In the Mix

Additives and Ingredients for Healthy Living

Over the years, the perception of food additives has been bedevilled by a lack of understanding that nutrition is a chemical process. In the Mix brings out the chemistry in familiar culinary tasks such as cake-making and shows how the use of additives is rooted in such processes as making sauces, jam, bread and wine.
How does the human body keep itself going? By taking in what it needs from the environment. That means food. But what we and the body think of as food is rather different. The body cannot digest whole food. It breaks it down into molecules of sugars and peptides which it then builds into body tissues: protein, fats, DNA and the rest. Body tissues are amazingly complicated chemical structures and they have to be made correctly or else they will not function at all.

Chemistry is the medium of life and whether the body works well or not depends on very precise chemistry. The only reason that the body prefers traditional solid food to a liquid diet of essential nutrients is that the gut has evolved as a churning machine and it needs bulk – fibre – to remain healthy.

Keeping this in mind, the debate about our diet takes on a new dimension. If, for example, instead of going through the usual digestive processes, food were broken down chemically outside the body and then swallowed, it would be taken up by the body in exactly the same way. A great deal is known about the chemistry of food and this knowledge is brought to bear in preparing food in order to improve its properties in many ways. This is where additives and ingredients come in.

In the early days of food science some visionaries went so far as to suggest that chemistry would one day provide all our essential nutrients in a palatable form, thus doing away with the need to grow food and rear animals. The distaste for messy, disease-ridden nature that some scientific nutritionists used to feel have been replaced by a veneration for all things natural and organic. But the body’s wisdom is closer to nutritionists’ vision than to that of the organic lobby. It needs the right chemicals in the right place at the right time and it really doesn’t mind how it gets them.
“In the early days of food science some visionaries went so far as to suggest that chemistry by itself would one day provide all our essential nutrients in a palatable form.”

One problem in understanding the chemical basis of food (and of life itself) is that what we know of it scientifically contradicts our subjective notions.

Everyday language leads us astray when we are dealing with the complexities of living systems. Words associated with nature are used to suggest simplicity, wholeness and purity, whereas the word chemistry suggests complexity and pollution. In fact, chemistry began with great simplicity, trying to understand what were the irreducibly pure elements in existence, such as hydrogen, oxygen and carbon. But when chemicals from living things were analysed they were found to be of bewildering complexity. Many chemists have devoted their life’s work to understanding the structure of a single molecule of life.

Scientists have discovered that out of the thousands of chemicals in living cells some have very specific functions.

Purity is not nature’s strong point: many of its apparently simple substances, like milk for example, contain hundreds of chemicals balanced in a delicate physical condition. Milk itself is a very complex emulsion of tiny fat particles suspended in a watery solution. Dissolved in the fatty particles are some vitamins, phospholipids, carotenoids and cholesterol; the watery portion contains proteins, mineral salts, milk sugar (lactose) and water-soluble vitamins.

These active chemicals are often synthesized and used instead of or alongside natural components. Citric acid, for example, the acid which gives lemons their tang, used to be extricated from lemons but is now usually made by microbiological fermentation. Citric acid is a very simple chemical – always the same whatever its source. Vanilla used to be a rare, expensive and exotic flavour extracted from the vanilla orchid, found in South America. The flavour is due in the main to a single chemical, vanillin, which was synthesized as early as 1874. So successful was the introduction of synthetic vanilla that “vanilla” is now a byword for the commonplace.

The chemical protein factory inside every cell. To function and keep the body going this intricate mechanism has to be fed with the right chemicals.
Sometimes, once a class of active compounds is recognised, similar but chemically distinct molecules are then developed which fulfil the same function but which may have enhanced properties. Particular chemical structures have particular properties, whether as antioxidants, emulsifiers, flavourings, and nature and chemist alike explore these properties in a variety of chemicals which have subtly different effects. There is no essential difference between additives of natural origin and those of purely synthetic derivation.

