1. FOOD ADDITIVES AND WHY THEY ARE USED (reprinted from www.rsc.org)

Introduction

The role of food additives in food manufacture has been much maligned and misunderstood in recent years. Additives fell victim to bad press to the extent that, at the height of the anti-"E" numbers campaign in the 1980s, the word "additive" became almost synonymous with "adulteration", and foods containing additives were as much to be avoided as foods containing genetically modified ingredients have become since their introduction in the late 1990s. Authors whose main objective appeared to be the denigration of the food manufacturing industry, particularly the major multinationals, found this easy meat in an atmosphere of consumer ignorance, and were guaranteed support for their cause by scaring their audience into believing that additives were responsible for a wide range of ill effects from intolerance and hyperactivity to long-term chronic diseases. Constantly prefacing the words "food additive" with "chemical" was sufficiently emotive to result in the perception of "nasty". Alongside this was the implication that ready-prepared, processed food was inherently inferior to, and less wholesome than food prepared in the home.

The catalyst for the 1980s focus on additives was a change in labelling legislation in 1986, which required the detailing of each individual additive in the ingredients list of most pre-packed products. Until that time, the use of additives had been indicated by reference to a generic functional group, such as "preservatives", "antioxidants" and "colours". The new labelling requirements resulted in the appearance on some food labels of some very long lists of additives, including some lengthy chemical names. Some products looked as though they were nothing more than a couple of simple ingredients held together by a dictionary of chemical substances. The "E" number system, intended to assist as a short code for some of the lengthier chemical names and to indicate common European safety approval, became the butt of the criticism against the use of additives, and consumers voted with their feet by leaving products containing long lists of "E" numbers on the shelf.

The interest in, and fear of, what was being put into food spawned a number of books on additives, their use in food, potential (harmful) effects and protocols for their safety approval, along with the author's specific treatise on the subject. Some were informative, intended to assist the consumer in understanding what additives were, how they were produced, why they were used and how to avoid them, if desired. Others were more politically motivated and used the fashionable attack on additives as an illustration of all that was bad about the food industry and the allegedly secretive systems of safety assessment of all chemicals

and processes used in food production. The implication was that any chemicals added to food, either as pesticides in primary production or additives in processing, were suspect.

A generation brought up on convenience foods, removed from the messy business of primary food production, fell easy prey to this suggestion, apparently oblivious to the substances and techniques employed by their grandmothers, when no self-respecting household would have been without baking powder, bicarbonate of soda, cream of tartar, a selection of flavourings and a bottle of cochineal – some of the most common everyday "food additives". These everyday ingredients might well be frowned upon by many a modern shopper uninitiated in the art of cookery, if spotted on the ingredients label of a manufactured product in the form of an "E number" or prefaced, as legislation requires, by its additive class. How many people think of additives when they buy a lemon or a bottle of vinegar? Yet these too are authorised additives (as citric and acetic acid, respectively) and widely used in food manufacture for their preservation properties, as well as their acidic taste, precisely as they are used in everyday cooking. The use of saltpetre as a preservative can be traced back to Roman times, and the controversy over additives use goes back to at least 1925, when the use of boric acid in food was banned under the Preservatives Regulations. However, in recent years the use of boric acid has been accepted under the Miscellaneous Food Additives Regulations 1995 as amended, but only for the treatment of caviar.

Whilst its complexity and scale do not lend modern food manufacture entirely to direct comparison with the traditional kitchen, it is often forgotten that the overall purpose is the same – to prepare, preserve, process and, as the case may be, cook basic raw ingredients to convert them into wholesome, attractive, better tasting and nutritious food, ready to be consumed. Every cook has his or her own techniques, and knows many a trick to prevent peeled vegetables and apples from browning, thicken sauces, brown the gravy, and transform an everyday dish into something special; he or she will also ease dinner party preparations by preparing in advance and storing the part-ready dishes for last-minute completion. Food manufacturers do much the same, and, over years of product development, first on the basis of trial and error and now underpinned by research programmes, have developed the most effective and economical methods of producing a wide range of foods to suit every taste and pocket. In order to achieve this, they need at their disposal a wide range of additives to perform a number of tasks in the process, from cleaning and refining the raw materials, to preserving them in optimal condition throughout further processing or distribution, combining them with other ingredients and ensuring that they

appear attractive to the consumer. The types of additive used and some of the functions they perform are explored in greater detail below.

The anti-additives campaign and consequent consumer pressure to remove or minimise the use of additives inevitably led to changes in manufacturing practice and marketing. In addition, trends towards more "fresh" foods and the growth in market share of chilled foods, together with changes in legislation following completion of the European harmonisation exercise, all had an impact on the use of additives. It is therefore timely to review the place and use of additives in the food supply, whilst bearing in mind that they will always be essential to food preparation, quality and preservation.

