# Understanding Smart Foods

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Smart foods is a new topic in the National Curriculum (NC) programme of study for design and technology. It is a collective term for new developments in food materials, which includes both ingredients and food products. Within the food industry, smart foods are more commonly referred to as ‘modern’ or ‘novel’ food materials. Within the UK, the Advisory Committee on Novel Foods and Processes (ACNFP) evaluates applications for approval of novel foods, including irradiation and genetic modification, under the EC Novel Food Regulations (258/97). Examples of approved applications are: lactobacillus GG, chymosin enzymes from genetically modified source organisms and herbicide tolerant soya beans.

School Context
The NC programme of study for design and technology at Key Stage 3 requires pupils to be ‘taught about the working characteristics and application of a range of modern materials, including smart materials’. The scope of smart foods in school is far wider than that of ACNFP and encompasses a range of new and exciting areas of study.

What are smart foods?
Smart foods are those that have been developed through the invention of new or improved processes, for example, as a result of man-made materials/ingredients or human intervention; in other words, not naturally occurring changes.

Smart foods may:
- have a function, other than that of providing energy and nutrients;
- perform a particular function never achieved by conventional foods;
- have had significant investment of intellectual property;
- have been developed for specialised applications, but some eventually become available for general use.

Based on the examples provided by the Qualifications and Curriculum Authority (QCA), the British Nutrition Foundation (BNF) and the Design and Technology Association (DATA) classify smart foods as:
- foods with novel molecular structures, e.g. modified starches, fat replacers and sweeteners
- functional foods, e.g. cholesterol-lowering spreads, probiotic yogurts, fortified eggs
- meat analogues, e.g. textured vegetable protein (TVP), myco-protein and tofu
- encapsulation technology, e.g. encapsulated flavours in confectionery
- modern biotechnology, e.g. soya bean, tomato plant, particular enzymes

Although not definitive, this document reviews each of the smart foods listed, highlighting their characteristics and giving some applications, with case study material from industry and the classroom as exemplification.

What does this mean to me the teacher?
- The programme of study requires pupils to be taught about smart foods
- Pupils are not required to use smart foods when designing and making their own products
- Learning about smart foods might include practical hands-on investigations and comparisons
- Smart foods form only one part of the pupils’ learning experience
- The study of smart foods can create exciting opportunities to look at new materials in food technology
- Natural links arise from this area of study for discussion of ethical, social and value issues
Aren’t all foods smart?

Many naturally occurring food ingredients appear to be smart, in that they can:
- respond to the application and removal of heat;
- react to light;
- change from one state to another, often reversibly.

Such working characteristics are already frequently exploited in food technology, e.g. colloidal systems (gels/sols). So, although arguably many naturally occurring foods could be classified as smart foods, the natural food ingredients are simply exhibiting their own working characteristics.

How can Smart Foods be used in school?

- comparison test reviewing the sensory characteristics, food chemistry and manufacturing ease of an instant dessert whip (using cold milk) compared with a traditional recipe, e.g. blancmange
- use of modified starches in experiments, e.g. chilling, freezing and syneresis
- product development using cholesterol-lowering spreads in biscuits and cereal bars
- investigation of the manufacture of cheese using chymosin, rather than rennin
- production of milkshakes and ice cream products using probiotic yogurts/drinks
- development of traditional meat-based products using meat analogues
- discussion of the ethical, moral and value issues surrounding the use of genetic modification technology in food production

Foresight - Food’s contribution to health in the future

The UK Government’s Foresight Task Force is investigating the relationship between food and health in our society. It seeks to identify opportunities for change that will improve the wellbeing of our population in the future.

Four futuristic scenarios have been generated by considering the factors that link diet and health in the UK population. These are:

**Brave world:** benefits of science have been realised in food production, telecommunications have been exploited to the full and all citizens are well educated;

**New world:** well educated population resents and resists applications of technology, e.g. biotechnology, and there is a move towards greater attention to ethical and spiritual matters;

**Lost world:** discoveries applied to food production, yet consumers are poorly educated and unable to make health-promoting, purchasing decisions;

**Stone world:** a grim place, with a divisive society controlled by famine, disease and war.

The interaction of effective communication and the adoption of science/technology defines the four worlds. The ellipse indicates the Foresight panel’s assessment of the status quo of the current UK population in 2000. The circle indicates an estimate of the position that the population could occupy in 2010. This move represents a shift towards ‘brave world’, with effective communication and adoption of technology.