How the cook uses a battery of chemical reagents (better known by their more homely names) to create familiar foods

Here is a complex chemical process described step by step:

In the first stage, glyceryl esters of fatty acids are warmed to increase their plasticity, then creamed with sucrose, during which stage air particles become trapped in the mix. Phosphatidyl-ethanolamine is beaten into the matrix which is now a foam emulsion with, dispersed inside it, droplets of glyceryl esters of fatty acids and air. Amylopectin and amylose, sodium bicarbonate and the protein gluten are added. Crosslinking occurs between disulphide bonds in the gluten, creating a rubbery texture, with air trapped in the mix. When the mix is heated, the air and water particles expand, making the foam rise. Ovalbumin coagulates and stiffens the lining of the cells. Amylopectin and amylose undergo gelatinisation which further stiffens the mix. The foam expands and becomes a solid gel with a light porous texture.

This might sound like the production process for something like expanded polystyrene but it is of course baking a cake, and it is indeed as precise a physical and chemical process as the description implies. The process is rarely regarded in such a technical light simply because of its homeliness. What are these ingredients doing? Each has a distinct physicochemical function: egg yolk contains an excellent emulsifier (lecithin), flour contains gluten which is (as in flour paste) a binding agent, sugar is a preservative and sweetener. These categories of course sound like additives – and that is really what they are. All these natural homely ingredients con
tain specific chemicals and they are used to achieve a definite effect. Chemical additives grew from our knowledge of the properties of these familiar kitchen ingredients. Everyone knows that cake-making is a very precise art – a false step can result in a soggy mass rather than a light, fluffy cake. And this is how additives are used – to achieve precise effects. The notion that they are superfluous and that good food could be produced simply by omitting them is as wrong-headed as hoping to produce a good cake by throwing the ingredients together and hoping for the best.

“Everyone knows that cake-making is a very precise art – a false step can result in a soggy mass rather than a light, fluffy cake”

Chemicals have always been welcome in the kitchen – sodium bicarbonate, pectin, acetic acid . . .

Every cook is a chemist. The first chemical laboratories, back in the Middle Ages, were glorified kitchens, and many chemical processes derived from techniques of cooking. The vital technique of distillation was perfected in the course of the search for intoxicating drinks. Such chemical processes have an ancient magic and glamour.

Every kitchen contains a battery of chemical reagents, each with their specific chemical purpose – eg sodium bicarbonate, pectin, vinegar, salt – and substances that are not usually thought of as chemicals, such as milk and eggs, are actually miracle reagents which chemists would still be incapable of creating if they didn’t already exist. In many cases, ingredients that sound like chemicals are derived from natural products: lecithin is found in soya and egg, acetic acid comes from vinegar, Vitamin C is the active ingredient of lemon juice, and so on. The principle of using additives is something that every cook, expert or beginner, is familiar with every time he or she cooks.

Additives have specific purposes and the main categories are: PRESERVATIVES, ANTIOXIDANTS, EMULSIFIERS, STABILISERS, COLOURS AND FLAVOURING AGENTS

Contrary to popular myth, the number of additives used today is actually not much greater than it was 30 or 40 years ago. A high proportion of additives are natural chemicals found in foodstuffs in lim-
Limited quantities, and very few new additives have been introduced in recent decades. All additives currently in use, new ones and old ones alike, must be shown to be safe. In the EU, this is the responsibility of the European Food Safety Agency (EFSA), a body of people appointed for their independence and expertise. It also has to be shown that additives are necessary as well as safe, and a list of permitted additives, together with the foods in which they are allowed and their levels of use, is laid down in EU-wide legislation. Each permitted additive has a unique E Number – the “E” simply means that the additive is approved for use across the EU.

Preservation began with traditional processes, no less chemical for that: salt, wood smoke, resin in wines

Many foods go off quickly without preservatives and wastage of food between the field and the table is still a problem (in Russia, with its huge size and poor infrastructure it is one of the country’s main problems). Traditional preservatives have been used for centuries to combat this. Wood smoke was the first, followed by vinegar, and honey. Smoking is actually the most dubious of methods because smoke contains a large number of polycyclic hydrocarbons, some of which are known carcinogens.

All organisms require a narrow range of conditions in which to live: too acid or too sweet and nothing, not even bacteria can live (it might seem surprising that sugar is a preservative, but jam, so long as water doesn’t separate out, is far too sweet for bacteria to grow – patches of mould on jam occur where water has formed on the surface, significantly diluting the concentration of sugar). Sulphur dioxide, the most widely used preservative, has actually been in use since Classical times: in Homer we read that: “one can drive away foul odours with sulphur and fire”.

