is therefore water soluble but its affinity for water means that unless high speed mixing (high shear mixing) and increased temperatures are used it is difficult for it to fully hydrate without the formation of lumps.

10. Pectin in a liquid state has had a quantity of water added to it. This greatly increases its mass and bulk compared to the powdered pectin alone. In the quantities used by industry this would increase transportation, storage and handling costs. This is particularly important when considering goods which are to be exported.

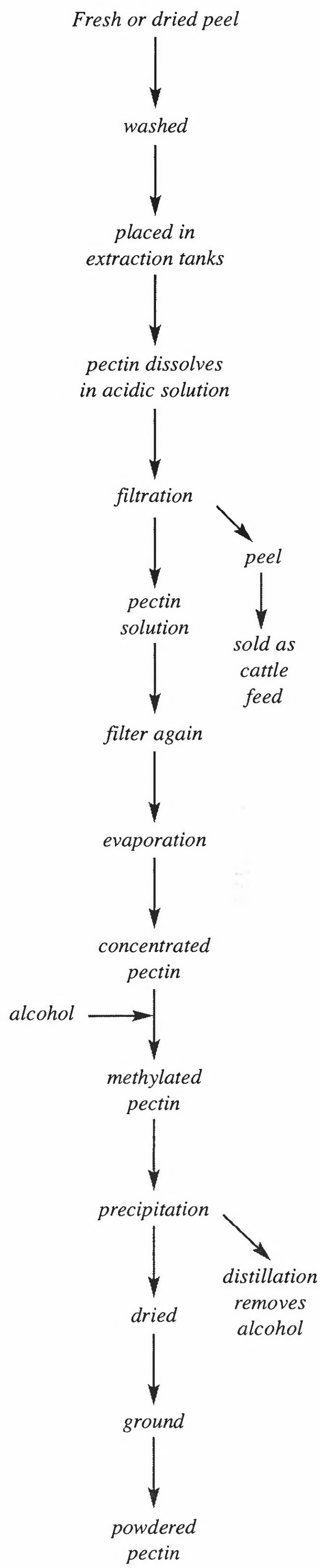
    There are other less obvious reasons as to why pectin, as a powder, is used in industry. Many more types of pectin can be produced in powdered form. Different products require pectin with different properties. For example, jams with large pieces of solid require a very quick setting pectin to ensure that the fruit pieces do not all sink to the bottom before the jam has set. Other products, which may be needed to be packed in very large quantities, require a slower set to prevent the jam setting whilst still in the machinery.

    The quality of performance for an industrial operation is much better when using powder rather than a liquid.

    Less powder needs to be used compared to liquid.

    Since the powdered form contains no water there is no need to preserve it in any other way.

The production of pectin



The production of jams is a very old and traditional method of preserving fruit. At the end of summer there is a large quantity of surplus fruit and vegetables that must not be wasted.

Jams and marmalade are made by boiling the fruit with water and sugar. On cooling the jam or marmalade will set. This is due to a special group of carbohydrates called **pectins**. In the correct conditions, pectin will produce a **gel**. Some fruits, e.g. apples, blackcurrants, contain a large amount of pectin. They can easily be turned into jam. Other fruits, e.g. strawberries, raspberries, have a low amount of pectin and need help to be turned into jam.

In this investigation you are going to find the conditions needed for pectin to produce a gel and, hence, the conditions needed for making jam.

SAFETY NOTE
REMEMBER TO WEAR GOGGLES

Method

It is very important that you measure the substances accurately.

You must also time accurately the different parts of this investigation.

1. Label five test tubes A - E.
2. Add 4 g of commercially produced pectin to each of the tubes.
3. Heat a beaker of water to use as a water bath.
4. Treat the tubes as follows:

   Tube A - leave as a control

   Tube B - no other additions

   Tube C - add 3.5 g of sugar

   Tube D - add a tiny amount of citric acid powder

   Tube E - add 3.5 g of sugar and a tiny amount of citric acid powder
5. Stir tubes C and E with different stirring rods.
6. When the water bath is boiling, place tubes B, C, D and E into it for 5 minutes. You will need to stir tubes C and E every now and then.
7. After 5 minutes remove the tubes and place them in a cold water bath to cool them down. Take out the stirring rods. Leave the tubes to cool for 5 minutes.

Results

You now need to compare the contents of the tubes to estimate how thick or viscous the liquid is and whether or not a gel is forming.

A simple way of doing this is to tilt the tubes and see how fast the liquid travels down the tube. Make this a fair test.

Write up your investigation. Put the tubes into a rank order by putting the thickest (most viscous) at the top and the thinnest (least viscous) at the bottom.

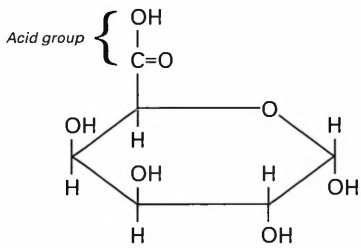
What conditions are needed for pectin to be able to produce a set?

Pectin is used to produce a wide range of preserves, jams, jellies and spreads, that is those sweet, fruit products which need to set. Some of these products are made in the home as well as on a commercial basis.

Pectin is not a single substance. The word describes a group of **polysaccharides** which are present in the cell walls, particularly near the middle lamella, of most land plants. In the intact plant, pectin is a very large molecule and is not soluble in water. Although its distribution among plants is widespread, there are only a few commercially viable sources from which pectin can be extracted. These are from the peel of citrus fruits and apple pomace (this is a pulpy residue from apples which have been pressed for cider making). Both of these sources are leftovers from the fruit juice industry.

Ripe fruit is used in the fruit juice industry. However, when ripening begins, enzymes in the fruit begin to break down pectin and it becomes soluble. This process decreases the quantity and quality of pectin obtainable from the fruit. Therefore, it is important for the pectin manufacturer to process the fruit obtained from the fruit juice industry as quickly as possible.

Like all natural materials, the molecules of pectin, within the same plant and between different plants, vary considerably. The major constituent of pectin is *galacturonic acid*.



galacturonic acid

Several hundred of these units are linked together to form a long chained molecule of *polygalacturonic* acid. A certain number of the acid groups, –COOH, are methylated, i.e. contain a methyl group, $-CH_3$. It is the number of these methyl groups which strongly influences the performance of the pectin in practical situations.

The production of pectin

Fresh or dried fruit peel is washed with water. It is then put into a series of extraction tanks. The conditions inside the tanks are carefully controlled with respect to acidity and temperature. The peel softens and swells due to the break down of the cell walls. The pectin is released and dissolves into the acidic solution. The peel is separated from the pectin extract by filtration. It is washed and sold as cattle feed.

The solution of pectin is filtered again in a special way to make a clearer solution. Some of the liquid is then evaporated so that the product is more concentrated. To produce a pectin with many methyl groups attached, the pectin liquid passes into the precipitation stage. In this, the pectin extract is mixed with alcohol. Pectin is insoluble in alcohol and so is precipitated. The alcohol is then recovered by distillation. Following precipitation, the pectin is dried and then ground or milled to a powder before the final stage of blending.

The use of pectin

Long before the development of chemical preservatives and the invention of the refrigerator, we had been using high concentrations of sugar to improve the keeping qualities of seasonal fruits. The boiling of fruit with added sugar forms the basis of all commercial jam making. This type of industry can be found in nearly every country in the world.

Home-made jam and marmalade making is still quite popular despite the readily available products from the supermarket shelves. As any home jam maker will tell you, it is easier to make jams and marmalades from fruits such as blackcurrants, damsons, gooseberries, plums, lemons and bitter oranges than it is from cherries, pears, peaches or strawberries. This is because the former contain large amounts of pectin and the conditions inside the fruit are acidic. Both of these are important factors in the production of a set. Liquid pectin, which can be bought from shops and supermarkets, can be used to assist in jam making, particularly when using the latter fruits.