Smart foods play a part in these scenarios, with elements of GM technology being prevalent in the ‘Brave World’ (where technology is adopted and communication is effective) and novel foods generating fear of the unknown (based on early disasters) resulting in ‘New World’ (technology rejected, yet communication effective) and the subsequent adoption of ‘organic food’.
Novel Molecular Structures: Ingredient Technology

The transition of food production from domestic to industrial contexts has resulted in new problems in terms of product consistency and quality. Although variation of quality would be tolerated on a domestic level, consumers expect consistently high standards in the food products that they purchase. In addition, health concerns and advances in scientific understanding have presented new possibilities in ingredient technology.

Within this booklet, novel molecular structures focuses on:
- modified starches, e.g. pre-gelatinised starch;
- fat replacers, e.g. olestra;
- sweeteners, e.g. aspartame.

Modified Starches
Starch consists of two types of glucose polymers: amylose and amylopectin. They occur together in starch granules, with approximately 20-25% usually being amylose. However, ‘waxy’ varieties of starch, e.g. maize, have very little amylose.

When gelatinised starch solutions are allowed to stand for a few hours, they begin to show changes in their rheological properties. For example, dilute solutions lose viscosity, and concentrated gels become rubbery and exude water. Both types of change are due to a phenomenon called retrogradation, which involves the amylose molecules. This is because, within the gelatinised solution, amylose acts to bind together the expanded granular structure of amylopectin molecules.

Understanding this natural phenomenon has led to the production of modified starches, which can be altered to provide consistent results, tailored to the needs of the product. Starch may be modified by physical means (e.g. heating and shearing) or chemical treatment (e.g. oxidation, derivatisation).

Modified Starch in Action

**Hot drinks and savoury sauces**
Modified starch is used to improve mouth-feel, thicken the drink/sauce with the addition of boiled water, and blend uniformly with no lumps.

**Pot Snacks**
The noodles are pre-gelatinised, so boiled water will re-heat and ‘cook’ them.

**Cook-chill meals**
Modified starch may be used to prevent syneresis, or act as a fat replacer in low-fat meals.

**French dressing**
Modified starch helps to stabilise an oil-in-water emulsion. In French dressing, the hydrophobic part of the starch wraps around the oil droplet, so the hydrophilic (water loving) part of the starch is in contact with the vinegar. This keeps the oil droplets suspended in the vinegar.
Fat Replacers

Demand for low-fat products has been driven by consumer interest in health, in general, but particularly by a concern about energy intake and, in some cases, fat. In the UK, 45% of men and 33% of women are overweight; 17% and 21%, respectively, are obese. Fat replacers can be a useful tool in reducing fat intake and can help reduce total energy intake. Examples of fat replacers are:

- Carbohydrate and protein-based
  - Modified glucose polymers
  - Modified starches, e.g. maize, potato and rice
  - Native proteins, e.g. gelatine, maize protein, whey-protein concentrate

- Lipid-based
  - Fatty acid esters of sugar or sugar alcohols
  - Medium-chain triacylglycerols
  - Emulsifiers, e.g. polyglycerol esters, lecithin.

Olestra

Olestra, marketed as Olean, has been developed as a fat substitute for use in some manufactured foods. Since it is neither digested nor absorbed by the body, it has the potential to reduce the intake of energy from fat in the diet. After 25 years of research, the US Food and Drug Administration (1996) approved olestra as a partial fat replacer.

One of the advantages of Olestra is that it is stable at high temperatures, so may be used in snack foods, for example crisps, biscuits and tortilla chips. It may also be used in place of fats and oils for frying and baking of pre-packaged savoury food products. Olestra is fortified with vitamins A, D, E and K to balance the potential reduction in intestinal absorption of these vitamins due to a non-absorbable lipid in the intestine. Olestra is not yet approved in the UK and there is no application currently pending.

Sweeteners

Sweeteners are classed as either intense or bulk. Intense sweeteners, e.g. saccharin and aspartame, are many times sweeter than sugar and so are only used in tiny amounts. This makes them suitable for use in products such as diet drinks, which are very low in energy. Bulk sweeteners, e.g. sorbitol, have a similar sweetness to sugar so are used in similar amounts. They are used in sugar-free confectionery.

What does this mean at school?

As part of Year 9 pupils’ experience with smart foods, the food technology teacher can introduce them to modified starches.

The pupils can watch demonstrations of the effects of heat, chilling, freezing and changes of pH on the physical and functional properties of a number of naturally occurring and modified starch samples. Pupils can record the results of the experiment for later use, noting signs of retrogradation (water leakage) and changes in viscosity. A discussion can be held with pupils to examine the likely use of the starch samples in different food products, e.g. cook-chill dishes, instant custard.