What are Food Additives and why are they Used?

The use of food additives is nothing new. Preserving food is an age-old necessity. Many of the techniques that we now take for granted, such as canning, refrigeration and freezing, are relatively new. Even the overwintering of farm animals was rare until the 17th century, when feeding and husbandry techniques became better understood. Any old or weakly livestock such as oxen, cows, sheep, pigs and poultry had to be slaughtered in the autumn, and the meat was dried, salted or pickled to preserve it for the winter months (1). When food shortage ceases to be a problem, greater emphasis is placed on making food look and taste good, and we look beyond food as a survival necessity to food as a pleasure and a treat.

Food additives are used either to facilitate or complement a wide variety of production methods in the modern food supply. Their two most basic functions are that they either make food safer by preserving it from bacteria and preventing oxidation and other chemical changes, or they make food look or taste better or feel more pleasing in the mouth.

The use of additives in food preservation is, not surprisingly, one of the oldest traditions. Our forbears may not have thought of saltpetre, used as a curing agent, or vinegar (acetic acid) as additives, but they would have been the mainstay for ensuring a longer-term supply of precious perishable foods. Salt, though not an additive by the modern definition, was the other essential.

Food additives are defined in European legislation as "any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food, whether or not it has nutritive value, the intentional addition of which to a food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods" (2).

Known as the additives "framework" Directive, this Directive also defines processing aids as "any substance not consumed as a food ingredient by itself, intentionally used in the processing of raw materials, foods or their ingredients, to fulfil a certain technological purpose during treatment or processing, and which may result in the unintentional but technically unavoidable presence of residues of the substance or its derivatives in the final product, provided that these residues do not present any health risk and do not have any technological effect on the finished product."

Processing aids

Whilst many of the substances used as additives may also be used as processing aids, the latter function is outside the scope of additives legislation. The differentiating criterion, and the question that any manufacturer must ask in terms of regulatory requirements, is "does it continue to function in the final food?" So, for example, sulphur dioxide (E220) may be used to prevent discoloration of fruit destined for pie making, but would have no effect in the fruit pie itself, and indeed would be cooked off during processing. Thus, in this application, it is a processing aid used in the making of a fruit pie, not an additive performing a function in the pie itself. Many of us will be used to similar techniques in the kitchen, such as using lemon juice to prevent discoloration. In the complex world of food manufacture, where production is increasingly specialised and expertise focused at specific sites, it is not unusual for the manufacturer of an end product to buy in many of his supplies as part-processed proprietary ingredients. So additives may be needed at the "intermediate" stage, but would have no function in the final product, and would therefore not appear on the label, unless considered to have the potential to cause an allergenic reaction (see Chapter 2). Thus, anti-caking agents may be required in dry ingredients to prevent them from turning lumpy before being made into a fancy cake, but will have no effect once the cake is baked and decorated, so the anti-caking agent functions as an additive in the dry mix, but is a processing aid as far as the cake is concerned. Other examples of processing aids are release agents used to prevent food from sticking to a mould or, perhaps, slicing equipment. Again, this is part of the process of production, not the composition of the food, even though there may be traces of the "processing aid" left on the product, as there would be on a cake from greasing the cake tin. This, then, is the essential technical difference between a processing aid and an additive.

The "framework" Directive identifies a number of classes of additives, e.g. sweeteners, colours and "miscellaneous" additives (including additive categories such as preservatives, antioxidants, emulsifiers, stabilisers, thickeners,

flavour enhancers etc.), for which more detailed legislation was eventually developed, and lays down general criteria for their use, notably that technological need must be demonstrated that cannot be achieved by other means; that their presence presents no hazard to the consumer; and that they do not mislead the consumer. Their use may be considered only where there is demonstrable benefit to the consumer, namely to preserve the nutritional quality of the food; to provide necessary ingredients or constituents for foods manufactured for groups of consumers with special dietary needs, or to enhance the keeping quality or stability of a food or to improve its organoleptic properties, provided that, in doing so, it does not deceive the consumer; and to assist in manufacture, processing, preparation, treatment, packing, transport or storage of food, provided that the additive is not used to disguise the effects of the use of faulty raw materials or of undesirable (including unhygienic) practices or techniques during the course of any of these activities. These are similar to the principles enshrined in the Codex Alimentarius, the joint FAO/WHO body responsible for international standards in food.

The harmonisation of European legislation was a prerequisite for trade in the Single Market as differences in national legislation constituted barriers to trade. This is explored in greater detail in a later chapter, but it is important to appreciate that the development of a new raft of additives legislation in the late 1980s and through the 1990s was not indicative of an absence of controls before that time, but a recognition that differences in national approaches throughout the Member States were not conducive to the free movement of goods within a single economic entity. The new legislation reinforced the requirement for justification of a case of need in the use of additives and of the importance of not deceiving the consumer.