Preservatives work by preventing the growth of, or eliminating, microorganisms, some of which are exceedingly dangerous. Most of the preservatives are simple chemicals, very closely related to natural substances: benzoic acid (E210) for example, occurs in several fruits (including the Scandinavian Cloudberry which has 50 times the legal limit of benzoic acid) and it is widely used in fruit preservation. Sorbic acid (E200) is an unsaturated acid found in some plants.

“One can drive away foul odours with sulphur and fire.”
Homer, c.800BC
“There is an increasing awareness that protection against the ravages of oxygen can have a very beneficial effect on health.”

Besides being life-giving, oxygen is a potent and dangerous gas; the body uses antioxidants to protect itself

One of the most potent and dangerous gases on earth is oxygen. Surprised? Surely oxygen is the stuff of life – it is other gases like nitrogen, carbon dioxide, chlorine that are life threatening. But because oxygen is indeed the gas that powers all animals we are blind to its destructive power. The atmospheric chemist James Lovelock has said that if the oxygen content of the atmosphere were a little higher, say 25% (instead of its actual level of 21%), the earth would be consumed in an enormous uncontrollable forest fire. On a more mundane level, rusting is a graphic demonstration of what oxygen does to iron. Living systems are protected against oxidation so long as they are alive. But all foodstuffs are vulnerable to oxidation. The most familiar examples are the browning of apples or potatoes exposed to the air. The well-known remedy for this – a drop of lemon juice – demonstrates the principle of antioxidation. Lemon juice contains vitamin C (E300), a powerful antioxidant.

In fats and oils, oxidation is the prime cause of rancidity. All fats and oils will become rancid given enough exposure to air, sunlight and heat. Rancid fats are certainly unpleasant to eat and are potentially dangerous: antioxidants are used to keep fats free from rancidity for a reasonable period of time.

Lemon juice contains the antioxidant vitamin C, which prevents the browning (oxidation) of apples.

Oxygen can cause breaks in DNA (and hence the risk of cancers), it can oxidise polyunsaturated fatty acids, and this can contribute towards heart disease and strokes; and it can damage the proteins that make up much of our tissue. The proteins in the eye are particularly vulnerable because light itself assists the oxidation process.

Oxygen is dangerous to living systems in many ways.

There is increasing awareness that protection against the ravages of oxygen can have a very beneficial effect on health, and a great deal of research is currently underway. There is no doubt that increasing the intake of antioxidants has a preventative effect against both cancer and heart disease but it is not clear which antioxidants are the most effective.
Fruits and vegetables contain several antioxidants besides vitamins C and E

Typical of these antioxidants in fruits and vegetables are the flavonoids (many of which also provide colour in food), of which quercetin in onions and apples and epigallocatechin in tea are typical examples. In one study, increasing vegetable intake by at least 400 g per day resulted in a 42% reduction in the risk of coronary heart disease. A fruit currently the subject of much interest is the tomato. Its principal red pigment, lycopene, has very strong antioxidant properties and lycopene extracts from tomatoes are being developed as dietary supplements and food colours.

Oxidation reactions are also implicated in the development of diabetes, and Vitamin E has been found to have a preventative role here too. Antioxidants thus have wide-ranging life-protecting properties. Vitamins C and E are the two substances present in living creatures, including ourselves, which fulfil the antioxidant role, and which are also widely used as additives in food processing. A recent survey concluded: “vitamin C inhibits the formation of carcinogenic nitrosamines, stimulates the immune system, protects against chromosome breakage, and regenerates vitamin E as part of the antioxidant defence system”. The most common synthetic antioxidants are butylated hydroxyanisole (BHA; E320) and butylated hydroxytoluene (BHT; E321).

We all love smooth foods, and they get that way through the use of emulsifiers and stabilisers

The smoothness and homogeneity of many foodstuffs are central to their appeal. Take mayonnaise or ice cream – if we find globs of oil separating out of mayonnaise sauce or chunks of ice in ice cream, we feel something has gone wrong. But such smoothness doesn’t happen “naturally” – it is a result of the process of emulsification, in which the two great legendary incompatibles – oil and water – are persuaded to resolve their differences.

An emulsifier is a molecule in which one end is oil-friendly and the other water-friendly. In this way droplets of oil are surrounded by the emulsifier molecule, with the oil core hidden by the water-friendly tails of the emulsifier. Many living systems use emulsifiers, because...
Life itself is a mixture of oil and water. The classic emulsion is milk, a complex mixture of fat droplets suspended in a watery solution. Nature’s emulsifiers are proteins and phospholipids. The word lipid means fat. In a phospholipid the phosphate end of the molecule is water-soluble and the lipid end fat-soluble.