Pupils can prepare a range of food products that exploit modified starches during a focused practical task to record their functionality and sensory attributes. This allows the pupils to relate their experimental findings to the applications of modified starch in the food industry.
The term ‘functional foods’ is used to describe any food that contains an ingredient that gives the food health-promoting properties over and above its usual nutritional value. The term ‘functional food’ encompasses a broad range of products, ranging from foods generated around a particular functional ingredient (e.g. sterol-enriched spreads), to staple everyday foods fortified with a nutrient that would not usually be present to any great extent (e.g. folic-acid-fortified bread).

**Foods with functional ingredients**

This is a rapidly expanding area of the food industry. Two popular types of products are the cholesterol-lowering spreads and the pre- and probiotic yogurts and milk drinks.

**Cholesterol-lowering spreads**

There are a number of these new types of spreads available and, although they contain slightly different ingredients, the principles of their actions are the same. The active ingredients are plant stanol or sterol esters. Plant stanols and sterols are naturally occurring substances found in many grains such as wheat, rye and maize, and are usually present in the diet in small amounts. Plant stanols and sterols have a similar structure to cholesterol and so have the ability to inhibit the absorption of cholesterol in the gut. The cholesterol present in the intestine comes from three sources: the diet, which contributes 300-400mg per day, the bile, which typically contributes 700-1200mg, and the cells of the gut wall, whose contribution is very small. These spreads may be helpful for people with raised blood cholesterol levels, if they are used to substitute a standard spread and eaten as part of a healthy diet.

**Pre- and probiotic products**

These products are designed to improve the health of the large bowel. The probiotic products (usually fermented milk drinks and yogurts) contain live bacteria that are claimed to colonise the large bowel, improving the microbial balance and so promoting health. The history of probiotics goes back many centuries and there are many products available that contain live bacteria, but their effectiveness is governed by whether the bacteria are able to survive passage through the stomach (many cannot and do not reach the large bowel). Probiotic products have been specially designed to ensure that the bacteria reach the large bowel.

Pre-biotic products contain non-digestible ingredients that can reach the large bowel and, once there, beneficially affect the gut ecosystem by stimulating the growth and activity of healthy bacteria. However, more extensive and conclusive research is needed to validate current claims.
Fortified foods

A great many products are fortified with a range of different nutrients. In some cases, they are fortified with a nutrient that has been lost during processing, e.g. thiamin, the B vitamin that is added to white flour to bring the content back up to levels found in wholemeal flour. In other cases, a substantial amount of a nutrient is added to a staple food that would not usually contain it to any great extent, e.g. breakfast cereals fortified with iron. Nutrients added to staple foods can boost the intake of that nutrient across the whole population. Finally, some foods have nutrients added which would never normally be present, e.g. omega-3 fatty acids in eggs and calcium in orange juice.

This can be particularly advantageous for people who cut out certain foods from their diets for social, cultural or medical reasons. Omega-3 fatty acids are known to be beneficial for heart health and the best source in the diet is oily fish. Other foods contain these fatty acids but in much smaller amounts. People who do not eat meat and fish may find fortified eggs a useful way of boosting their intake. The hens’ diet is supplemented with omega-3 fatty acids resulting in the fortified egg.

Do functional foods work?

As more and more functional foods are developed and become available it is important to assess each individual food on its own merits. In particular, it is necessary that good scientific evidence exists to support the claims being made. This should include evidence that the substance is absorbed or reaches its site of action; that consumption of the food has a beneficial influence on a physiological function and that this effect has an impact on health.

The level of consumption of the food that is required to achieve the beneficial effect is also a consideration. It should be possible achieve the required level of intake of the food within a normal diet. The food should also be likely to be eaten by the people needing the benefit.

Functional foods should not be seen as magic answers to unhealthy diets and lifestyles. They can only be effective in the context of a healthy balanced diet.

What does this mean at school?

DMAs
Develop a range of products that use probiotic yogurts as their base, e.g. milkshake and ice cream.

The manufacturer of a cholesterol-lowering spread wishes to extend the use of their product into other areas. Design a range of biscuits or cereal bars that could be marketed as part of the scheme.

Discuss the need for functional food in the context of a healthy balanced diet, for example:
  Are functional foods needed?
  What are the cost implications of their use?

Investigate the origins of food fortification in the UK, for example:
  Why was it introduced?
  Which types of food products are fortified?
**Meat analogues**

Although not new, meat analogues use either naturally occurring ingredients (e.g. soya bean) or fermentation technology to manufacture a food which has been altered to perform a particular function, i.e. act as an alternative to meat.

