Food additives

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Summary

Food additives are discussed from the food technology point of view. The reasons for their use are summarized:

- (1) to protect food from chemical and microbiological attack;**
- (2) to even out seasonal supplies;**
- (3) to improve their eating quality;**
- (4) to improve their nutritional value.**

The various types of food additives are considered, e.g. colours, flavours, emulsifiers, bread and flour additives, preservatives, and nutritional additives. The paper concludes with consideration of those circumstances in which the use of additives is (a) justified and (b) unjustified.

Food additives have been defined by the Joint WHO/FAO Committee in 1955 (FAO, 1956) as substances 'which are added intentionally to food, generally in small quantities, to improve its appearance, flavour, texture, or storage properties'. This definition excludes substances which find their way into foods, but which have not been deliberately added, and are usually classed as contaminants. For the purpose of this contribution I propose to include substances intentionally added for nutritional purposes.

Additions to food have been made for many thousands of years. It is known that the ancient Egyptians used colours in food over 3500 years ago, and that preservatives such as acid, salt, sugar and smoke have a long history. The Chinese are reported to have used ethylene released from burning oil to ripen fruit and the Greeks of olden times treated raisins with alkaline ash before drying them.

Why substances are added to food

In considering the reasons for the addition of chemical substances to food, it is worth reminding ourselves that foods, after all, are mixtures of chemicals. It was Liebig (1851) who, in the middle of the 19th century, was one of the pioneers of investigation into the study of foods which led to our present understanding of the chemical composition of foods.

An important factor behind this question of add-

ing substances to food is the fact of rapidly expanding populations all over the world; and the imperative need to conserve as much food as possible and save what we can from the marauding attacks of pests and bacteria, fungi and natural spoilage. It was reported a few years ago that the wastage of food under storage as a result of the activities of rodents, insects and fungi amounted in one year to over 33 million tons, enough to feed over 200 million people (Mrak, 1962).

Seasonal surpluses in the less developed countries, and the lack of storage and transport facilities provide good reasons for applying methods of preservation of food, of which the use of preservatives is an important example. In such countries, high temperature and humidity speed up the rate of attack by bacteria and fungi, justifying the use of anti-microbial agents. In hot countries where the risk of loss of food as a result of rancidity is greatest, the use of anti-oxidants will improve the keeping quality of foods.

The World Health Organization and the Food and Agriculture Organization have estimated that about 15% of the world's population are seriously undernourished, and that a further 35% suffer from malnutrition. Any disadvantages in using these preservatives are more than outweighed by the fact that more food is made available in areas where starvation and malnutrition are common.

Other substances added to food improve their eating quality. By improving the colour, flavour and texture of foods, the proportion of food which might otherwise be rejected is reduced. Food is therefore made more acceptable and appetizing by the use of such additives as colours, flavours, emulsifying and other texture improving agents.

The manufacture of such foods as ice-cream and margarine; the immense range of frozen, dehydrated and freeze-dried foods, and the increasing variety of easy-to-prepare and ready-cooked foods and dishes which cut down the labour of the busy housewife are all made possible by the use of additives of various kinds.

In addition, a significant group of foods contain substances which are added to increase their nutritional value. Such additions may be required by law, or are made at the discretion of the manufacturer. They are usually added in order to make good losses sustained as a result of processing, and in any case fulfil a valuable role in helping to maintain a satisfactory nutritional status among sections of the population who might otherwise suffer from nutritional deficiencies.

General legal considerations

Britain was one of the first countries to establish control over food quality in general, and in particular over food additives. Regulations controlling various groups of additives are made by the Minister under the Food and Drugs Acts. In addition, standards of composition are laid down for selected foods which stipulate also the additives which are permitted in those foods. For example, under the Bread and Flour Order the only permitted colour is caramel.

Limits of tolerance are laid down where appropriate on the basis of experimental evidence which is examined by specialist sub-committees. Maximum permitted limits apply, for example, to preservatives; and it is usual to have separate figures for different foods, based largely on the amount consumed *per capita*. In the case of colouring matters and emulsifying agents, no limits are normally imposed, since the amounts used are self-limiting, and the effects produced would vary with the type of food.

Types of food additives

A. Substances added to improve the quality of food

- (1) Colouring matters.
- (2) Flavours in foods.
- (3) Substances used to improve texture.
- (4) Bleaching and maturing agents.

B. Preservatives

- (1) Anti-microbial substances.
- (2) Anti-oxidants.