The primary aim of the food-manufacturing industry is to provide a wide range of safe, wholesome, nutritious and attractive products at affordable prices all year round in order to meet consumer requirements for quality, convenience and variety. It would be impossible to do this without the use of food additives. They are essential in the battery of tools used by the food manufacturer to convert agricultural raw materials into products that are safe, stable, of consistent quality and readily prepared and consumed.

Different types of additive are used for different purposes, though many individual additives perform more than one function. For the purposes of both classification and regulation, they are grouped according to their primary function. The main groupings, or classes, of additives are explained below, together with their functions and some examples of their use.

Preservatives

Preservatives are probably the single most important class of additives, as they play an important role in the safety of the food supply. Despite this fact, any chemical used to counteract the perishability of food raw materials has often become perceived as suspect, and any food containing a preservative has been considered inferior or unsafe. Yet the use of chemical preservatives, such as sulphur dioxide and sulphites, is but a continuation of the age-old practices of using salt, sulphite and spices to preserve perishable foods in the days before refrigeration and modern processing techniques. All food raw materials are subject to biochemical processes and microbiological action, which limit their keeping qualities. Preservatives are used to extend the shelf-life of certain products and ensure their safety through that extended period. Most importantly, they retard bacterial degradation, which can lead to the production of toxins and cause food poisoning. Thus they offer a clear consumer benefit in keeping food safe over the shelf-life of the product, which itself may be extended by their use and thus meet the demands of modern lifestyles, including infrequent bulk shopping expeditions. The continued perception of preservatives as undesirable, to which the many labels protesting "no artificial preservatives" testify, is therefore an unfortunate consumer misapprehension.

Antioxidants

Antioxidants reduce the oxidative deterioration that leads to rancidity, loss of flavour, colour and nutritive value of foodstuffs. Fats, oils, flavouring substances, vitamins and colours can all oxidise spontaneously with oxygen when exposed to air. The rate of deterioration can vary considerably and is influenced by the presence of natural antioxidants and other components, availability of oxygen, and sensitivity of the substance to oxidation, temperature and light, for example. Oxidation can be avoided, or retarded, by a number of means, such as replacing air by inert packaging gases, removal of oxygen with glucose oxidase, incorporation of UV-absorbing substances in transparent packaging materials, cooling, and use of sequestering agents. These may not be possible in all cases, or sufficient for an adequate shelf-life for some foods. Thus antioxidants are used to retard oxidative deterioration and extend shelf-life. Some antioxidants actually remove oxygen by self-oxidation, e.g. ascorbic acid, whilst others interfere in the mechanism of oxidation, e.g. tocopherols, gallic acid esters, BHA and BHT. All have specific properties, making them more effective in some applications than in others. Often a combination of two or more antioxidants is more effective than any one used simply because of their synergistic effects. The presence of

sequestering agents, such as citric acid, may also have a synergistic effect, by reducing the availability of metallic ions that may catalyse oxidation reactions. The use of the powerful synthetic antioxidants BHA, BHT and the gallic acid esters is very restricted. Tocopherols, which can be either natural or synthetic, are less restricted but are less effective in the protection of processed foods. Antioxidants cannot restore oxidised food; they can only retard the oxidation process. As oxidation is a chain reaction process, it needs to be retarded as early as possible. The most effective use of antioxidants is therefore in the fats and oils used in the manufacturing process.

Emulsifiers and stabilisers

The purpose of emulsifiers and stabilisers is to facilitate the mixing together of ingredients that normally would not mix, namely fat and water. This mixing of the aqueous and lipid phases is then maintained by stabilisers. These additives are essential in the production of mayonnaise, chocolate products and fat spreads, for example. The manufacture of fat spreads (reduced-fat substitutes for butter and margarine), has made a significant contribution to consumer choice and dietary change, and would not be possible without the use of emulsifiers and stabilisers. Other reduced- and low-fat versions of a number of products are similarly dependent on this technology. Anyone who has ever made an emulsified sauce, such as mayonnaise or hollandaise, will appreciate the benefits of this technology – still more so those who have failed miserably in the technique and ended up with an expensive mess of curdled ingredients!

In addition to this function, the term stabiliser is also used for substances that can stabilise, retain or intensify an existing colour of a foodstuff and substances that increase the binding capacity of the food to allow the binding of food pieces into reconstituted food.

The increasing awareness of problems with food allergy and intolerance has led to the requirement to state the source of certain emulsifiers on food labelling. For example, lecithin derived from soya is not suitable for an individual with an allergy to soya, therefore clear labelling of the source of the ingredient is vital to aid in consumer choice of products safe for individuals with specific dietary requirements (see Chapter 2).