In large scale commercial jam making, pectin is used in addition to the pectin already present in the fruit. The manufacturer is able to manipulate the production conditions so that a huge variety of different preserves can be made according to fruit type, desired set strength, quantity of product, quantity of sugar, type of sugar and many other factors. Most of the pectin used commercially is in the form of a powder rather than a liquid.

It is extremely difficult, using ordinary methods, to dissolve powdered pectin in water. Industry makes use of high speed mixers and raised temperatures in order to dissolve it. A powder form is preferable in industry where very large quantities of pectin are used.

Questions

1. What is meant by a polysaccharide? Name two other polysaccharides, apart from pectin, that are found in plants.
2. Draw a diagram of three or four simple plant cells to show the position of the cell wall and the middle lamella.
3. What material makes up the greatest proportion of plant cell walls?
4. Jam recipes always advise that fruit to be used in jam making should be only just ripe. Use the information in the third paragraph to explain this.
5. Using the information in 'The production of pectin' section, draw a flow chart which shows the stages in pectin production.
6. Explain the scientific processes of filtration, evaporation, distillation and precipitation.
7. Explain what is meant by 'commercially viable'.
8. Liquid pectin is readily available in shops so that making a jam such as strawberry at home now presents few problems. How else can a strawberry jam be produced without the use of liquid pectin?
9. Why would powdered pectin be unsuitable to use in home jam making?
10. Industry uses large quantities of powdered pectin. Suggest some reasons why industry does not use liquid pectin.

P1. The conditions necessary for the growth of microbes

KS3
science and food technology

***Timing - 15 minutes** to set up the apparatus; the tubes then need to be looked at after approximately 1 and 2 weeks.*

Pupil activity sheet P1 accompanies this activity.

Requirements
- *test tubes or boiling tubes*
- *dry, uncooked rice*
- *cooked (boiled and drained) rice*
- *cotton wool*
- *access to a refrigerator (not where food for consumption is stored)*
- *marker pens or sticky labels*

Pupils store uncooked and cooked rice under different conditions to determine the conditions needed for microorganisms to grow.

SAFETY NOTE: ONCE THE INVESTIGATION IS UNDERWAY, DO NOT ALLOW PUPILS TO OPEN THE TUBES. THE TUBES AND CONTENTS SHOULD BE DISPOSED OF BY AUTOCLAVING.

The following results can be expected:

	conditions in the tube	appearance after 1 week	appearance after 2 weeks
uncooked rice	no water, warm, air present	rice looks same	rice looks the same
cooked rice alone	water present, warm, air present	mould starting to grow	more mould present
cooked rice in refrigerator	water present, cold, air present	rice looks the same	rice looks the same
cooked rice with oil	water present, warm, layer of oil stops air reaching rice	rice looks the same	rice looks the same

You are advised to check the tubes periodically, and show them to the pupils when some mould has appeared in tube B. None of the other tubes should show this in the same period of time. The tubes can be left for longer if desired, in which case mould growth will occur in the other tubes except tube A. However, this may take a number of weeks.

The follow up discussion should reach the conclusion that water/moisture, warm temperature and air (oxygen from the air) are needed for the growth of microorganisms. Mould growth occurs because air containing mould spores has been able to get into the tubes.

The tubes and contents should be disposed of by autoclaving.

P2. Food preservation

KS3
science and food technology

***Timing - 15 minutes** to set up apparatus; tubes to be left at least 24 hours.*

Two Pupil activity P2 sheets (plus optional table sheet) accompany this activity.

Pupils store frozen peas with a variety of preservatives in order to investigate their effects.

SAFTEY NOTES:

SOME ASTHMATICS ARE VERY SUSCEPTIBLE TO SULPHUR DIOXIDE VAPOURS; THE SODIUM META BISULPHITE SOLUTION MUST BE PREPARED BY A TEACHER OR TECHNICIAN.

SODIUM NITRITE SOLUTION IS TOXIC; WEAR GLOVES WHEN HANDLING THE CONTAINER AND TRANSFERRING THE LIQUID.

ALL THE SOLUTIONS MUST BE PREPARED BY A TEACHER OR TECHNICIAN.

THE TUBES MUST NOT BE OPENED BY THE PUPILS.

THE TUBES SHOULD BE DISPOSED OF BY AUTOCLAVING.

A table for results is provided (third page of P2) for those pupils unable to design one easily.

Requirements
- *test tubes or boiling tubes*
- *marker pens or labels*
- *distilled water*
- *salt solution - 20 g of sodium chloride in 100 cm^3 of distilled water*
- *sugar solution - 10 g sucrose in 100 cm^3 of distilled water*
- *vinegar*
- *sodium nitrite solution - 0.1M maximum concentration*
- *sodium metabisulphite - to give a dilute solution of sulphur dioxide use 2 g in 100 cm^3 of water*
- *goggles*
- *cotton wool*
- *frozen peas*
- *forceps*
- *access to a refrigerator (not one where food for consumption is stored)*

Peas are used here merely as an *easily available medium*. Alternatively, you could try cooked rice, cooked and pulped apple or cooked and pulped tomato. None of these foods are ever preserved by the methods investigated in this practical; in commercial food processing they are either dried, canned or frozen.

After 24 hours the liquid in tubes C and E should already have gone cloudy (check this). It is possible to stop the experiment at this point. Leaving the tubes for 72 hours merely increases the cloudiness of these two tubes. Leaving the tubes for a week will show the growth of mould. You may like to prepare such a tube a week before it is needed.

Tube G tends to look green as the colour is removed from the peas.

Answers to questions on Pupil sheet P2:

1. Tube 2 should show more signs of spoilage than tube A. Tube A was at a lower temperature and thus microbial growth is slowed down.

2. Salt solution, vinegar, sodium nitrate solution and sulphur dioxide solution act as preservatives. The liquid in these tubes remain clear. After 24 hours the liquids in tubes C and E go cloudy; this shows the presence of fungal (mould) growth.

   Note: peas in the acidic vinegar and dilute sulphur dioxide solution have discoloured. In alkali the colours would have been much brighter (see C1 *It looks good enough to eat!*, page 55). As preservation methods may well alter the natural colour of foods, certain foods have colours added to them after processing.

3. Strong salt solution removes, by osmosis, the water necessary for microbial growth.

   Vinegar is acidic; microbial growth is retarded at pH below 4.5; at certain concentrations acetic acid is bactericidal.

   Sodium nitrite and sulphur dioxide both kill microbes. Sodium nitrite is particularly important for inhibiting the growth of *Clostridium botulinum* (the bacterium responsible for botulism) in meat products. Its level is strictly controlled in food products.

4. Salt imparts a particularly strong flavour which would be undesirable for many products and tastes.

5. The most obvious are fruits and vegetables in jams, marmalades and pickles.

6. Sodium nitrite (E250) is used mainly for preserving meat products.

7. Sulphur dioxide (E220) is used to preserve soft fruits and alcoholic beverages.

8. Drying removes the water necessary for microbial growth.

   Freezing places microbes at a low enough temperature to slow down and sometimes completely stop microbial growth. It is important to remember that low temperatures do not kill microbes and that the normal processes of decay will begin as soon as the food is warmed up.

   In canning, food is heated to a temperature at which microbes are killed. The cans are then sealed to prevent the entry of new microbes.