As with many food additives, the emulsifiers used in food production are sometimes purified natural products and sometimes synthetic chemicals.

In cooking, one of the most versatile emulsifiers is egg phospholipid (lecithin). In many sauces, such as mayonnaise or béarnaise sauce, it is egg yolk that does the binding and homogenisation. The humble ice cream is actually one of the most complex foods we encounter – both a foam and an emulsion – and it could not exist without emulsifiers.

The naturals and synthetics have very similar structures. Typical emulsifiers are lecithins (E322) (mixtures of phospholipids, e.g., phosphatidylcholine and phosphatidylethanolamine, usually from soya), alginates (E400-4) (derived from seaweed), mono- and di-glycerides of fatty acids (E471), and esters of monoglycerides of fatty acids (E472a-f).

It isn’t only creamy sauces that use emulsifiers. Bread and other baked products, in which solid particles are dispersed in an airy foam, are enhanced by emulsifiers. Bread, for example, would stale very quickly without emulsifiers.

At many stages before it reaches the lips food needs to keep flowing.

The physical properties of food – how it handles – are increasingly important in the world of fast food. Coffee in vending machines, non-dairy creamers, toppings, all need to flow freely and not to agglomerate. Naturally many foods tend to stick together when left and specific agents are needed to prevent this. Many anti-caking agents are natural products such as talc (E533b) and bentonite (E558), and some are manufactured, such as silicon dioxide (E551) (chemically the same as sand but much purer), calcium silicate (E552) and sodium aluminosilicate (E554).
Texture – important both for the feel of food and its digestion – is maintained by thickening and stabilising agents

Thickening and stabilising agents are gums that help to maintain the texture of many water-based foods. Technically, gums are not quite what the term usually implies in everyday use: they are thick and viscous but they are not usually tacky.

Gums come from a range of sources. Many are substances exuded from plants (gum arabic, locust bean gum), whilst others are derived from seaweeds (carrageenan and alginates), and many more are derived from cellulose by chemical modification. Yet another category is produced by microbiological fermentation – these include gellan gum and xanthan gum.

All gums are polysaccharides – that is they are related to sugars but with many sugar units making up a large molecule. This large, cage-like structure is responsible for the thickness of gums when mixed with water. The molecule has groups with affinity for water but the large lattice structure prevents the total solution that occurs with simple sugars – the result is a gel.

The gums are bland – generally odourless, tasteless and of no energy value. They do though have a nutritional function besides their mechanical and cosmetic ones: in digestion they function as fibre, easing bowel function, and some are used as laxatives.

We need colour in food because all the senses contribute to the experience of eating

The impression food makes on us is a blend of sensations, and colour and surface appearance are amongst the most important. Many of the great experiences in life involve a mix of sensations. In some cuisines, colour has played a more important part than others – Indian food, for example, with its saffron-coloured rice and the lurid red of tandoori chicken, is very colourful. Often we associate such colours
with strong flavours when in fact what produces the colour and the flavour are entirely distinct.

Colouring agents are sometimes added to foods that are unlikely to reach supermarket shelves with their colour at its peak. Examples include canned foods, such as peas and strawberries, which would be khaki and dull brown, respectively, without added colour.

Natural colours are, in the main, extracted from plants but are nonetheless chemical entities. They are present at low levels in plants but still impart intense colour, for example in the red skin of a ripe apple. Extracting such colours from plants is often not practical or economic and so synthetic colours are often used instead. These are generally more intense in colouring action than natural colours and hence are used in very small concentrations: generally in the 0.0001% to 0.005% range.

The main trend in food colours is towards the use of flavonoid colours. Flavonoids are the principle type of pigment employed by nature in flowers and fruits. At present they are mainly consumed in foods which naturally contain them, such as red wine, but they will increasingly be consumed as additives which have been extracted from one plant source and used to colour totally different foods. There is also some evidence that flavonoids have beneficial health properties. They have antioxidant properties and contribute to the positive health effects of red wine. Other sources of flavonoids, besides red grapes, are elderberries, red cabbage, blood orange, the less familiar black chokeberry, and the sweet potato.