Colours

Colours are used to enhance the visual properties of foods. Their use is particularly controversial, partly because colour is perceived by some as a means of deceiving the consumer about the nature of the food, but also because some of

the most brightly coloured products are those aimed at children. As with all additives, their use is strictly controlled and permitted only where a case of need is proven, e.g. to restore colour that is lost in processing, such as in canning or heat treatment; to ensure consistency of colour; and for visual decoration. The use of colour in food has a long and noble tradition in the UK. Medieval cooks were particularly fond of it. The brilliant yellow of saffron (from which Saffron Walden derives its name) and the reddish hue of saunders (powdered sandalwood) were used along with green spinach and parsley juice to colour soups in stripes or to give marbleised effects (1). So, whilst adding colour to food may appear to some to be an unnecessary cosmetic, which is not in the consumer's interests, there can be no doubt that the judicious use of colour enhances the attractiveness of many foods. Some retailers tried introducing ranges of canned vegetables and fruits such as strawberries and peas without adding back the colour leached out by heat processing. They were still trying to dispose of the unsold returns several years later! Colour is important in consumer perception of food and often denotes a specific flavour. Thus, strawberry flavour is expected to be red and orange flavour orange-coloured. Consumer expectation is therefore a legitimate reason for adding colour.

Food colourings, in particular, have long been the scapegoat in the popular press for behaviour problems in children. It has been over 30 years since Feingold suggested that artificial food colours and preservatives had a detrimental effect on the behaviour of children (3).

Since then, research into the effect of colours and preservatives in foods on children's behaviour has added fuel to the fire of negative consumer perception of these additives, particularly in products aimed specifically at this age group (4). Significant changes were found in the hyperactivity behaviour of children by removing colorants and preservatives from the diet. There was no gender difference in this result and the reduction of hyperactivity was independent of whether the child was initially extremely hyperactive, or not hyperactive at all. More recently in 2007, a study on the effect of two mixtures of certain artificial food colours together with the preservative sodium benzoate showed an adverse effect on the hyperactive behaviour of children in some age groups in comparison with a placebo, although the increases in the levels of children's hyperactive behaviour were not consistently significant for the 2 mixtures or in the 2 age groups (5). The findings of this new study replicate and extend the findings from an earlier study in preschool children in 2004 (6). The colours used in this study are already included in work of the European Food Safety Authority (EFSA) on the re-evaluation of colours.

Colouring Foodstuffs

The term 'colouring foodstuffs' has been adopted for colourings that are derived from recognised foods and processed in such a way that the essential characteristics of the food from which they have been derived are maintained.

This is a different situation to natural colours that are regarded as additives where the pigment is selectively extracted and concentrated.

A colouring foodstuff can be declared as an ingredient on the label without a requirement for its function to be listed, as legislation only requires this of additives.

These colouring foodstuffs include bright yellow colours derived from turmeric, oleoresin and safflower; golden yellow to natural orange colours from carrots and paprika; toffee brown colour from caramelised sugar syrup; green colours from spinach leaves and stinging nettles, both rich in chlorophylls; and red, blue and purple colour from concentrates of red and blue fruits, red cabbage and beetroot, rich in anthocyanins.

It is clear that the full spectrum of colour shades is achievable using colouring foodstuffs, although developers should ensure that the colouring foodstuff exhibits the same stability and vibrancy of colour in the final application as a conventional food colouring would.

Sweeteners

Sweeteners perform an obvious function. They come in two basic types – “bulk” and “intense”, and are permitted in foods that are either energy-reduced or have no added sugar. They are also sold direct to consumers as “table-top” sweeteners – well-known to dieters and diabetics. For example the table top sweetener Sunette contains acesulfame-K while Splenda contains sucralose. Intense sweeteners, such as aspartame, saccharin, acesulfame-K and sucralose have, as their name suggests, a very high sweetening property, variable from type to type but generally several magnitudes greater than that of sucrose. (For example, aspartame is approximately 200 times sweeter than sugar, weight for weight; saccharin 300–500 times; and acesulfame-K 130–200 times.) Bulk sweeteners, where the majority are polyols, including erythritol, sorbitol, isomalt and lactitol are less sweet, but provide volume and hence mouthfeel. Amongst the polyols, maltitol is one of the sweetest and xylitol, which is the sweetest, has the same sweetness intensity as sucrose. Due to the reduced sweetness characteristics of the majority of polyols, it is possible to blend them with other polyols or with intense sweeteners to improve the sweetness and taste quality. This property is known as sweetness synergy. Another benefit is the ability to mask the undesired bitter

metallic aftertaste of some intense sweeteners. Commonly used combinations include, saccharin with cyclamate, acesulfame-K with aspartame, erythritol with acesulfame-K and there are many more. Both types of sweetener (bulk or intense) are useful in low-calorie products, and are increasingly sought after by many consumers, and for special dietary products such as for diabetics. The absence of sucrose also lowers the cariogenic properties of the product.