Further investigations

Some of the following suggestions may be suitable for the assessment of Sc1 skills. The last two may be homeworks or projects.

a. High salt concentrations are effective preservatives. However, pupils will realise that this may produce unpalatable results and the lowest concentration which still gives some preserving power may be desirable. A range of concentrations between 0 and 20% could be investigated. If pupils have some scientific knowledge of osmosis, then this could be an investigation suitable for a complete Sc1 investigation.

b. Sugar, when used in high enough concentrations, can act as a preservative because it binds (i.e. inactivates) the water necessary for microbial growth. This fact is used in jams, etc. Pupils could design a similar experiment to the original which investigates concentrations of sugar above 10%.

c. Artificial sweeteners do not have osmotic activity and hence are not capable of copying the preserving properties of sugar. A simple investigation similar to the original one with peas may show this. You may like to use visking tubing to demonstrate that osmotic activity is indeed absent. The labels from diabetic (low sugar) jams may be used to help point out that these products do not have keeping qualities as good as traditional jams.

d. KS3 pupils should use sodium nitrite solution with a maximum concentration of 0.1M. Keeping this constant and adding salt to other tests will find out whether salt does enhance the performance. A range of salt concentrations could be investigated.

e. Cook a few slices of raw apple for about 10 minutes in plenty of water. When cool rub through some muslin or a sieve or liquidise to produce a smooth pulp. This can then be used to see if the addition of cloves prevents the apple from going off.

f. Most households will have food stocks which are preserved by a variety of methods. A lot of information can be gained as to the keeping qualities of these products.

g. Louis Pasteur developed the process which now bears his name when he was approached by the wine producers of France. Many producers were finding that wine was turning into vinegar and hence the wine became an unacceptable product. The solution to the problem was to heat the wine to a temperature of around 60 °C which killed the majority of the microbes responsible for the spoilage. Pasteur was responsible for saving the French wine industry.

The pasteurisation process is applied to milk. The most common method is to heat milk to 72 °C , for not less than 15 seconds. After treatment, the milk is rapidly cooled.

The heat treatment kills most microbes but does not alter the flavour of the milk. Milk which is heated to a high enough temperature to sterilise it, results in a flavour that is not to the liking of the majority of consumers.

KS3
science or food technology

Timing - 30 mins; *a possible homework exercise*

Two pupil activity sheets P3 accompany this activity.

P3. Methods of food preservation

This activity helps to summarise the main methods of food preservation.

The activity includes a table of preservation methods with statements which give descriptions of how the methods prevent the spoilage of food.

Pupils have to match each description with the correct method.

Pupils complete the table by adding examples of foods preserved by each method.

The correct matching is as follows:

a. freezing, e.g. a great variety of foods including meat, vegetables

b. curing, e.g. meat

c. chemical preservatives, e.g. cooked meats, wine, some cheeses

d. canning/bottling, e.g. fruit, vegetables

e. cooking, e.g. various

f. jam making, e.g. most fruits

g. dehydration, e.g. soups, vegetables, pasta

h. pickling, e.g. fruit, vegetables

i. irradiation, e.g. herbs and spices only[1]

j. chilling (domestic refrigeration), e.g. milk, cream, butter

k. gas or vacuum packing, e.g. bacon

[1]Herbs and spices are the only foods which are allowed to be irradiated in bulk at the present time. In practice, however, although the technology is available, it is rarely used – presumably because it is still controversial.

As soon as food is picked (harvested) or slaughtered it will begin to deteriorate as the microorganisms that cause food spoilage begin to attack.

What conditions do microbes need in order to make our food go 'off' or 'bad'?

Carry out the following experiment to be able to answer this question.

SAFETY NOTE
ONCE PREPARED: DO NOT REMOVE COTTON WOOL BUNG FROM TUBES

Method

1. Label four tubes A - D.
2. Place some uncooked rice in tube A.
3. Place some cooked rice in tubes B, C and D.
4. Place enough cooking oil in tube D to just cover the rice.
5. Put a cotton wool bung in each tube.
6. Put tube C in a refrigerator.
7. Leave the other tubes at room temperature.
8. Look at the tubes after 1 week and 2 weeks.

Results

Look for the growth of mould in the tubes. Decide what the conditions were like in each tube during the experiment. Fill in the table below:

	conditions in the tube	appearance after 1 week	appearance after 2 weeks
uncooked rice			
cooked rice alone			
cooked rice in refrigerator			
cooked rice with oil			

What conditions are needed for microorganisms to grow?

If mould has grown in any of the tubes, where has the mould come from?

We have a constant demand for safe and nutritious food. However, most production of raw food, such as fruit and vegetables, is seasonal. There are times of the year when such food is plentiful and other times when certain foods are scarce.

Food may have to be transported over large distances from the site of production to the places where it is to be eaten. Imported food may travel thousands of miles over several days before it reaches our tables.

We have been developing methods of food preservation for thousands of years. Preserving meat using the *smoke* from wood fires was probably one of the earliest methods as was *drying* food in the sun. *Irradiation* is often thought of as the preservation method of the future.

Preservatives are food additives which are numbered from E200 to E283 (you may find some antioxidants here as well). They are chemicals which destroy or slow down the growth of bacteria and fungi.

There are many traditional ways of preserving food. You will probably be familiar with most of these.

In this investigation you will be looking at some ways of preserving food.

SAFETY NOTE
SODIUM NITRITE SOLUTION IS POISONOUS; USE WITH EXTREME CARE AND WEAR GLOVES.
SULPHUR DIOXIDE SOLUTION IS HARMFUL; USE WITH EXTREME CARE.
ASTHMATICS MAY BE SENSITIVE TO SULPHUR DIOXIDE.
WEAR GOGGLES WHEN USING THE SOLUTIONS.
DO NOT REMOVE THE COTTON WOOL BUNGS FROM THE TUBES.

Method

1. Label eight test tubes A - H. Put your initials and the date on each tube.
2. Use forceps to put three peas (these were frozen peas) in each test tube.
3. Treat the tubes and the peas in the following ways:
   Tube A - add nothing to this tube
   Tube B - add nothing to this tube
   Tube C - half fill with distilled *water*
   Tube D - half fill with a strong *salt solution*
   Tube E - half fill with a strong *sugar solution*
   Tube F - half fill with *vinegar* (this is acetic acid (E260))
   Tube G - half fill with *sodium nitrite solution* (E250)
   Tube H - half fill with a dilute *sulphur dioxide solution* (E220)
4. Put a cotton wool bung in each tube.
5. Put tube A in the refrigerator.
6. Leave tubes B - H in a warm place until next lesson.

Results

1. Construct a results table into which you will be able to put your observations from each tube. You will be looking at what has happened to both the peas and the liquid. You will need to decide whether the peas look different to normal. A cloudy liquid shows that mould is beginning to grow.
2. Look at the peas and the liquid in each tube after 24 hours and 72 hours. You may also like to leave the tubes for a week and then examine them again.

Questions

1. Compare tubes A and B. What differences are there? How can you explain these differences?
2. Which of the solutions used in tubes C - H act as preservatives? How were you able to tell this?
3. Why are these solutions able to act as preservatives? You will have to do some research to find this out. Your teacher may discuss this with you.
4. A very strong salt solution may act as a very good preservative. Why might it be an unsuitable preservative for some foods?
5. What sort of foods are preserved using a strong sugar solution?
6. What sort of foods are preserved using sodium nitrite?
7. What sort of foods are preserved using sulphur dioxide?
8. Other methods of preservation include drying, freezing and canning. Explain how these processes prevent food from going bad.

Suggestions for further investigations

a. Design an experiment to find out the lowest concentration of salt solution which will stop a particular food from going bad in a particular length of time.

b. Design an experiment to find out at what concentration sugar will act as a preservative.

c. Sugar is being replaced in some food situations by artificial sweeteners. Do these sweeteners have similar preserving properties to sugar? Design an experiment to find out.

d. It has been suggested that the antimicrobial action of sodium nitrite can be enhanced (made even better) by the presence of salt. Design an experiment to investigate this.

e. Design an experiment to find out whether cloves added to cooked apple pulp have a preservative effect or not.

f. Make a survey of the sorts of foods you and your friends have at home. What methods of food preservation are used? For how long will the different foods using the different methods of preservation stay fresh?

g. One of the most important methods of food preservation is pasteurisation. Find out the history behind this method and the details involved in its modern day usage.