The challenge for food chemists is to find colours that are safe to use in food. It isn’t enough to say: use natural colours

The principal natural colours, most of which, in refined form, are used as additives, are the green pigment chlorophyll, the carotenoids, which give yellow to red colours, and the flavonoids, which give flowers and fruits their red to blue colours. Increasingly, food additive colours are based on flavonoids derived from sources such as red grapes or beet but the first additive colours were synthetic dyes.

When synthetic dyes were discovered (mauve was the first, discovered in 1856 by the English chemist William Perkin) they were initially used in textiles, but by 1900 eighty chemical dyes were used in food in the USA. Many of these dyes were originally derived from coal-tar, and were commonly called "coal-tar dyes". The term is still sometimes used but they are no longer made from this source. They are strictly called azo dyes after the azo chemical grouping they all contain. A few well-tested azo dyes are used in foods.

All permitted colours, be they natural or synthetic, are checked for safety before they can be used in food. In the EU, this is the responsibility of the European Food Safety Agency (EFSA).
In truth there are only really five flavours: sweet, sour, bitter, salt and savoury. What we call flavour is mostly odour.

Flavour is the essence of food, and flavour chemistry one of the most fascinating studies. Many flavours are the result of combinations of dozens of chemicals: for example, more than 350 volatile flavour compounds have been identified in grape juice. Each chemical adds a distinctive “note” to the flavour, such as “rosy”, “candy”, “caramel nutty”. Flavour chemists have identified 16 principal flavour “notes”. Some flavours are essentially one chemical, such as vanilla, already mentioned. Some flavourings contain highly pungent materials. Others contain naturally occurring components whose use as additives, in the pure form, is restricted. An example of this is safrole, which is found in a range of products, including nutmeg.

Many of our favourite flavours are the result of specific chemical processes: fermentation (cheese, yogurt, alcoholic drinks) or roasting and frying (meat, chocolate, toast, coffee, deep-fat-fried food). Fermentation, roasting and toasting create specific chemical reactions in the foods, and the chemicals concerned have been identified. The sweet caramelly taste of fried onions for example, or gravy, or the crackling on pork can be traced to a single process – the browning reaction – discovered by a French chemist, L. C. Maillard, in 1912. This process involves a chemical reaction between proteins and carbohydrates. Variations on the browning reaction produce many of the most delicious flavours: chemicals associated with particular flavours have been identified: methyl pyrazines gives a roasted nutlike flavour; methoxypyrazines earthy vegetables; 2-isobutyl-3 methoxypyrazine gives green pepper, and acetyl-l-pyrazines popcorn; 2-acetoxy pyrazine produces toasted flavours.

“Many of our favourite flavours are the result of specific chemical processes.”

Ours is a sweet-tooth society but sugar isn’t the only way of satisfying it.

There are several natural sugars. The common granulated sugar is sucrose, a combination of the two simpler sugars: glucose and fructose. Lactose, milk sugar, consists of glucose and galactose, whilst maltose, produced by the malting of barley, is a combination of two molecules of glucose.
Sugar has the dual attraction of providing quick energy and of being sweet. It is not surprising that sugar consumption has increased dramatically in all societies that have reached a certain stage of development. Sugars provide about 20% of the energy intake in the USA. But there are problems with sugar: over consumption is implicated in obesity and diabetes, so sweeteners with no energy content are obviously desirable in many foods.

Intense sweeteners are many times sweeter than natural sugars and have no energy content whatsoever

Intense sweeteners currently used are acesulfame K (130 times as sweet as sucrose: E950), aspartame (200 times as sweet as sucrose: E951), saccharin (300 times as sweet as sucrose: E954), sucralose (600 times as sweet as sucrose: E955), neohesperidine dihydrochalcone (400-600 times as sweet as sucrose: E959), and thaumatin (2-3000 times as sweet as sucrose: E957). They are used in drinks, yogurt and other desserts.

All sweeteners have been extensively tested. Aspartame and sucralose were both tested for well over a decade before being approved. Aspartame contains the amino acid phenylalanine and a very few people who have the hereditary disease phenylketonuria cannot metabolise phenylalanine. Therefore products containing aspartame have to have a label warning against such use.

Some new sweeteners are still being developed. Alitame is derived from the nutrient amino acids aspartic acid, alanine and an amide component. It is 2000 times sweeter than sucrose.