Flavour enhancers

This is a group of additives that has attracted adverse attention, in particular monosodium glutamate (MSG:E621), which is widely blamed for an intolerance reaction that became known as "Chinese Restaurant Syndrome".

Flavour enhancers are substances that have no pronounced flavour or taste of their own but which bring out and improve the flavours in the foods to which they are added. Although salt has a distinctive taste of its own and is not classed as a food additive, it is in fact the most widely used flavour enhancer. The next best known is glutamic acid and its salts, most commonly found in the form of monosodium glutamate, which has been used for several centuries in the Far East as a condiment in savoury products. It is a normal constituent of all proteins, an essential amino acid and present in the body. The alleged intolerance reaction was never confirmed in sound scientific studies. Anyone showing a reaction to MSG used as an additive would necessarily also react to foods that contain it naturally in high quantities, such as tomatoes and cheese.

Some sweeteners have also been found to have flavour-enhancing properties and have been authorised for use as such. For example, neohesperidine DC (E959) can enhance the flavour of meat products and margarine, and acesulfame K, aspartame and thaumatin are used to enhance the flavour of chewing gum and desserts.

Flavourings

Although flavour enhancers are categorised as additives, flavourings are technologically different and regulated separately, even though they are often considered by the general public to be the same thing. Flavourings are defined as imparting odour and/or taste to foods and are generally used in the form of mixtures of a number of flavouring preparations and defined chemical substances. These do not include edible substances and products intended to be consumed as such, or substances that have exclusively a sweet, sour or salty taste, i.e. ordinary food ingredients such as sugar, lemon juice, vinegar or salt. The latest draft of the proposed new EC Regulation on Flavourings would also exclude from the

definition of flavourings raw foods and non-compound foods, and mixtures of spices or herbs, mixtures of tea provided they are not used as food ingredients. In addition to the types of flavouring such as process flavours or smoke flavours, there are three distinct classes of flavouring substances: natural, e.g. citral; nature-identical, e.g. vanillin; and artificial, e.g. ethyl vanillin. Some 2700 substances were identified and included in a European register following Commission Decision (EC) 1999/217/EC as amended. Then there are flavouring preparations, e.g. vanilla extract. Many flavourings are sold as a complex mixture of individual preparations and flavouring substances, generally confidential to the company that has produced the flavouring. Legislation has been designed to protect commercial confidentiality in registering on the EC list newly discovered flavouring substances. Because of the complexity of the flavouring used in a food, labels generally indicate simply "flavourings" in the ingredients list. This is all that is legally required, as to list every individual substance would often be extremely lengthy and virtually incomprehensible to the consumer, although the manufacturer may be more specific if he wishes. Any flavourings labelled as "natural" must meet the legal definition. The Food Standards Agency has issued criteria for the use of the term "natural" in product labelling. The new proposal for an EC Regulation on flavourings and certain food ingredients with flavouring properties for use in and on foods means that in future there are likely to be stricter controls for the labelling of natural flavourings (7).

As with additives, some flavourings are sold direct to the consumer for domestic culinary use. Vanilla and peppermint are amongst the best known, as well as the popular brandy and rum essences. Anyone who has ever added too much flavouring to a home-made cake or a batch of peppermint creams will appreciate the minute quantities in which they are used. Similarly, in commercial manufacture, the quantity of flavouring used is extremely small in relation to that of other ingredients. Most flavourings are developed from substances naturally present in foods. Citrus and orange oils, for example, are amongst the most common natural source materials used in flavouring preparations and substances.

Other additives

Colours and sweeteners are very specific, well-defined classes of additives and, because of the nature of their function, are subject to specific legislation. All other classes of additive now fall under the general heading of "miscellaneous". In addition to the larger groups mentioned above, there are other categories within this more general grouping – namely thickeners, acids, acidity regulators, anti-caking agents, anti-foaming agents, bulking agents, carriers, glazing agents, humectants, raising agents and sequestrants.

The function of most of these is obvious from the name, with the possible exception of sequestrants. These are substances that form chemical complexes with metallic ions. They are not widely used and this is a class of additives rarely seen on a food label. Thickeners, on the other hand, are amongst the most commonly used additives, as they exert an effect on the texture and viscosity of food and drinks products. Much as various types of flour are used extensively in the kitchen to thicken sauces, soups, stews and other dishes with a high liquid content, most commercial thickeners are starch- or gum-based and serve much the same purpose.