Results - after 24 hours

Tube	What do the peas look like?	What does the liquid look like?
A in refrigerator		
B room temperature		
C distilled water		
D salt solution		
E sugar solution		
F vinegar		
G sodium nitrite solution		
H sulphur dioxide solution		

There is a need to preserve and process much of the food that is grown. Preservation of food is necessary to ensure a safe supply of nutritious food to all individuals. It is a way of preventing wastage of food when this is in quantities too great for immediate consumption. It allows foods to be eaten out of season and gives variety and nutritional quality to our diets all year round.

Many foods must be processed before they are fit for us to eat. Processing often involves making the food easier to digest, preserving it, improving its flavour and its texture.

Methods of processing vary from being simple, such as cooking raw vegetables at home, to extremely complicated. Processing can be a great art as shown by the blending of many ingredients to create superb dishes by skilled chefs. It can be on a huge industrial scale such as the commercial baking of bread.

As soon as food is harvested (picked or slaughtered) the organisms of decay begin breaking it down. This leads to unacceptable deterioration and the possible production of dangerous substances. Preserving food must try to stop or greatly slow down this natural process.

The skill in preserving and processing food is to get the best quality of product that is possible. The aim is to produce the best colour, texture and flavour but without reducing the nutritive value of the food. Processing must not introduce toxic material and must be done at a cost that is acceptable to the consumer.

For you to do

The table, on the next page, shows the main methods of food preservation. Below it are descriptions of how the methods of preservation are able to stop the spoilage of food.

Match the method of preservation with how it works. The first is done for you.

In the final column of the table add the names of foods that can be preserved by each method.

METHODS OF FOOD PRESERVATION

Method	How does it work?	Examples of foods
Cooking	e	meat, vegetables, eggs, etc.
Domestic refrigeration		
Freezing		
Canning/ bottling		
Dehydration		
Curing		
Pickling		
Jam making		
Gas or vacuum packing		
Chemical preservatives		
Irradiation		

Match these statements against food preservation methods.

a. slows down reactions considerably; 'removes' water by turning it into a solid so that it cannot be used

b. salt is added which makes the liquid environment very concentrated; inhibits the action of enzymes and the processes of microorganisms

c. substances such as sulphur dioxide and sodium benzoate interfere with microbial growth

d. high temperatures destroy enzymes and microorganisms; removes and excludes oxygen

e. destroys enzymes and most microorganisms

f. adds sugar which makes the liquid environment very concentrated; inhibits the action of enzymes; inhibits the processes of microorganisms

g. removes water completely; makes the food a solid

h. adds (usually) vinegar; makes the environment too acidic for enzymes and bacteria to function normally

i. rays from a radioactive source are passed through food; microorganisms are destroyed

j. slows down reactions

k removes and excludes oxygen to inhibit the growth of organisms which require this

S1. Diabetes mellitus

KS3
science and food technology

***Timing - 15 - 25 minutes** depending on the resources available*

Pupil activity sheet S1 accompanies this activity.

In this text-based activity pupils are given a simple introduction to **diabetes** and are asked to carry out some research.

The answers to the questions *cannot* be found on the sheet, the pupils will have to undertake a literature search.

Answers to the questions on Pupil activity sheet S1:

1. 16 correct foods appear in the pack of playing cards from the introductory section of this resource.
2. 15 correct foods appear in the playing cards from the introduction section of this resource.
3. starch
4. glycogen
5. The most well known ones are saccharin, aspartame and acesulphame K. Others may be found in the full list of additives and E-numbers which features in the reference material of this resource.
6. Insulin is a protein which will be digested and, hence, broken down into its constituent amino acids if taken orally.
7. adrenalin
8. Tooth decay (dental caries) is caused by bacteria. The bacterial enzymes break down sugary and starchy foods in the mouth and produce acids as by-products. Acids dissolve the calcium salts in the teeth forming cavities.

S2. Diagnosis of diabetes mellitus

KS3 and KS4
science

Timing - 30 - 40 minutes

Pupil activity sheet S2 accompanies this activity.

Requirements
- *3 samples of 'urine':*
  water + food colouring - labelled A
  water + glucose + food colouring - labelled B
  water + food colouring - labelled C
  (the food colouring is to make the liquids look realistic!)
- *Benedict's reagent*
- *test tubes or boiling tubes*
- *test tube holder*
- *test tube rack*
- *water bath (beaker of water heated over Bunsen flame)*
- *safety goggles*
- *stop clocks*
- *Clinistix - available from pharmacists follow the instructions on the pack very carefully)*

Pupils test samples of 'urine' with Benedict's solution and Clinistix.

You will find that tube B will not clean after the test has been carried out; a small amount of bench HCl added to the tube will remove the orange colour.

Answers to questions on pupil sheet S2:

1. only sample B
2. sample B
3. The information from the second paragraph will help pupils form an answer.

S3. Controlling the level of glucose in the blood

In this text-based activity pupils compare glucose and insulin levels recorded for a diabetic and a non-diabetic.

Answers to questions on pupil sheet S3:

Task 1

1. Graph
2. Rapidly reduces the level of blood glucose.

Task 2

1. Rises steeply/quickly.

KS4
science

Timing - 20-25 minutes; *possible homework exercise*

Two pupil activity sheets S3 accompany this activity.

Graph paper is needed

2. Eating a meal involves the digestion of food; this will increase the amount of glucose in the blood; this stimulates the production of insulin.

3. Returns to the original level (*not* to zero); it is important to note that there is a 'background' level of insulin in the bloodstream.

4. This is zero; this is not so in a 'normal' person.

5. It rises (but not as rapidly or to the same level as the 'normal' graph).

6. After an injection of insulin, there is a delay before it becomes 'actively' present in the blood. Insulin is normally injected about half an hour before a meal. (There are now types available which can be injected just before eating.)

7. Zero; insulin-dependent diabetics cannot make their own insulin. 'Normal' people can make insulin and there is always some present in the bloodstream.

KS4 and above
science and technology

Timing - various

This is an extension exercise; it could be a homework.

Two pupil activity sheets S4 accompany this activity.

The case study is a true account of a colleague's experiences.

Diabetic retinopathy affects the blood vessels supplying the retina (the light sensitive region of the eye). Blood vessels in this area may become blocked, leaky or grow haphazardly. This may eventually impair vision seriously and permanently.

By drinking orange juice, Ms G was actually adding more sugar into her bloodstream hence exacerbating the situation.

S4. A case history

In this text-based activity pupils read a case history and carry out some literature research.

None of the answers can be found on the sheet; all have to be researched.

Answers to Pupil activity sheet S4:

1. Abnormal blood **glucose** levels, frequent in diabetes, can result in blurred vision. The technical term for the complications that can result from abnormal blood glucose is *diabetic retinopathy*. Retinopathy generally has no obvious symptoms until it is well advanced. It is important, therefore, for diabetics to have regular (annual) eye examinations.

2. In diabetes glucose levels in the blood rise. Eventually this glucose will reach a level where it cannot be reabsorbed back into the bloodstream in the kidney tubules. After this *threshold* level, glucose will begin to appear in the urine. Since glucose is removed from the body in solution, more water than normal will be lost from the body as the glucose is excreted. This tends to dehydrate the body with the response that the individual will feel thirsty.

3. *hyper*glycaemia - a higher blood glucose than normal. Symptoms include an increased thirst, increased frequency of passing urine, blurring of vision, nausea or vomiting, drowsiness, stomach pain, cold, dry skin, deep rapid breathing, sweet smell on the breath.