Bulk sweeteners are less concentrated and are similar in sweetening power to natural sugars; in fact they are derived from them by hydrogenation. Such sweeteners – maltitol (80% sucrose sweetness: E965), xylitol (equivalent to sucrose sweetness: E967), and lactitol (35% sucrose sweetness: E966) – do not require insulin to metabolize them and can thus be used by diabetics. Studies have been made on the diet of young people and their intake of non-sugar sweeteners. Young people are the group most likely to consume more of the foods that contain these additives. The studies show that the acceptable daily intake is not exceeded even in this group.
We like zest in food, especially in drinks; acids do the trick

Sharpness of taste is always due to acids. The classic examples are cola drinks where, besides the carbon dioxide which produces the actual fizz, phosphoric acid (E338) gives the sharpness. All fruits contain varying degrees of sugar but without their characteristic acids – citric in lemons, malic in apples, tartaric in grapes etc – they would be sickly and dull. The word acid does not have particularly friendly connotations, but acids of one kind or another are a major component of natural foods. The acids that are added to food are made by microbial fermentation and are chemically identical to the natural acids found in fruits (phosphoric acid is the exception, being a mineral acid, not found in nature in the free state).

Besides imparting sharpness, acids are used because the overall acidity of foods can be crucial. In jam-making for example the acidity of the fruit determines its setting properties. Acids also have preservative and antioxidant properties.

Some food ingredients are “modified” to produce certain desirable properties – this does not imply genetic modification

The word “modified” has acquired notoriety thanks to genetically modified food but food ingredients have been "modified" in various non-genetic ways for a very long time. The most common term used is the term "modified starch" which is starch that has been modified to withstand heat and acids. Another form of modification allows the starch to form a paste with cold water (standard starch needs hot water) and this is used in instant foods such as desserts, mousses, toppings and whips.

There is sometimes a suspicion of anything modified, as if most foods weren’t modified by definition. Cream, butter and cheese are modified milk, but when the term “milk solids” appears on labels it is sometimes viewed with suspicion. Butter is milk solids, separated out from the milk and, even in the most traditional way of making, subjected to an industrial process. Bread is a wholly unnatural substance conjured into being by an entirely human-devised industrial process.
If genetically modified crops were to enter the food chain, might additives derived from such crops be in any way different from non-GM additives? There is no reason to suppose that they would. All additives and ingredients have a particular chemical composition, as we have stressed in this booklet: unless a genetic modification was specifically designed to alter a particular chemical structure there would be no change in the additive or ingredient extracted from the GM crop.

**As our knowledge of biology grows we are beginning to learn more about specific interactions between foods and our body’s biochemical systems**

“Functional foods” have emerged in the last ten years. But what are functional foods? They have been defined by the US Institute of Medicine as “Any modified food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains”. So it might be a bacterial culture that helps to maintain a healthy gut, or a cholesterol-lowering margarine, or high fibre cereals which protect against degenerative disease such as diabetes, or drinks fortified with cranberry juice, which has antioxidant properties.

Functional foods are the product of our growing understanding of body chemistry. As the precise chemical nature of food and our bodies’ requirements become known foods can be tailored to fit – designer foods, if you like – that make a better match than was ever possible in the old hit and miss days when all we had to go on was folk wisdom such as “a little of what you fancy does you good”.

**Very many natural foodstuffs contain dangerous toxins; traditional food preparation techniques and additives minimize the dangers**

Everyone knows about poisonous plants – deadly nightshade, foxgloves, hemlock – but the sheer scale of chemical warfare waged by natural creatures, both plant and animal comes as a surprise. Even in Britain, a high proportion of the common plants is poisonous to a greater or lesser degree. The reason is that poison is a countermeasure in the struggle for life. Plants are poisonous to prevent them being eaten and the reason more people aren’t poisoned is that most

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**Some Natural Toxins in Foods**