Some people choose not to eat meat because of a variety of ethical, social and value issues and obtain all their protein from other sources. In recent years, manufacturers have produced many meat-like products, called ‘meat analogues’, which mimic the sensory properties of meat and can be used to replace or extend meat in traditional products, e.g. textured vegetable protein (TVP), myco-protein and tofu. Many of these analogues are also fortified with vitamins and minerals, e.g. vitamin B₁₂ and iron.

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### Textured Vegetable, Protein (TVP)

**What is it?**
It is composed of bundles of short fibres of extruded soya protein. The globular soya protein is gelled by heat and shear to form a fibrous structure. Plain TVP may have a ‘beany’ taste, so needs to be flavoured. Varieties of flavoured TVP are available.

**Uses**
- It is used in sausages, pies, Cornish pasties, burgers and pasta dishes.

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### Tofu

**What is it?**
It is produced from ground soya beans, which have been sieved. The proteins are coagulated, producing a soft cheese-like product. Tofu is semi-solid and is available in plain and smoked forms. As it is quite soft, it absorbs flavours well.

**Uses**
- It does not have a meaty texture, yet may be used for many dishes as a substitute for meat, e.g. in stir-fries and steamed dishes.

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### Myco-protein

**What is it?**
It is produced by fermentation of a particular organism (*Fusarium graminearum*) to produce fine fibres, which are formed together to produce a meat analogue. It has similar textural properties to meat and contains a small amount of fibre. The myco-protein undergoes forming, cutting and texturising according to the nature of the product to be made.

**Uses**
- Myco-protein absorbs flavours well and may be cooked in many different ways. It is easily formed into many different shapes, e.g. mince, burgers, fillets and sausages.

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### What does this mean at school?

Development of traditional meat based products using meat analogues.
Sensory evaluation tests between meat analogue and meat-based products, e.g. sausages.
Discussion of the ethical, moral and value issues surrounding this area of study.
Product evaluation: look at existing food products that use meat analogues in their composition.
Investigation into how a meat analogue is produced. Present findings as a flow-chart.
Encapsulation technology is applied in many industries, including food, medicines, fragrance and scratch-n-sniff products. Within food technology, encapsulation is used to:

- act as a vehicle for the addition of yeast in brewing or lactic acid starter cultures in dairy fermentation
- enhance the appearance or flavour of food through natural and artificial flavours and colours
- fortify food products with additional nutrients, e.g. functional foods
- aid preservation
- ensure consistency.

**What is encapsulation?**

Encapsulation involves the coating of a fine particle of an active core with an outer shell into small capsules. Encapsulation can be applied to any scale, although for the context of this booklet, micro-encapsulation will be dealt with, i.e. capsules ranging from 1 to 1000 micro metres (1 micro = 1,000th mm), although smaller capsules can be manufactured, which are known as nano-capsules (1 nano metre = 1,000,000th mm). Essentially, encapsulation is a barrier technology, preventing ingredients from reacting prematurely with their environment or degrading during processing or storage.

**Why encapsulate?**

Encapsulation technology can:

- achieve a controlled release of a core material, e.g. sustained release of the core material over a period of time at a constant rate
- mask the taste of a capsule’s core
- reduce the reactivity of core material, e.g. to oxygen and water
- ease the handling of the core, e.g. by prevent lumping, converting a liquid to a solid and by being easy to mix
- dilute the core material, when used in small amounts, but achieve a uniform dispersion

**How are the core materials released?**

Core materials within capsules may be released through the shell by:

- mechanical compressive force
- dissolving in liquid (e.g. flavour capsules in a powder being diluted)
- melting during baking
- breaking and opening due to the shear in a blender
- diffusing at a slow rate due to water or temperature increase

**How is encapsulation technology used in food products?**

- Jellybeans use encapsulated flavours for enhanced sensory appeal.
- Some breads use encapsulated leavening agents to prevent premature release and reaction.
- Specially formulated ‘sports bars’ are fortified with encapsulated nutrients.
Biotechnology is the use of biological processes to make or change a product, for example bread is produced using yeasts. Biotechnology processes are widely used within industry, agriculture and medicine. The aim is to improve the attributes, quantity, safety, ease of processing and production economies of food.

How does biotechnology apply to food?

Although the term, ‘biotechnology’, sounds very modern, biotechnology is not new. Traditional biotechnology has played a key role in the production of food for thousands of years. For many centuries, the process of fermentation has used micro-organisms (yeasts and bacteria) to make beer, yogurt and cheese. Bread making, beer brewing and vegetable pickling all use naturally occurring micro-organisms. For example, traditional biotechnology techniques are still used widely in the production and preservation of foods.