   *hypo*glycaemia - a lower blood glucose level than normal. Symptoms include hunger, sweating, trembling, tingling of the lips, palpitations, blurring of vision, irritability.

4. If a diabetic were to have an accident whilst away from home or on their own, it is important for other people who are trying to care for them to know that they are diabetic. Being diabetic can have important consequences for the use of drugs, anaesthetics, etc.

5. It may happen that a diabetic will suffer from mild hypoglycaemia (have a mild 'hypo') if meals are slightly delayed or if extra exercise than expected was taken. By having sweets, etc. handy, it is possible to quickly reverse the symptoms.

6. Advice to diabetics:

   When travelling by aeroplane carry all the diabetic equipment in hand luggage as suitcases have been known to go missing. Also the luggage hold is not heated and insulin stored at too low a temperature may freeze and be inactive.

   Always take spares of everything including insulin. This will cover breakages or delays in returning home. Some countries will not be able to supply the exact type of insulin used in this country.

   Take extra food and snacks in hand luggage in case meals are missed.

   In very hot climates special arrangements may have to be made to store insulin in a cool place.

   Sugar free drinks may be difficult to get in some countries.

   Meals should not really be a problem but it may be wise to check with a dietician before travelling.

   Make sure that appropriate health insurance has been taken out.

   On arrival make sure the whereabouts of the nearest doctor and hospital are known.

   The effects of travelling through different time zones may have to be compensated for.

   If the person suffers from travel sickness it may be appropriate to take travel sickness tablets; if sickness occurs then access to snacks to replace lost carbohydrate may be needed.

7. Diabetes is not caused by a microorganism. There is no way that a diabetic can pass on the condition by any of the obvious methods of transmission. Like many conditions, it has been suggested that diabetes may run in families but it cannot be 'caught' from anyone.

8. The technique of *genetic engineering* has enabled the human insulin gene to be transferred to more simple organisms. These organisms are then able to produce large quantities of pure human insulin in a relatively short time.

   (Some pupils may go into more detail about the procedures involved in genetic engineering.)

Insulin keeps best in a fridge.

S5. Sweeter than sugar

KS4
science and food technology

Timing - 40 - 60 minutes

Two pupil activity sheets S5 accompany this activity.

Requirements
- *artificial sweetener tablets*
- *granulated artificial sweetener*
- *ordinary table sugar (sucrose)*
- *balance, accurate to 0.1 g*
- *teaspoons*
- *distilled water*
- *10 cm^3 graduated pipettes*
- *teat pipettes*
- *small beakers or similar*
- *sample of 'ordinary' lemonade labelled A*
- *sample of 'diet' lemonade (be sure that it does not contain sugar) labelled B*
- *the empty bottles/containers from the lemonade or the labels from the containers or copies of these*
- *apparatus for testing for reducing sugar/glucose, i.e. heating equipment, water bath, Benedict's solution, test tubes or boiling tubes, test tube holder, test tube rack, safety goggles, Clinistix (if available), stop clock*
- *samples of any other drinks such as cola; these should be in labelled beakers but should not have their ingredients labels with them; the drinks will be used to find their sugar content*
- *graph paper*

Pupils do practical activities to compare the 'densities' of drinks containing artifical sweeteners and sugar.

Answers to questions on Pupil activity sheet S5.

Task 1

The accurate measurement of volumes is very important.

1. aspartame, saccharin and acesulphame K are the most common
2. this will vary depending on the tablets
3. ~3.0 g
4. ~22.0 g
5. The artificial sweeteners weigh considerably less than equivalent *volumes* of sugar. These volumes have the *same* sweetness. The artificial sweeteners are

considerably sweeter than sugar and are therefore present in relatively tiny amounts.

6. ~9.9 g

7. ~10.5 g

8. The sugar solution weighs more than an equal volume of sweetener solution. It has a greater *density*. The sweetener present has a much smaller mass than the sugar.

Task 2

1. Typical ingredients (e.g. Sainsbury's own brand lemonade):

'diet' lemonade	'ordinary' lemonade
carbonated water, citric acid, flavouring, acidity regulator: sodium citrate; artificial sweetener: aspartame; preservative: sodium benzoate; stabiliser: carboxymethyl cellulose	carbonated water, sugar, citric acid, flavouring, preservative: sodium benzoate; artificial sweetener: saccharin

2. Knowledge of food labelling will show that *sugar* appears before the artificial sweeteners and citric acid in the 'ordinary' lemonade. 'Ordinary' lemonade has a certain amount of dissolved sugar in it whereas 'diet' lemonade does not. Using the knowledge gained from Task 1, pupils need only to weigh equal volumes of the two samples to discover which is which. 10 cm^3 of 'ordinary' lemonade does indeed have a greater mass than 10 cm^3 of 'diet' lemonade ('ordinary' lemonade has a greater density than 'diet' lemonade).

Task 3

1. graph; make sure that a suitable scale is used for the vertical axis.

2. ~10.3 g

3. This will vary depending on which drinks you have chosen to test.

S6. Food for diabetics

KS4
project in food technology

Timing - various

Pupil activity sheet S6 accompanies this activity.

Pupils are presented with basic information on the dietary requirements of people with diabetes and asked to find out more. They are required to produce a booklet for a diabetic (of their own age) which details diet, menus and a recipe.

Research

Information about diabetes is available from many different sources.* The amount of research will depend upon interest and ability.

The overall aim is to produce a booklet which concentrates on the special dietary aspects of this condition. The booklet is to be aimed at the pupils' own age group. Pupils are asked to design, prepare and test one dish in which an artificial sweetener is used.

The most important and obvious area in a diabetic's diet is the intake of **carbohydrate**.

When someone without diabetes eats food which contains carbohydrate, the pancreas produces a correct dosage of insulin to cope with any glucose which eventually reaches the bloodstream after digestion of the carbohydrate. This is not the case with diabetics.

*

British Diabetic Association, 10 Queen Anne Street, London, W1M 0BD
tel: 0171 323 1531
fax: 0171 637 3644

Diabetes centres of the major hospitals

Many supermarkets produce leaflets on diet and foods for diabetics

Diabetics must balance the amount of carbohydrate they eat with the amount of insulin they are injecting and with the amount of exercise they are taking. They must try to keep the level of blood glucose as near normal as is possible. Both situations of too much blood glucose and too little blood glucose are potentially very dangerous. The diet of a diabetic is therefore of considerable importance.

Designing menus

Pupils are asked to produce *menus* but not to cook vast quantities of food. The aim of the exercise is to give a greater understanding of the special dietary needs of a diabetic, particularly in relation to carbohydrate intake.

Diabetics are advised to adapt their existing diets rather than to buy specialist diabetic products. This should be reflected in the work produced by the pupils. However, the inclusion of the so called 'diet' drinks in a diabetic's diet is encouraged since they do not contribute to blood glucose levels. You could carry out parts of the activity S5 *Sweeter than sugar*, page 73, to show this.

The use of artificial sweeteners in tea, coffee, etc. is also recommended. These sweeteners, in granulated form, can also be used to produce puddings, cakes, biscuits, etc. and it is in this area that pupils are asked to develop their own recipe and product.

Diabetes is a condition in which people are unable to control the amount of **glucose** that is in their blood. Glucose is a simple sugar. It belongs to the group of nutrients called **carbohydrates**.

All of the cells in your body need a constant supply of glucose. When you are exercising, the cells in your muscles will need a greater supply than normal. Glucose is used in the process known as **respiration**. This process produces energy.

The amount of glucose in your blood is controlled by special substances called hormones. The hormones that control the amount of blood glucose are called *insulin* and *glucagon*. Diabetes happens if a person is unable to produce insulin. Without insulin the cells of your body are unable to use glucose. Some of the first symptoms of diabetes include lethargy (extreme tiredness), thirst and the presence of glucose in the urine. The disease can lead to serious problems. In some cases it can be fatal.