C. Nutritional additives

Substances added to improve the colour of food

The colour of many manufactured foods such as butter and cheese varies from season to season, and some foods lose colour in the course of processing. Consumers prefer to buy foods with the colour they are accustomed to, and therefore canned peas which have turned brown in the sterilizing process simply do not sell. Custard, margarine and ice-cream would look a deathly white if processed without added colour, and therefore in all these cases it is usual to add harmless colour.

The available colours before the middle of the 19th century were few and, on the whole, rather dull. The coal-tar or aniline colours developed by Perkin (1856) were much brighter, more concentrated, and offered greater variety. Some of these were unsafe to eat (butter yellow for example was carcinogenic) and have been drastically eliminated, so that we now have the colours permitted in foods by the 1966 Colouring Matters in Foods Regulations, which are summarized in Table 1.

TABLE 1. The Colouring Matters in Foods Regulations, 1966

Permitted colours	
Coal-tar colours	Non coal-tar colours
<i>Water-soluble</i>	Caramel
Red 9 colours	Carmine
Yellow 2 colours	Vegetable colours 14 colours
Orange 3 colours	Carotenoid colours 3 colours
Blue 1 colour	Colours of metal origin 3 colours
Green 1 colour	Carbons 2 colours
Violet 1 colour	Ultramarine 1 colour
Brown 3 colours	
Black 2 colours	
<i>Oil soluble</i>	
Yellow 2 colours	

Whilst the coal-tar colours are only required in minute amounts, the remaining colours, most of which are of the traditional type, are used in much higher concentrations. It is of interest to note that two of them may make significant nutritional contributions to the food. They are; (1) beta-carotene, the most widely used carotenoid colour which has vitamin A activity; and (2) iron oxide, one of the metal colours, which when used to colour such products as anchovy sauce, is used in fairly large amounts.

Caramel and saffron may confer flavour as well as colour to food. The sole colour of animal origin, carmine, or cochineal, is extracted from the female of the insect *Coccus cacti*, which lives on certain types of cactus plants in Mexico.

Flavour additions

Great Britain has a highly developed and vigorous flavour industry allied with the perfume industry. Their products can be roughly classified into volatile and non-volatile flavours. *Volatile flavours* can be grouped into three classes.

- (a) Flavours derived only from natural sources.
- (b) Synthetic flavours.
- (c) Mixed or compounded flavours.

(a) *Natural flavours* include a large array of extracts from fruits and other foods in various forms, e.g. essential oil of lemon.

(b) *Synthetic flavours*. As a result of intensive research into the chemical nature of the flavours in

foods, using techniques such as gas chromatography and mass spectrometry, it has been possible to identify a large number of the chemical components of these flavours. This knowledge has led the workers in this field to blend combinations of such components in an attempt to copy nature's art, with varying degrees of success.

(c) *Compounded flavours*. These are mixtures of the entirely synthetic blends with naturally produced flavours which approximate still more closely to the original flavour.

The Food and Drugs Act contains no regulation limiting the use of such flavours, although in 1965 the Food Standards Committee recommended the issue of a list of sixteen prohibited flavours. In 1966 it was decided, in view of the difficulties surrounding the exercise, to replace this by a permitted list, but no such list has been issued yet. The whole subject is under review by the appropriate body responsible to the Council of Europe.

Non-volatile flavours

There are a large number of such flavouring substances, and they include salt, spices, sugar, non-sugar sweeteners, protein hydrolysates, monosodium glutamate, and ribo-nucleotides. The last three are flavour enhancers as well as flavours in their own right. They tend to accentuate the flavour of chicken, meat and other foods.

The only control exercised in this country is in respect of artificial sweeteners. Only saccharin is permitted and maximum tolerances in specified foods are listed in the Artificial Sweeteners Regulations, 1969.

Substances added to improve texture

This group of food additives includes substances of various kinds, and may be classified as follows.

- (a) Emulsifying and other surface-active agents.
- (b) Stabilizers and thickeners.
- (c) Phosphates.

There is a permitted list of emulsifying and stabilizing agents in the Regulations issued, 1962 (Table 2).

TABLE 2. Emulsifiers and Stabilizers in Foods Regulations, 1962

Permitted list
Stearyl tartrate
Partial and complete glycerol esters
Partial polyglycerol esters
Propylene glycol esters
Monostearin sodium sulphoacetate
Sorbitan esters of fatty acids and their poly-oxy-ethylene derivatives
Cellulose ethers
Sodium carboxymethyl cellulose

Naturally occurring emulsifying agents such as lecithin, and stabilizers such as pectin, alginates (from seaweed) and tragacanth and other gums are permitted automatically by virtue of their being present in foodstuffs.