One class of additive that has no domestic equivalent is that of packaging gases. These are the natural atmospheric gases now widely used in certain types of pre-packed products, such as meat, fish and seafood, fresh pastas and ready-prepared vegetables found on the chilled food counters in sealed containers. The "headspace" of the container is filled with one or a combination of the gases, depending on the product, to replace the air and modify the atmosphere within the pack to help retard bacteriological deterioration, which would occur under normal atmospheric conditions – hence the term "packaged in a protective atmosphere". Arguably, the gases do not have an additive function as they are not detectable in the food itself and function only to preserve the food for longer in its packaged state, but for regulatory purposes they were deemed to be additives and must therefore be labelled. Carbon dioxide will, of course, also be familiar as an ingredient in many fizzy drinks - an illustration of the many different functions and uses of additives.

Current EC legislation on additives does not cover the use of enzymes apart from invertase and lysozyme. However, in July 2006, the European Commission published a package of legislative proposals to introduce harmonised EU legislation on food enzymes for the first time and upgrade current rules for food flavourings and additives to bring them into line with the latest scientific and technological developments. The proposals were amended in October 2007 and are discussed further in the next chapter.

Safety of Additives

The safety of all food additives, whether of natural origin or synthetically produced, is rigorously tested and periodically re-assessed. In the UK, the responsible authority is the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), a Government-appointed expert advisory committee, which provides advice to the Food Standards Agency, the Department of Health and other Government Departments and Agencies on matters concerning the toxicity of chemicals, including food additives. At

European level, all additives approved for use in legislation have been evaluated by the Scientific Committee on Food (SCF) or, since May 2003, by its replacement the European Food Safety Authority (EFSA). Therefore, EFSA's Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food (AFC panel) is now responsible for the safety evaluation of new food additives (8,9).

Only additives evaluated in this way are given an "E" number; thus the "E" number is an indication of European safety approval, as well as a short code for the name of the additive.

In evaluating an additive, EFSA allocates an "Acceptable Daily Intake" (ADI), the amount of the substance that the panel considers may be safely consumed, daily, throughout a lifetime. This assessment is used to set the maximum amount of a particular additive (or chemically related group of additives) permitted in a specific food, either as a specified number of grams or milligrams per kilogram or litre of the food or, if the ADI is very high or "non-specified", at *quantum satis*, i.e. as much as is needed to achieve the required technological effect, according to Good Manufacturing Practice.

In establishing the ADI, a safety factor is always built in, usually 100-fold, to ensure that intake of any additive is unlikely to exceed an amount that is anywhere near toxicologically harmful. To ensure that consumers are not exceeding the ADI by consuming too much of or too many products containing a particular additive, the EU legislation requires that intake studies be carried out to assess any changes in consumption patterns.

The UK has carried out a number of intake surveys involving specific additives. None has culminated in results that have given cause for concern, except that in its 1994 survey of artificial sweeteners, consumption by some toddlers was considered to be excessive, given their high consumption of fruit squash. This potential problem was resolved by advice to add extra water to squash given to toddlers. It also raised questions about the establishment and application of the ADI, given that it is intended to cover changes in patterns of eating throughout a lifetime, from weaning to old age, but that is a separate scientific debate in itself.

At international level, there is a further level of evaluation of food additives, contaminants and residues of veterinary drugs in food by the Joint Expert Committee on Food Additives (JECFA), which advises the UN's Food and Agriculture Organization (FAO) and World Health Organization (WHO) Codex Alimentarius, which sets international standards. This has become increasingly important in recent years as World Trade Organisation (WTO) arrangements specify that Codex standards will apply in any dispute over sanitary and phytosanitary standards, i.e. the safety and composition of foods. For this reason,

the Codex General Standard for Food Additives (GSFA), was adopted to recommend usage levels of food additives in all products traded internationally.

As part of EFSA's role in the area of food additives, it is involved in the re-evaluation of all authorised food additives in the EU.

In September 2004, EFSA issued an opinion on the safety of parabens (E214-219) used as preservatives in foods following a risk assessment of its use in foods. As a result, Directive 2006/52/EC amending Directive 95/2/EC on food additives other than colours and sweeteners and Directive 94/35/EC on sweeteners for use in foodstuffs, deleted the preservatives, E216 propyl p-hydroxybenzoate and E217 sodium propyl p-hydroxybenzoate from the list of permitted preservatives in Annex III (10).

In the area of sweeteners, the safety of aspartame was considered controversial, especially following a long-term study on its carcinogenicity in 2005. Hence, EFSA evaluated findings from this study, and, in this case, confirmed that there was no need to revise the previously established ADI (11).

On the other hand, in re-evaluating the colour E128, Red 2G, in 2007, EFSA decided that there was a safety concern, and later the Commission suspended its use (12,13).