Diabetics (people who have diabetes) have two main ways in which they can correct the problems due to this condition. Some of them can lead a normal life simply by keeping a tight check on the amount of carbohydrate they eat. Other diabetics have to have regular *injections* of insulin as well as being careful of the amount of carbohydrate they eat.

It can be seen that it is very important for diabetics to know how much carbohydrate is in the food they eat. It is very easy for them to eat too many sugary foods.

Some food companies have produced **artificial sweeteners**. Their availability is very helpful to diabetics. The sweeteners can be used in the production of foods such as jams, chocolate and drinks. They can also be use in baking. Artificial sweeteners are sweet tasting substances but they do not add to the amount of glucose in the bloodstream. Artificial sweeteners are useful because they can also be used to produce foods to be included in a *weight reducing diet*. Their use in fizzy drinks, for example, can also help in the battle against tooth decay.

Task

Find out the answers to the following questions. You will have to research the answers; none of them can be found on this sheet.

1. Find the names of *four* foods which have *less* than 5 g of carbohydrate per 100 g of food.
2. Find the names of *four* foods which have *more* than 40 g of carbohydrate per 100 g of food.
3. What is the name of the *storage carbohydrate* in *plants*?
4. What is the name of the *storage carbohydrate* in *animals*?
5. Find the names of *two artificial sweeteners*.
6. Why does insulin have to be *injected* into the blood rather than taken by mouth?
7. Find the name of the *hormone* which is produced in times of stress. It makes your heart beat faster and is a favourite of sports commentators!
8. What is the sequence of events that leads to *tooth decay*?

The presence of **glucose** in the urine is one of the signs that a person may be suffering from diabetes.

There is a normal amount of glucose contained within the blood. When this blood is filtered as it passes through the kidney, all of the glucose is reabsorbed back into the bloodstream. This means that under normal circumstances glucose should not be present in the urine. However, in a person suffering from diabetes there is an abnormally high level of glucose in the blood. As this blood passes through the kidneys not all of the glucose can be returned to the blood. Hence, some of it will be present in the urine.

It is quite easy to test for the presence of glucose in a liquid such as urine. Glucose is an example of a *reducing sugar*. It can be detected using a test called the *Benedict's test*.

An unknown sample of liquid is boiled with *Benedict's solution*. If an *orange-red* precipitate appears then the unknown sample does contain glucose. This is a *positive* result.

You are given three samples of 'urine' labelled A - C (it is not real urine!). Carry out the following test on small samples of each 'urine'. Each test must be carried out in a separate test tube.

SAFETY NOTE
REMEMBER TO WEAR GOGGLES

1. Pour about 2 cm depth of 'urine' into a test tube.

2. Add an equal depth of Benedict's solution. This is a *blue* solution.

3. Place the tube in a boiling water bath.

4. After about 60 - 90 seconds record the colour of the mixture in the tube.

5. Repeat the test with the other samples.

Questions

1. Which of the samples contained glucose?
2. Which of the samples could be from a person suffering from diabetes?
3. Imagine you were the doctor carrying out similar tests. How would you explain simply the presence of glucose in the urine to the patient whose urine you had tested?

Doctors do not usually carry out a Benedict's test in their surgeries. Instead, they can carry out a test which takes just a few seconds. This test uses a special piece of equipment called a Clinistix. If these are available you could use them to confirm the results from the Benedict's test.

CONTROLLING THE LEVEL OF GLUCOSE IN THE BLOOD

The level of glucose in the blood is normally controlled by two *hormones*. These are called *insulin* and *glucagon*. Both of these are produced in the *pancreas*. This means that the pancreas has two different but very important functions. These are the production of digestive **enzymes** and the production of *hormones*.

The parts of the pancreas that produce the hormones are called the *Islets of Langerhans* (islets - the tissue looked liked small islands; Langerhans- Paul Langerhans discovered this tissue).

The control of blood sugar is an example of homeostasis (maintenance of a constant internal environment). Insulin and glucagon work in opposition to one another. Insulin works to remove excess glucose from the blood. Glucagon adds glucose to the blood in times of shortage.

Insulin stimulates the conversion of glucose into a substance called *glycogen*. Glycogen is a storage **carbohydrate**. It is stored in the *liver* and *muscles*. Insulin also stimulates the uptake of glucose by the cells of the body. Glucose is used in the process that produces energy, i.e. respiration. Insulin stimulates processes which have the effect of *lowering* the amount of glucose in the blood.

Glucagon stimulates the conversion of glycogen from the liver into glucose. This has the opposite effect to insulin. This will *increase* the amount of glucose in the blood.

Early onset diabetes (Insulin Dependant Diabetes, IDD) is a severe form of the condition *diabetes mellitus*. In this condition there is a complete failure of the pancreas to produce insulin. If this is left entirely untreated it will be fatal. Patients suffering from this form of the disease have to regularly monitor the level of glucose in their blood. (The level of glucose in the blood is measured in millimoles per cubic decimetre (mmol/dm^3)). In response to this patients have to have regular injections of insulin.

Task 1

The following questions show the effect that insulin has on the level of glucose in the blood of a 'normal' person.

A person's level of blood glucose was measured. They were then given an injection of insulin. The level of blood glucose was remeasured over time. The results are shown below.

	TIME (minutes)	LEVEL OF BLOOD GLUCOSE (mmol/dm^3)
	0	4.1
insulin injection	15	4.1
	30	1.9
	40	3.8
	60	3.8
	90	3.9
	120	4.2

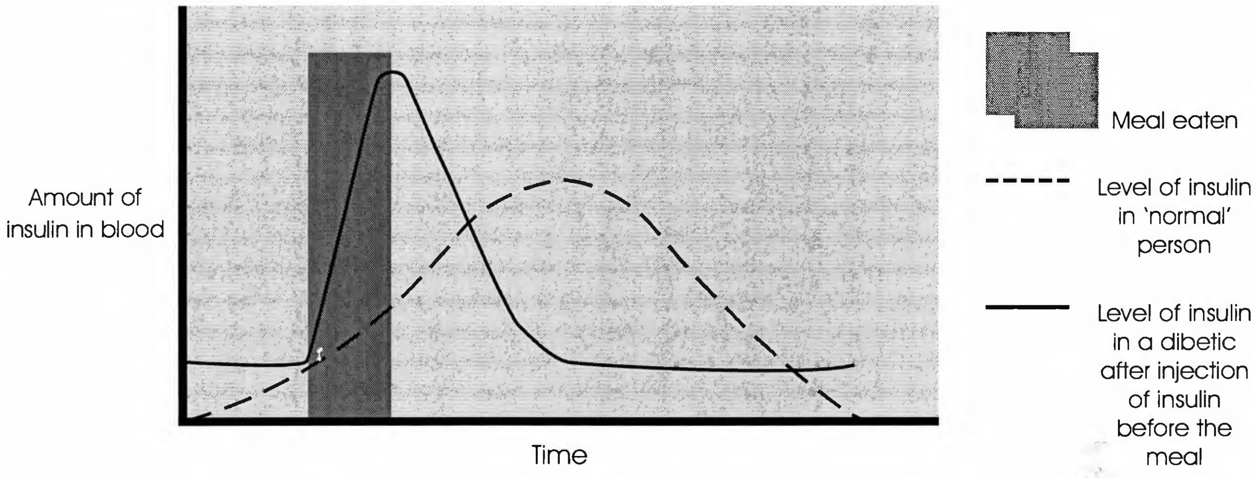
1. Plot a line graph of these results. Put time along the bottom (x axis). Put the level of glucose (mmol/dm^3) up the side (y axis).

   Remember to give your graph a title. Label the axes. Show where the injection of insulin was given.
2. What effect does insulin have on the level of glucose in the blood?

