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The Chemical Preservation, Colouring and Flavouring of Foodstuffs with Special Reference to Fruit and Vegetables

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The addition of substances to foodstuffs for the purpose of preservation, colouring and flavouring is nowadays carried out in accordance with the strict definition and limitations imposed by the Food and Drugs (Adulteration) Act of 1928 and by the Preservatives in Food Regulations of 1927. Much of the objectionable and unsuitable treatment applied in the past was apparently practised as much out of ignorance as with the object of fraud.

The ideal methods of preservation are those effecting sterilization either by heat treatment, as in canning, or by freezing. These methods are not always practicable or economic; moreover, the highly specialized plant required cannot be made available for 'on the spot' preservation of such perishable foodstuffs as fruit. In such cases chemical preservation is of importance in saving valuable foodstuffs. The Food and Drugs Act defines a 'chemical preservative' as a substance added to foodstuffs to hinder or retard undesirable changes, and specifically excludes from restriction those substances which we may class as 'traditional preservatives', e.g. salt, sugar, vinegar, saltpetre, spices, wood smoke, alcohol and hops. Barnard (1911) listed the requirements for a preservative in the form of eight points which are worth repeating: (1) the substance used must not, under reasonable circumstances, injure health; (2) it must not make possible the use of unfit raw material; (3) its use must not make possible the use of careless or imperfect methods of handling; (4) it must be non-poisonous and non-irritant; (5) it must be efficient; (6) it must not retard the action of the digestive enzymes; (7) it must not decompose within the body into substances more toxic than itself; (8) it should lend itself to simple methods of estimation in order to simplify control.

There are only two preservatives permitted in the U.K., U.S.A. and many other countries, namely, sulphur dioxide and benzoic acid. As a wartime measure the regulations have been relaxed to some extent to enable foodstuffs to be imported from countries allowing other preservatives; for example, Canada, Australia and New Zealand still permit the use of boric acid and of salicylic acid.

Preservation with sulphur dioxide

The principle of preservation with sulphur dioxide is an old one; for example, it was the subject of legislation in Augsburg in 1400, and the excessive sulphuring of wine was condemned in London in 1600. A more understanding view is taken to-day, and we are in fact urged to make use of this preservative for the household preservation of fruits. Sulphites as preservatives are of particular value for use with acidic materials, fruits, etc., and are more effective in preventing the growth of moulds than of yeasts; in fact, once fruit pulp is actively fermenting, the fermentation cannot be checked by the addition of sulphur dioxide. A special advantage is that they are eliminated almost entirely by boiling, so that the final preservative content of the cooked foodstuff is negligible; this is evident from the legal limit of 40 p.p.m. in jam, which, of course, is not intended as a permitted addition but as a residual maximum remaining from the ingredients employed. Removal of the sulphur dioxide, however, is not an essential feature; for example, in fruit syrups in which 350 p.p.m. are permitted, the drink as it is consumed would contain 70 or 80 p.p.m. Sulphur dioxide does not cause serious loss of ascorbic acid. Although it bleaches the colour of most fruits, particularly of red varieties, the colour is largely restored when the sulphur dioxide is boiled off.

In practice, there are several methods by which the sulphite may be added to the material to be preserved. One of the easiest is to bubble sulphur dioxide gas from a siphon or cylinder into barrels containing the fruit either immersed in water or in the form of pulp prepared by forcing the fruit through a sieve. The amount added is controlled by finding the loss in weight of the siphon as well as by analysis of the material. Alternatively, the sulphur dioxide may be bubbled into water until a solution containing about 6% of sulphur dioxide is obtained, and this solution may be added to the material to give the required concentration; or the metabisulphite of sodium, potassium or calcium may be employed and the correct amount of solid or solution of known strength added. In using calcium salts, account must be taken of the hardening effect which calcium ions exert on plant tissue; this effect may be turned to advantage to render soft fruits firmer and better able to resist any subsequent treatment. A typical example of this is afforded by the Bigarreux cherries which are preserved by sulphiting for use in the preparation of *glacé* cherries.

Mention should be made of the household preservation of fruits with 'Campden' tablets, the introduction and use of which was sponsored by the Ministry of Food. These tablets consist of metabisulphite of either sodium or potassium; two tablets dissolved in one pint of water yield a solution containing approximately 1000 p.p.m. of sulphur dioxide.