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<tr>
<th>Food</th>
<th>Toxin and Effect</th>
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<tbody>
<tr>
<td>Almonds, tapioca, Lima beans</td>
<td>Cyanide: interferes with tissue respiration</td>
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<tr>
<td>Bananas</td>
<td>5-hydroxytryptamine: causes hallucinations</td>
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<tr>
<td>Cabbages and other brassicas</td>
<td>Goitrogens: cause thyroid damage</td>
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<tr>
<td>Celery, parsley, parsnips, peas</td>
<td>Psoralens: with UV light cause mutations</td>
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<tr>
<td>Cheeses, yeast extract, wines</td>
<td>Tyramine: causes high blood pressure; migraine</td>
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<tr>
<td>Green potatoes</td>
<td>Solanines: cause gastro-enteritis</td>
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<tr>
<td>Mustard</td>
<td>Sanguinarine: causes dropsy</td>
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<tr>
<td>Nutmeg</td>
<td>Myristicin: causes hallucinations</td>
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<tr>
<td>Rhubarb</td>
<td>Oxalic acid: removes calcium from blood</td>
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<tr>
<td>Shell-fish</td>
<td>Arsenic: causes vomiting and diarrhoea</td>
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poisonous plants taste very bad. The range of potential toxins in nature is wide: from rhododendron-flower honey to the highly toxic fugu, the liver of the blow fish which contains a poison so deadly it has been said that “the element of risk in eating fugu may be one of the reasons why the dish is so popular with Japanese gourmets”.

Besides these natural toxins, there are of course the hazards of microbial contamination – in fact the worst danger lurking in food. Toxins produced by fungal and bacterial growth on foodstuffs caused devastation in years gone by: ergot, which used to grow on rye, is a powerful hallucinogen; aflatoxin, a potent carcinogen produced by an Aspergillus fungus, is still sometimes found in food such as peanuts.

Sensitivity to a wide variety of substances – most of them natural – does sometimes occur but bad reactions to additives are rare

The fact that some susceptible people react badly to certain foods is a centuries-old phenomenon, acknowledged in the saying “One man’s meat is another man’s poison”. Very many substances produce adverse reactions in susceptible individuals: grass pollen is probably the most widespread, causing hay fever. Shellfish are notorious, and in recent years intolerance to nuts has become widely noticed, with even the low-level contamination of other products by nut fragments causing problems in some individuals. In this context, intolerance to some additives by a few individuals is inevitable.

It is difficult to obtain reliable figures on the incidence of intolerance to additives and a link with hyperactivity but some things are clear. People who are severely allergic, eg asthmatics, hay fever and urticaria sufferers, sometimes suffer intolerance to some additives. But this is a part of a general problem. The additives have not created their condition. In a study conducted by questionnaire in the UK, 7% of those responding claimed that they reacted badly to food additives, but in follow-up tests only 1-23 in 10,000 (0.01-0.23%) proved to be intolerant to additives. The same UK study showed that about 1 in 70 people reacted badly to a number of common foods, including cow’s milk, hen’s eggs, wheat, soya, oranges, prawns and nuts. In other words, intolerance to everyday foods is much more widespread than intolerance to additives.

“All things are poisons; nothing is without poison; only the dose determines whether there is a harmful effect.”
Paracelsus, 16th C
It is worth distinguishing between allergic and other reactions

Allergy involves the body’s immune system and to trigger a response requires a large biological molecule such as a protein. Hay fever involves grass pollen and is a true allergy. Reactions to food such as cows’ milk, eggs, shellfish and nuts are allergic reactions. Additives, however, are small chemical molecules and as such are incapable of causing immune reactions. But chemicals naturally present in foods can still cause toxic reactions. Some chemicals found in natural food-stuffs are commonly implicated in intolerant reactions: one of the most common is tyramine, present in cheese, chocolate, some wines etc. The problem is caused by the lack of an enzyme needed to process the chemical normally. Tyramine can cause migraine in susceptible persons and is responsible for the phenomenon of copious dreaming following such foods eaten just before going to bed.

Living systems are the most complex systems in the universe, dwarfing human hi-tech achievements

It is not surprising that the question of what makes for a healthy diet should not be as simple as we’d like it to be. But some things are clear: the basis of life and nutrition is chemical and there is no one obviously natural diet. A better understanding of specific interactions between food and our bodies will enable all our foods to be more functionally efficient, and that means better additives and ingredients.
The Food Additives and Ingredients Association is affiliated to the Chemical Industries Association and represents key UK companies whose principal business is the manufacture and marketing of food additives and ingredients. The organization promotes better awareness of the role additives play in modern food. Initiatives have included the educational project Understanding Food Additives (2005), produced in collaboration with the University of York's Chemical Industry Education Centre.