Task 2

The following sketch graph shows the level of *insulin* (*not* glucose) in a 'normal' person. The graph shows what happens to this level after a meal has been eaten.

The graph also shows the level of insulin in a diabetic in the same situation. The diabetic has been given an injection of insulin before the meal.



Look at the 'normal' line.

1. What happens to the amount of insulin in the blood when the meal is being eaten?
2. Why does eating a meal bring about this change?
3. What eventually happens to the amount of insulin?

Look at the 'diabetic' line.

4. What is the level of insulin in the blood before the injection is given? In what way is this different to the 'normal' graph?
5. Describe what happens to the level of insulin in the blood following the injection.
6. Why should an injection of insulin be given about half an hour before a meal is eaten?
7. What is the level of insulin in the blood at the end of the graph? Explain this level. In what way is this different to the 'normal' graph?

A CASE HISTORY

This is the story of a 39 year old woman who has been diagnosed as suffering from the more severe form of diabetes (early onset diabetes). It is quite unusual for someone to be diagnosed as having this more severe form of diabetes so late in life.

"I had been experiencing 'strange' vision for a few weeks. I had very poor long sight but my short sight did not seem to be affected. My vision often appeared 'misty'. I could recognise large shapes, like trees, but couldn't see detail, such as the leaves on the tree. I thought I ought to see an optician about getting some glasses. I made an appointment. As it turned out, I didn't get to that appointment.

I had other symptoms. I was very lethargic and felt very thirsty. I was drinking litres of orange juice at a time to try and quench my thirst. It was on a Thursday of one particular week that I began to feel really ill. I tried to make an appointment with the doctor but could not get one until the following Tuesday.

The following day I could not even go to work. By the time Saturday arrived I was so desperate that I rang the doctor for an emergency appointment and went down to the surgery. Whilst sitting in the waiting room I remember feeling almost 'drunk' and 'completely out of it'.

On hearing my symptoms, the doctor immediately suggested that I may be developing diabetes. I gave the doctor a sample of urine so that it could be tested for the presence of glucose. This test proved positive. The doctor then took a drop of blood from my finger to measure the amount of glucose in it. The normal level of glucose is between 4 - 7 mmol/dm^3. Mine was 26mmol/dm^3!! The doctor told me that this was a very good indication that I had a serious problem. He sent me immediately to hospital. I remained remarkably calm given the circumstances. I think I was just too ill to have any other sort of reaction!

I arrived at the hospital at about 10.30am. I was weighed and had my height measured. They carried out two more tests. One tested for the presence of substances called ketones in the urine. These substances appear when the amount of insulin in the blood is low. This result was positive but it was not a major cause for concern at that stage. The other test is called the glycosylated haemoglobin test. This test is able to indicate the average glucose level in the blood for the previous few months. This resulted in a higher figure than normal. There was no doubt about it; I was definitely developing diabetes.

These tests had taken quite a long time to perform. It was not until 2.30pm that the hospital decided they had enough information about me to enable them to estimate a correct amount of insulin to inject me with at that moment. They then taught me how to inject myself and how to measure my blood glucose levels. By 4.00pm that afternoon I was in a healthy enough state to be sent home.

I returned the following morning and two days later for more help and information.

It wasn't for a few more days after my diagnosis that the whole thing hit me. I felt very unhappy and I cried. I knew that measuring blood glucose levels and injecting myself with insulin were here for the rest of my life.

Now, a few months after the diagnosis, this change to my lifestyle is simply routine. It's not nice, but it's manageable."

Ms G has at least two very good factors in her favour. Firstly, she is not at all overweight. Secondly, she was already eating a suitable diet. The only changes she has had to make is that she avoids sweet, sugary foods like chocolate, cakes and puddings. She drinks low calorie (low kcal/kJ) or 'diet' versions of drinks. The only specialist diabetic product she has purchased is low sugar jam.

For Ms G the greatest inconvenience is not the twice daily measuring of blood glucose levels. It isn't even the twice daily insulin injections. It is how nothing 'unexpected' can be allowed to happen with respect to food. There can be no skipped or missed meals; no surprise bars of chocolate; no unexpected delays at meal times, for example, in restaurants. It has also been surprising to find out that some people think they will be able 'catch' diabetes from her!

Diabetics can and do lead full and active lives. More often than not their condition and their self discipline remain entirely unnoticed by the rest of us.

You will have to do some research to answer the following questions.

1. At the beginning, Ms G described how her vision was being affected. Diabetics are allowed to have free and regular eye examinations. Find out why there is concern for a diabetic's eyes.
2. Ms G felt very thirsty and drank large amounts of orange juice. Why does diabetes make someone so thirsty? Why was drinking orange juice actually a mistake?
3. Diabetics can suffer hyperglycaemia and hypoglycaemia. What do these words mean? What symptoms are associated with these situations?
4. Diabetics are advised to wear some form of identification, such as a necklace or bracelet, explaining that they have insulin dependent diabetes. Why is this a sensible precaution?
5. Diabetics are advised to always carry with them some sugar or sweets. Why is this a sensible precaution?
6. What special considerations should a diabetic take when planning a holiday abroad?
7. How would you explain to someone that you cannot 'catch' diabetes from a diabetic?
8. Insulin was originally obtained by extracting it from the pancreas of cows. This led to objections from diabetics who were vegetarian. Also cow insulin is not the same as human insulin. Find out how modern technology has been able to produce sufficient quantities of 'human' insulin.

There are a number of **artificial sweeteners** available to consumers. The most common examples are the very small 'tablets', each equivalent to a teaspoon of sugar which many people use to sweeten tea and coffee drinks. Sweeteners are also available in a *granulated* form (it looks like ordinary sugar) for use in cooking and for sprinkling over food. Again, one teaspoon of the granulated sweetener has the equivalent sweetness of one teaspoon of sugar.

SAFETY NOTE
YOU MUST NOT EAT OR DRINK ANY OF THE SUBSTANCES USED IN THIS INVESTIGATION

Task 1

You are given samples of sweetener tablets, a granulated sweetener and ordinary sugar (sucrose).

1. Find out, from the labels the chemical names of the artificial sweeteners .
2. Find the mass of four of the small tablets.
3. Find the mass of four teaspoons of the granulated sweetener.
4. Find the mass of four teaspoons of ordinary sugar.
5. What do you notice? How do you explain this?
6. Dissolve the four teaspoons of granulated sweetener in 100 cm^3 of water. Find the mass of 10 cm^3 of this solution as accurately as you can.
7. Dissolve the four teaspoons of sugar in 100 cm^3 of water. Find the mass of 10 cm^3 of this solution as accurately as you can.
8. What do you notice? How do you explain this?

Task 2

Artificial sweeteners can be used in the production of so-called 'diet' drinks, such as 'diet' lemonade and 'diet' cola.

You are given the empty bottles, or labels, from two bottles of lemonade. One of then is 'diet' lemonade and the other is 'ordinary' lemonade.

1. Copy, into a table, the ingredients in each lemonade, in the order they appear.

Remember - the ingredients are shown in *descending* order of mass, i.e. the ingredient present in the largest amount is always *first*.

2. You are now given samples of the liquids from each bottle, but you do not know which is which! Using only the information you have learnt so far, devise a simple way of finding out which sample is 'ordinary' lemonade and which sample is 'diet' lemonade. Do not use up all of the lemonades.

   Explain your test and the results.
3. Carry out the Benedict's test (and/or the Clinistix test) on a small sample of each liquid to confirm your results.

Task 3

You are given information about the *mass* of different sugar solutions.

Amount of sugar (g) dissolved in 100 cm^3 of water	Mass (g) of 10 cm^3 of this solution
0	9.94
2	10.01
6	10.14
10	10.28
14	10.41
18	10.55
22	10.68

1. Plot a graph of this information. Put the amount of sugar dissolved (g) along the bottom (x axis). Put the mass of 10 cm^3 of solution up the side (y axis).