Intolerance

Additives have often been blamed for causing intolerance or allergic reactions, especially hyperactivity in children. Whilst there is no doubt that certain foods and food ingredients, including additives, are responsible for intolerance reactions, the prevalence of such reactions has often been greatly exaggerated. Genuine intolerance to food additives is extremely rare. It has been estimated that the true prevalence of intolerance to foods is about 2% in adults and up to 20% in children, and for food additives from 0.01 to 0.23%. The substantial overestimation of such reactions by the general public probably owes itself to the adverse media coverage and anti-additives campaigning of the 1980s, when popular belief was that additives were responsible for harmful behavioural effects and hyperactivity was attributed solely to the consumption of tartrazine (E102). The result was that tartrazine, an azo (synthetic) colour, was removed from a wide range of products, especially sweets and soft drinks that were likely to be consumed by children, as consumers in their droves ceased to buy anything that was labelled as containing it. Manufacturers are still reluctant to use this colour, unless there is nothing else in the palette of yellow colours authorised for the product. Such is the power of consumer choice, be it informed or otherwise.

Food intolerance, and especially allergy, is again under the spotlight, not now because of alleged hyperactivity in children, but, far more seriously, because

of the seemingly growing prevalence of severe allergic reactions, particularly to peanuts. Since the mid-1990s, there have been a number of widely reported incidents, including several tragic deaths as a result of anaphylactic shock, a severe allergic reaction to specific proteins, most commonly those found in tree nuts and peanuts and a small number of other foods, including milk, wheat, eggs, soya, fish and shellfish. The reasons for such reactions are not yet fully understood and are still under investigation, as are the causes of this apparently growing problem, but the need to address the issue and do everything possible to assist the small but significant number of people affected by this most severe form of allergy caused the European Commission to task its former Scientific Committee for Food (SCF) with identifying the scope of the problem and the foods and ingredients associated with it. This 1996 Report reaffirmed the SCF's earlier (1982) estimation of intolerance to additives as affecting from 0.01 to 0.02% of the European population (14). More specifically, the prevalence of intolerance to food additives in the population was put at 0.026%, or about 3 people per 10,000 of the population. This compares with the prevalence of adverse reactions to cows' milk of 1 to 3%. The most commonly observed reaction is now to sulphur dioxide (E220) and sulphites, especially in asthma sufferers, again growing in number or perhaps being more frequently reported.

It must be understood that the incidence of genuine intolerance to additives is very low. Accurate labelling is the key to avoiding unnecessary suffering of an adverse reaction, such as urticaria, asthma or atopic symptoms, in the case of sensitised consumers, or adverse publicity in the case of food producers, and for this reason the EC Labelling Directive 2000/13/EC was amended in 2002, 2003, 2006 (to establish a list of potential allergens that must be declared by name on food labels) and in 2007 (see Chapter 2).

Myths and Fallacies

Nothing is guaranteed to fill column inches and dominate the airwaves more than a good food scare. Additives have seen their share of these, though not on the scale of the 1996 BSE crisis or the more recent controversy over genetic modification: though equally long-running and bearing similarities to the latter issue, additives were never the butt of a concerted campaign by environmentalists and others dedicated to the downfall of a specific technology. Anti-additives campaigns would either target a specific additive or class of additives, for whatever reason, or cite the use of additives as part of a general thrust to disparage the modern food-manufacturing industry and seek to encourage a “back to basics” trend towards good old-fashioned home cooking and away from the purported

less healthy foods produced by industrial processing for the UK's largely urbanised society.

Hence the periodic targeting of preservatives, antioxidants, azo colours, sweeteners and monosodium glutamate. The evidence of such "scares" still abounds on the labels of countless products that claim to be free from "artificial" preservatives, colours and additives in general. This is indicative of the susceptibility of both marketing men and consumers to perceived adverse effects of particular additives. Such a response is unhelpful; whilst it is understandable that consumer concern in response to a media scare may result in a company removing an additive, or indeed any other ingredient, from a product for reasons of short-term expediency, the options and alternatives will inevitably become reduced every time something is removed from the range of ingredients, and the controversy left unresolved. It would be far better to address the issue through appropriate scientific investigation and seek to ensure that evidence of safety and absence of adverse effects are given at least some airing in the public domain to explode the myth engendered by the original controversy.

This, of course, is not easy, as good news is, generally speaking, no news at all and certainly unlikely to make the headlines. The tabloid newspapers had a field day with the Food Commission's stories that "Cyclamates 'may cause testicular atrophy'" (15) and "Aspartame 'may cause brain tumours'" (16). Refuting such headlines is not easy; the full barrage of scientific evidence generally needs to be brought out in defence of any food ingredient or additive placed under the media spotlight and accused of causing some adverse effect. Often the "evidence" produced in support of the story needs to be pulled apart under the microscope and any deficiencies, such as in the research protocols or the way in which any experimentation was conducted, identified. The motivation for publishing such "research", and any exaggeration of the findings, also need to be examined.