Desirable characteristics of plants or animals can be improved or enhanced through selective breeding. Similarly, selective breeding can be used to reduce or eliminate undesirable characteristics in plants or animals. This has applications in the production of primary food sources, such as meat and cereals. Some natural biological processes, such as ripening or fermenting, are used by different sectors of the food industry to produce everyday food products, including cheese and bread. Scientists also use biotechnology techniques to genetically modify plants or animals and control particular attributes, such as resistance to disease. This is commonly known as modern biotechnology.

What is modern biotechnology?

Traditional breeding methods involve many generations of livestock or crops, which takes considerable amounts of time for desirable traits to be achieved, e.g. cross breeding pigs to produce pork with less fat. Newer modern biotechnology techniques allow scientists to identify individual genes that control particular characteristics. The selected gene can be transferred to another plant or animal to bring about a desired change more rapidly. This technique is quicker than traditional methods and is more exact. Its primary advantage is the ability to introduce or remove selected genetic material to an existing species. However, the benefit must be carefully assessed and will be subject to rigorous safety assessment. Conventional breeding can also be used with modern biotechnology to improve varieties and will still be used where possible.

Genes, DNA and traits

All plant and animal cells contain genes, which determine their individual characteristics, e.g. the colour of a plant’s leaves. Genes are composed of specific lengths of deoxyribonucleic acid (DNA). DNA is made up from two strands intertwined in a spiral - this is known as the double helix. Each strand is made up from four nucleotide bases; the amounts of these bases vary. The bases are put together in different sequences to create a unique code. Each code carries a particular instruction which the cells follow to reproduce individual traits, e.g. height and colour.

Understanding the nature of DNA has led the way to modern biotechnology, sometimes referred to as genetic modification. Modern biotechnology allows specific sequences of DNA to be manipulated to modify the characteristics in plants and animals.
An enzyme is a protein that speeds up (catalyses) chemical reactions in physiological processes in the body (e.g. digestion) and industrial applications for food products (e.g. fermentation of wine and curdling of cheese). An enzyme acts as a catalyst, regulating the rate of chemical reaction taking place without itself being altered at the end of the process.

Enzymes are used in food production, rather than other chemical modifications, because enzymic reactions are carried out under mild temperature and pH conditions and are highly specific. They have also been used as they can help to reduce processing costs, increase yield and improve product handling, shelf-life and sensory characteristics.

Enzymes produced from Modified Organisms: Chymosin

During the 1960s, the Food and Agriculture Organisation of the United Nations predicted a shortage of calf rennin. It was anticipated that an increased demand for meat would lead to more calves being reared to maturity, and hence less rennet would be available. Work therefore started on finding an alternative.

Chymosin is produced by micro-organisms that have been modified genetically to yield an enzyme identical to that obtained from animals. Today, about 90% of the hard cheese in the UK is made using chymosin. The cheese is not made using a genetically modified organism (GMO), but rather the product of a GMO (the enzyme). Consequently, all cheeses on sale are ‘GMO free’. Like all enzymes, it is required only in very small quantities and because it is a relatively unstable protein, it breaks down as the cheese matures. The enzyme does not remain in the finished cheese.

Modified Enzymes

Advances in biotechnology have had an effect on the number and type of enzymes that are available for food use. A modified enzyme exists where the enzyme has been chemically modified to have a specific characteristic; for example, the ability to work within special pH or temperature ranges.

What does this mean at school?

Investigation of cheese manufacturing process using the internet.
Discussion of the ethical, moral and value issues surrounding the use of genetic modification technology.
Investigating the labelling requirements for GM food products.
Sources of further information

- Advisory Committee of Novel Foods and Processes
- British Nutrition Foundation
- Design and Technology Association
- Food Additives and Ingredients Association
- Food and Drink Federation
- Food Forum
- Food Ingredients On-line
- Food Product Design Magazine
- Food Standards Agency
- Foresight
- Institute of Food Research
- Institute of Food Science and Technology
- Olean (Olestra)
- John Innes Centre
- Qualifications and Curriculum Authority
- Myco-protein
- Cholesterol Lowering spreads
- Honeywill & Stein Limited
- Enzymes Services and Consultancy
- Taste of Success
- UK Food Laws by Dr D J Jukes
- UK Food Labels by Dr D J Jukes
- www.nutrition.org.uk
- www.data.org.uk
- www.faia.org.uk
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- www.proactivscience.com
- www.honeywill.co.uk/encapsulation.htm
- www.enzymes.co.uk
- www.jsainsbury.co.uk/tasteofsuccess
- www.fst.rdg.ac.uk/foodlaw
- www.fst.rdg.ac.uk/foodlaw/label/index.htm

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