Sulphiting may be carried out literally in the field, the fruit being placed in casks and covered with preservative solution as it is picked, so that loss and deterioration during transport may be avoided. Fruit for jam-making may thus be preserved and stored for subsequent use, so rendering jam-making less of a seasonal occupation and avoiding losses due to glut.

The action of some enzymes, notably pectase, is not entirely prevented by sulphites, and it is advisable therefore that fruits which are used for their ability to give good pectin gels should be prepared by a hot process in which the fruit is heated sufficiently to inactivate the enzymes before sulphite is added. Further, since combined sulphite is almost entirely without preserving action, ingredients containing chemical groups capable of combining with sulphur dioxide (notably the aldehyde group of sugars such as dextrose) serve to reduce the effective concentration of preservative. Methods are available for finding the amount of sulphur dioxide so combined, and Bennett & Donovan (1943) have shown that in citrus juices, such as have been imported during the past few years for the preparation of fruit syrups and cordials, as much as two-thirds of the added sulphur dioxide is rendered inactive in this manner in the more highly concentrated juices, i.e. those concentrated five times or more.

Finally, mention must be made of the use of sulphur dioxide in modern developments of the age-old processes of preserving foodstuffs by drying. Sulphur dioxide is used to preserve the colour and flavour of fruits dried either in the sun or by artificial heat. The process, known as 'dry sulphuring', consists in exposing the fruit before, and sometimes during, drying to the fumes of burning sulphur. The absorbed sulphur dioxide serves to prevent the darkening and development of 'burnt' flavours in such fruits as apricots and pears during storage after drying. Recent work in America (Stadtman, Barker, Haas, Mrak & MacKinney, 1946), has shown that the degree of darkening was positively correlated with the oxygen consumption and that the latter could be reduced by decreasing the moisture content, by reducing the oxygen available, e.g. by tight packing, and by increasing the sulphur dioxide content. About 45% of the oxygen available could be consumed in oxidizing the sulphur dioxide.

Similarly, the oxidative changes causing the development of hay- or straw-like flavours in dehydrated carrots and cabbage, as well as deterioration of colour and loss of ascorbic acid, are retarded by sulphur-dioxide treatment before drying. These advantages are now so well established as to have become a normal practice and to have received official sanction in an amendment to the preservative regulations.

Preservation with benzoic acid

The second preservative generally permitted is benzoic acid and its salts. In a sense, it is complementary to sulphur dioxide, as it is more effective against the growth of yeasts than of moulds. It does not affect the colour of the preserved material or, in the concentrations permitted, the flavour. On the other hand, it is not readily removable, so that the full amount added is consumed. In practice the preservative is added in the form of a small amount of a strong solution, usually of the sodium salt owing to the relative insolubility of the free acid. As the use of benzoic acid is

permitted in only two classes of foodstuffs, pickles and non-alcoholic beverages, it is to be regarded, at least by implication, as less desirable than sulphur dioxide.

From a purely chemical aspect there is considerable scope for research on preservatives. For example, it is known that the introduction of a side chain or of substituted groups in the benzoic acid molecule increases many times the antiseptic properties.

Colours

It is obvious that the fundamental criteria, apart from those concerned with preservative action already given for preservatives, must apply to any colours added to foods. From a legal standpoint, two main courses are followed, some countries, notably the U.S.A., Canada, Australia, France, specifying those colours which may be used, while others, including the United Kingdom and South Africa, specify those (five) which may not be used; an attempt has also been made in Canada to limit the amount of added colour to a maximum of 2 gr./lb.

Consumers of prepared foodstuffs have very definite colour preferences, and every care must therefore be taken during preparation or manufacture to develop and retain the most acceptable colour in the product concerned. Nevertheless, changes in colour do occur by reason of heat treatment, oxidation and bleaching reactions, or, perhaps, from traces of chlorine in the water. The restoration of a bright, attractive and natural colour is therefore desirable to improve the acceptability of the product and, by psychological reaction, the nutritive value. The importance attached to the colour of food can be judged by the many experiments on such points as the colour preferences of panels representative of different age groups or the effect of colour on the ability to identify particular flavours.

The colouring matters now used in foods are almost entirely synthetic organic compounds, the azo-dyes forming the major group. The amounts necessary to produce the required tint are extremely small; as a rule quantities of the order of one part of colour in 50,000 of the food are adequate, and a colour would have to be indeed objectionable for such a trace to assume importance. By applying the principles of chromatographic analysis, it is possible to separate and identify the colours used even in these minute quantities.