Emulsifying agents promote emulsions in salad dressings, ice-cream sauces, margarine and many other foods, by virtue of their chemical structure.

Emulsifying agents are used widely in the baking industry to improve the quality and shelf life of baked foods, since some of them act as anti-staling agents. However, only two of the latter are permitted in bread.

Stabilizers and thickeners are hydrophilic colloids which help to stabilize emulsions because of the high viscosity of the aqueous solutions of these substances. Examples of these are pectin, alginates, gelatin, starch and albumen. They are also used in their own right to produce foods of high viscosity, e.g. jam, jelly, malted milk, sauces.

Alginates are used extensively in ice-cream; cellulose ethers are used for imitation cream and for stabilizing beer foam; pectin is used for jam; gum tragacanth is used in pickles and sauces.

Phosphates, which are not subject to regulation, are used extensively in the food industry as meat binders in sausages and in processed cheese to give smooth products; and as starch modifiers to increase the shelf life of starch products.

Bleaching and maturing agents

These substances, like the last group, come under the heading of substances which assist in the processing of foods. Their use is based on the fact that freshly milled flour has a yellow tinge which produces greyish bread and cakes; and the bread has a rather tight structure and poor volume. Long storage or the use of some oxidizing agents remove this discoloration ('bleaching' agents) while other oxidizing agents improve the texture and volume of the bread ('maturing' or 'improving' agents). Others again exert a dual action (Birch, Cameron and Spencer, 1972). The bleaching and maturing agents, which are strictly limited to those contained in the Bread and Flour Regulations 1963 (amended in 1972), are given in Table 3.

These additions may not be made to wholemeal flour. It is noteworthy that ascorbic acid has been found to be necessary for the highly successful Chorleywood Bread Process, which has resulted in great economy in bread production without any loss of quality. The ascorbic acid does not, however, contribute to the nutritional value of the bread, since it is destroyed in baking.

Chlorine and chlorine dioxide have been shown to reduce the α -tocopherol level of flour, as does long storage. However, flour is not an important source

TABLE 3. Bread and Flour Regulations, 1963 (as amended 1972)

Permitted bleaching and maturing agents
Ascorbic acid
Potassium bromate
Potassium and ammonium persulphate
Monocalcium phosphate
Chlorine (for cakes)
Chlorine dioxide
Benzoyl peroxide (max. 50 parts/10 ⁶)
Azodicarbonamide (max. 45 parts/10 ⁶)
L-cysteine hydrochloride (max. 75 parts/10 ⁶)
Sulphur dioxide (for biscuits—max. 200 parts/10 ⁶)

of α -tocopherol in the diet, and hence it is unlikely that α -tocopherol deficiency (about which little is known in relation to human nutrition) would be brought about as a result of this treatment.

An example of the formation of a toxic compound as a result of the action of an additive has been demonstrated in the case of a once used bleaching and improving agent—nitrogen trichloride ('agene'). This was shown to produce in flour the toxic factor methionine sulfoximine, as a result of which discovery, the use of this substance was barred.

Preservatives

These may be conveniently classified into antimicrobial preservatives and anti-oxidants.

Anti-microbial preservatives

These are chemical substances which are added to food to prevent microbiological spoilage (Spencer, 1960). Such a definition includes sugar, salt and other traditional preservatives, which are not therefore included in the Preservatives in Food Regulations 1962.

The traditional preservatives. Sugar and salt have been used as preservatives since time immemorial, and function by virtue of their osmotic pressure which inhibits the growth of organisms, in such products as jam and brined herrings.

Nitrates and nitrites are used in cured meats, along with salt, primarily to produce desirable colour, flavour and texture, although the nitrite does have some preservative effect. Some concern has been expressed at the possibility that nitrosamines, which may function as liver poisons, may be produced in food, or during metabolism in the body (Food Additives and Contaminants Committee 1972). Current work indicates that only minute traces have been found in food, but the regulations have been amended by imposing upper limits on nitrate and nitrite content.

As well as imparting a very pleasant flavour, smoking preserves foods for a limited period because of surface dehydration and impregnation with preservative chemicals such as phenols and formaldehyde.