All this takes time and will not protect any company using the additive or additives concerned from a barrage of enquiries from worried customers who, not unnaturally, seek reassurances that they have not already been harmed or will not be if they continue to consume the product. Again, a sense of proportion is important. The "problem" needs to be placed in context, given perspective against the wide range of risk factors to which all of us are exposed in daily life, and consumers assisted and encouraged to develop their own sense of risk assessment and risk management. This will become all the more important as communication becomes ever more global and instantaneous. The internet offers both threats and benefits: threats in that anyone can rapidly set off a scare by posting adverse information about, say, a specific sweetener. This may be a genuine concern that some possible risk to, perhaps, a certain sector of the population has been found,

maybe to people suffering from a specific condition. It may also be that an unscrupulous company seeking to target that group with a new product decides to set off a scare shortly before launching its product, which is marketed as "free from" that additive or ingredient. The benefit lies in being able to expose such scares equally quickly, and the opportunity to post true and accurate information about food production for those who want to know.

Clean Labels

The growing demand from health-conscious consumers is for the replacement of artificial food additives with 'natural' ingredients, which perform similar technological functions. Thus, food processors are continuously seeking natural alternatives to food additives as, when these are listed on labels as the named ingredients rather by E-number, it gives the food product a 'clean label' declaration.

Clean label declarations are not regulated; however, the Food Standards Agency in the UK has issued "Criteria for the use of the terms Fresh, Pure, Natural etc." which could be used as guidance. In addition, when incorporating new substances into foods one would also need to comply with the EC Regulation 258/97 concerning Novel Foods and Novel Food Ingredients.

A number of ingredients are now being manufactured that claim to give foods a clean label status e.g. emulsifiers such as lecithin and soya protein; antioxidants including grape seed, chestnut and olive leaf extracts; colours for example, lycopene, anthocyanin and chlorophyll; and preservatives including cinnamic acid, carvacol, chitosan, and lysozyme.

Some bacterial cultures, known as 'protective cultures', able to inhibit the growth of pathogenic bacteria and mycotoxin-producing mould are being used as inhibitors of foodborne microorganisms. These protective cultures produce antimicrobial metabolites like organic acids (lactic and acetic acid), and bacteriocins (nisin and natamycin), and are substitutes for conventional additives, helping manufacturers make the 'Clean Label' claim.

It will be some time before we see a complete shift to clean label products, and in some situations this may not be possible due to a lack of suitable natural alternatives.

Conclusions

Much has happened to and in the food industry and the market for food since the great focus on additives in the 1980s. The popular books produced on the subject at that time focused largely on the potential adverse effects of additives; the

potential misleading of consumers about the food they were eating; and the profit-driven nature of the industry motivated to use additives in their products (17,18,19). But not all of this criticism was without justification, and there were undoubtedly bad practices in place in some sectors of the industry, where unscrupulous traders saw opportunities for quick profit. The use of phosphates in reconstituted meat and fish products to make them appear as better-quality cuts and fillets or to add weight to a chicken was a dodge that trading standards officers rightly pursued with some zeal. This is not a criticism of the legitimate use of phosphates in meat products such as hams, but of the instances of false description of reconstituted products as prime cuts, and frozen "scampi" that disintegrated on defrosting. Any business will always have its unscrupulous operators, but strict regulation and enforcement now make this increasingly difficult in the food industry.

The 1990 Food Safety Act provided the framework of primary legislation for the food industry in the UK. The raft of legislation on food additives developed as part of the European Single Market, and explored in detail in a later chapter, strictly controls the use of all additives.

The establishment of the Food Standards Agency, with its dual role of protecting and informing the consumer, may well influence both trends in the use of additives and public perceptions of their worth.

Furthermore, the market has changed considerably in recent years, partly as a result of European integration and partly because consumers have become more sophisticated, more knowledgeable, and more affluent. Overseas travel has greatly broadened the British palate and increased demand for a wide range of exotic and adventurous foods that have been sampled overseas. Our increasingly cosmopolitan society has also led to the availability of more and more "ethnic" foods, both in restaurants and for domestic consumption, while busy lifestyles, and the increasing number of working women have led to more and more food being consumed outside the home.

Never has the range and choice of foods been so great, in terms of availability in the supermarkets and specialist food shops, or through the catering trade. This is not to say that additives are less widely used or less relevant – far from it. But those who wish to avoid them, either as manufacturers or consumers, should find it possible to do so, and those who do use them need have no concerns, except to obey the law in the case of manufacturers, and to understand the meaning of the ingredients list in the case of consumers. Astute consumers now notice that it is not only pre-packed foods that contain additives: foods sold "loose" at delicatessen counters are now also labelled to indicate the content of additives – or should be. And it has not escaped the notice of public health analysts that the greatest use of food colours is in ethnic restaurants. Public

protection is ensured and additives cannot be used to deceive, but we would be deceiving ourselves if we thought that we could continue to enjoy the choice, ease and convenience of our food supply without them. Like them or not, they are a fact of life and their usefulness cannot be denied.

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