   Remember to give your graph a title. Label the axes.
2. Use your graph to predict the mass of a solution containing 10.5 g of sugar.

You are now given some samples of drinks.

3. Find the mass of 10 cm^3 of each of the samples. Use your graph to find out how much sugar is in each of the drinks. Record your results in a suitable table. Do all drinks contain the same amount of sugar?

Diabetics do not have to drastically alter their diet. They do have to keep a much closer check on the food, particularly carbohydrate, that they eat. There are guidelines for them to follow. These include:-

- Eat regular meals. Try to eat similar amounts of starchy foods from day to day.
- Try to eat more high fibre (non-starch polysaccharide (NSP)) foods. The fibre in beans, peas, lentils, vegetables, fruit and oats is particularly good.
- Cut down on fried and fatty foods such as butter, margarine, fatty meat and cheese.
- Reduce the amount of sugar you eat by swapping high sugar foods for low sugar foods.
- Try to get to the body weight that is right for your height and build and stay there.
- Be careful not to use too much salt.

Task

Your task is to produce a *Diet Booklet for Diabetics* aimed to help them to eat a healthy diet for their special needs. Aim the booklet at your own age group.

Suggestions for research:

- Find out as much as you can about the dietary needs of a diabetic.
- Carry out a survey of the information and products available to diabetics. This could include looking in supermarkets and chemists for specialist products and facts about diabetes.
- Find special recipes for particular dishes.
- Collect the labels of diabetic products or write down their ingredients. You can then compare them to their equivalent 'normal' product.

It is not necessary that a diabetic diet should include specialist products. It is better to just adapt ordinary food. However, imagine that one of the days' meals includes a party, maybe for a birthday, at which guests will want to eat some special dishes. Some of these must be suitable for a diabetic and will contain an artificial sweetener.

Your final booklet must contain menus (not recipes) for 2 days worth of meals.

Plan, prepare, cook and market test *one* of the dishes from your menus which uses an artificial sweetener. The recipe for this dish should appear in your booklet.

SR1. A recipe for disaster

This is a text-based activity.

The fictitious situation aims to highlight some of the errors, misconceptions and mistakes that people may make when preparing food. The pupils are asked to identify mistakes and explain the dangers. The meeting could be acted out by pupils.

Some of the errors include:

Joy - will prepare food whilst having a cough and cold; thus possibly transmitting bacteria by droplet infection. Individuals suffering such symptoms should not be allowed to prepare food.

Gill - has purchased dented and slightly damaged cans and foods just out of date. It is possible that dented or damaged cans may have allowed the entry of air containing microbes and, as such, the process of decay may have begun. Date marking on products can be confusing (see margin box).

Rahat - has purchased eggs with cracked shells and intends to use these in dishes that will be eaten raw; raw eggs sometimes contain bacteria that cause food poisoning. These bacteria can only be killed by thorough cooking. Eggs with cracked shells are particularly susceptible to bacterial invasion.

Anil - intends to cook some foods well before the start of the event and store them at room temperature for some time before consumption. Room temperature provides ideal conditions for microbial growth, thus leaving food in these conditions may result in a massive rise in bacterial numbers and result in food poisoning.

Liz - will stack the dirty dishes from the first course next to clean crockery, cutlery and raw fruit; cooked leftovers will provide suitable breeding grounds for microbes. If waste food is left near raw food for any length of time there is the possibility of cross infection. There is one sink in the kitchen; ideally there should be a separate sink for general washing of hands as opposed to washing of food and utensils.

Anil - the desserts will be stored in the refrigerator on a shelf below the raw meat intended for a later event; there is great potential here for cross contamination between raw and cooked foods. This is enhanced with the possibility of blood/juices from the raw meat dripping onto the cooked food. Raw meat should always be carefully wrapped and stored *below* other foods. In shops and restaurants, cooked and raw products should not be stored together. Recommendations suggest that, where possible, raw and cooked food should be served by different assistants.

Rahat - intends to put food onto the tables more than 3 hours before it will be eaten; only some of the food will be covered. 3 hours is the absolute maximum that food should be left in this type of situation before consumption; storage at low temperatures is desirable. The delay between production and consumption only allows for the growth of microbes. All food, even raw salad, should be adequately covered to prevent flies, etc. landing on the food.

KS3/4
science or food technology

Timing - various
A possible homework exercise if food safety has already been discussed; a discussion activity if food safety has not been covered.

Pupil activity sheet SR1 accompanies this activity.

*A '**Use by**' date is marked on highly perishable foods, i.e. those foods which will go 'off' quickly. Keeping and eating the food beyond the **Use by** date could be a health risk. However, it is possible to extend the 'eat by' of some foods by cooking or freezing the food once at home, e.g. freezing fresh meat.*

*Most foods are less perishable and carry a '**Best before**' date. When this date has passed it does not mean that the food has suddenly become unfit for consumption. It means that the food may no longer be at its very best. It is important to remember that date marking is often accompanied by storage instructions and these should be followed carefully since non compliance may affect the quality and eating life of the product. The MAFF booklet 'Understanding food labels', number 3 in the Food Sense series, is very useful.*

The social events committee at the local school are meeting to plan an important social event in the school calendar. They have the responsibility of organising the Summer fete and buffet lunch at which many pupils, teachers, parents and governors will be present. You have decided to go and listen in on the conversation of their final meeting the day before the lunch.

José: Right everyone. Are we ready to start the meeting?

Anil: Yes! I think everyone is here!

Liz: Joy isn't here! She's coughing and sneezing all over the place! But don't worry, nothing will keep her away from helping us tomorrow no matter how sick she feels!

José: It's better for her to be here tomorrow than at this meeting. We can do this business without her. Now Gill, how are you and Rahat getting on with the shopping?

Gill: Well, I know we are on a tight budget for this event. I'm a good shopper and I can spot the bargains. I managed to buy a lot of food by choosing the dented and slightly damaged canned foods which were on a special shelf at the supermarket.

Rahat: Yes, and I saved money by buying the eggs at half price because some of the shells were cracked. It doesn't matter about the shells because we're going to make mayonnaise from the eggs.

Gill: I also bought some foods that were just out of date and so were cheaper. I checked them by smelling them and looking at them. They seemed fine.

José: All sounds good to me! Anil have you finalised the menu yet?

Anil: We're almost there. We're definitely having those cooked chicken pieces. They always go down well. Because the kitchen is so small and we only have one oven, I'm going to cook the chicken, sausage rolls, quiches, etc. first thing in the morning and put them out of everyone's way on that top shelf above the door.

Liz: Yes, space is a bit of a problem. As the dirty dishes accumulate, they will have be stacked next to the crockery, cutlery and fruit that's waiting to go out with the puddings. That way the one sink will still be free for all the other uses.

José: How are the puddings coming along then?

Anil: That's quite easy. All of them are going to be cold and they're going to stay in the big fridge in the corner after they're prepared until there's enough space to move them. There's only just enough room. The day after the buffet lunch, someone else is organising a barbecue. I've told them they can put their meat, etc. on the top two shelves in the fridge after they've done their shopping today. That leaves all the lower part for our desserts.

José: Aren't we all going to miss out on the entertainments if we're having to put food out?

Rahat: No, we've thought about that. We can get into the dining room about three hours before we're due to eat. Almost everything can be put out on the tables then. Don't worry, we've got a few large paper tablecloths that can cover it all except the salads - but they don't really need covering.

José: Good! It sounds like it's a recipe for a really enjoyable day. Well done everyone!!

You are very worried by what you have heard. It sounds much more like a recipe for a disaster than for a successful event. You feel you must talk to the committee and point out and explain all the ways in which you think they will really be cooking up a danger to everyone's health.

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