Acid preservatives. Acetic acid is used as a preservative in pickle and sauce manufacture, and in bakeries to prevent 'rope' in bread (*Bacillus mesentericus*).

Sorbic acid is effective against fungi and yeasts, and in baked goods is an effective mould inhibitor. Unfortunately, its use must be confined to cakes, because it inhibits yeast fermentation.

Propionic acid does not suffer from this disadvantage and will effectively protect bread and cakes from mould and 'rope'.

Whilst benzoic acid is an effective preservative the substituted esters of p-hydroxybenzoic acid are more effective and, in addition, are safer (Chichester and Tanner, 1968).

Sulphur dioxide and metabisulphites have extensive uses in food processing: in preserving fruit pulp and juices, dried fruit and in wine-making. They are also used to prevent enzymic and non-enzymic browning in such products as peeled chipped potatoes and apple slices. Although they preserve vitamin C, they tend to destroy thiamin, and consequently may only be added to certain foods up to prescribed limits.

Antibiotics. Tetracyclines may be used for preserving fish in the form of antibiotic ice on trawlers which are out at sea for protracted periods. Its use has been diminishing, and FAO/WHO Reports (1969) have discouraged the use of medical antibiotics in food.

Nisin has no medical strings and is a natural constituent of some cheeses. It is used in the manufacture of other cheeses to inhibit clostridia and other spoilage organisms (Lilley, 1958).

Anti-oxidants

Anti-oxidants are used to prevent various types of oxidation spoilage, principally oxidative rancidity of fats and fatty foods.

The permitted anti-oxidants include: propyl, octyl and dodecyl gallates; butylated hydroxy anisole (BHA); butylated hydroxy toluene (BHT). These and naturally occurring anti-oxidants such as tocopherols and lecithin may be added to fats, butter for manufacturing purposes, and to essential oils up to specified limits. They may not be added to foods as such.

Most commercial fats have been so treated, and these help in protecting from rancidity foods such as biscuits, crisps, cake-mixes and dehydrated soups (Food Standards Committee, 1963).

Nutritional additives

The main foods which must contain added nutrients by law are as follows.

(1) *Flour.* The Flour and Bread Regulations 1963 specify that all flour except wholemeal must contain

minimum amounts of thiamin, nicotinic acid, iron, and calcium carbonate. These largely replace the nutrients lost in milling and are added by the miller.

(2) *Margarine*. Vitamins A and D must be added to household margarine in specified amounts, which are equal to or greater than their content in butter.

Other foods to which nutrients are sometimes added purely at the discretion of the manufacturer include: breakfast cereals (lysine and vitamins); fruit juices (vitamin C); mashed potato powder (vitamin C); milk powder for infants and mothers (vitamin D and calcium).

Because of the growing use of food additives today it is worth summarizing the situations in which their use is justified, and those in which their use is not justified (WHO, 1957).

Situations justifying the use of food additives

Improving the keeping quality of foods with resulting reduction in waste.

Making foods more attractive to the consumer.

Providing essential aids in food processing.

Maintaining or improving the nutritional value of foods.

One should add to this that food additives must be safe. Before an additive is permitted in any food, there must be critical evaluation in animals and in man of its physiological and biochemical behaviour. A safe level and freedom from possible toxic effects must be based on knowledge of the maximum dietary level that provides no unfavourable response in test animals (Frazer, 1968).

Situations in which food additives should not be used

To disguise the use of faulty processing and handling techniques

The use of food additives might lead to abuses which may be difficult to detect, and possibly to unhygienic food.

To deceive the consumer

Additives should never be used to boost the apparent quality above that of the real quality. For example, the use of strong flavours to mask spoilage; or the use of colours to convey the impression that certain ingredients have been used.

This risk would be greater in raw than in processed foods. In general, raw foods should not contain additives.

When nutritional value is significantly reduced

Examples of this would be the use of sulphur dioxide in foods which are important sources of thiamin in the diet.

When good manufacturing practices can achieve the desired effect

A new or improved process may eliminate the need for an additive. The modern process of dehydration, for example, retains most of the green colour, thus obviating the need for adding green colour to traditionally dried peas, in which most of the green colour is lost.

In conclusion, the whole of our food legislation, including that dealing with additives, is under review in the light of our entry into the Common Market (Martin, 1973).

In some cases, such as preservatives and anti-oxidants, little difficulty will be experienced. With regard to legislation concerning colours and flour additives, considerable negotiation and experimentation will be called for. It will take many years before the process of harmonization is complete.

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