Most users take great care to choose colours specially manufactured for use in foodstuffs, particular attention being paid to the presence of not more than traces of metallic contaminants. Hence there can be no objection to the reasonable and proper use of colours; of the indiscriminate use, for obscuring the use of substandard materials or methods, or of the actual use of unsuitable or dangerous colours, enough has been said in the past, and no manufacturer with a reputation to guard would consider such a practice.

Flavours

The flavouring substances of foodstuffs, either of natural origin or due to additions, form a broad and ill-defined group; where, for example, can one draw the line between the normal precautions necessary to safeguard and develop the required flavour by

the addition of salt or spices, or the control of temperature, and the addition of specific flavouring materials? Should salt and spices be included as added flavour? From the recently published labelling regulations, any material other than salt added for the purpose of modifying the flavour would count as added flavour; perhaps fortunately for the peace of mind of the old-fashioned chefs, these regulations apply only to pre-packed food. Broadly speaking, flavouring materials can be placed in three main categories: (1) the natural flavours, which would include spices and such material as vanilla or fruit juices; (2) those which we may term semi-natural, comprising flavouring ingredients and components derived from natural sources—the essential oils and esters are typical of this group; (3) purely synthetic materials used on account of their pleasant odour and flavour. This grouping is, of course, very arbitrary; for example, acetaldehyde, amyl formate and other substances usually considered as chemicals are in fact normal constituents of the flavour of apples, as amyl acetate is of bananas. The natural flavours are in general nothing more than rather complicated mixtures of chemicals, chiefly esters, aldehydes, ketones, ethers and alcohols. The only nitrogen-containing substances likely to be present in flavours are musks (used as fixatives) or methyl anthranilate, which is a natural component of Concord grape juice (Power & Chesnut, 1921).

Foodstuffs owe their characteristic flavour to the combination of the four primary factors, sourness, saltiness, sweetness and bitterness, in conjunction with the aromatic principle detected high in the nasal cavity and almost identical with odour. Hence, while the flavour of a product may be so characteristic that any modification may be superfluous, or even regarded as sacrilege in the case of wines and liqueurs, it often happens that the modification of one of these factors is desirable in order to standardize or develop the desirable character of the product. Thus cocoa beans are carefully blended, roasted, and conched in order to develop the delicate flavour to the maximum degree and to obtain a standard flavour from batch to batch. Similarly, the desired flavour, aroma and colour of coffee are obtained by the careful selection, blending and roasting of the beans, while in the case of tea these qualities are obtained entirely by blending. In connexion with tea, it is of interest to note that as many as twenty varieties may be included in a popular medium-priced tea, and the maintenance of a blend of standard flavour, colour and aroma suiting the variations in the water supply of different localities by taste alone is indicative of the delicacy to which the palate of a tea-taster can be trained. These are examples of foodstuffs to which flavour is not specifically added except in the sense that the roasting and other processes may be said to add to or, what is perhaps a better term, develop, the flavour.

On the other hand, there are other types of foodstuffs which depend entirely on added flavours for their palatability, e.g. many types of confectionery and table jellies. Here entirely natural flavouring materials find only limited application; fruit juices may be used to impart a desired fruit flavour, but often they are too dilute. By concentrating the juice this defect is partly overcome, but at the cost of some loss of quality. Methods are available at the present time to minimize this loss, such as concentration by freezing or the trapping of the volatile constituents of the flavour, commonly called the esters, which distil off during concentration in vacuo, and the subsequent return of

these fractions to the concentrate. It is possible to concentrate the flavour from five to ten times in this way.

From this it is but a step to the reinforcement of natural flavours by the addition of carefully chosen substances. Such reinforced flavours are frequently used in table jellies or chocolate centres. It is, however, not always possible to use such flavouring materials, either owing to the unsuitability of the base to be flavoured, as in boiled sweets, or to the fact that the required flavour cannot be obtained from natural sources. It is then necessary to employ a compounded or 'synthetic' flavour in a suitable volatile solvent. The development of such flavours, which may consist of mixtures of a considerable number of components, is an art similar to that of the perfumer and calls for considerable skill and experience. To continue the parallel, just as there are good and crude perfumes, so there are variations in flavours and correct and incorrect methods of using them.

The use of added flavour for the purpose of concealing imperfections cannot, of course, be too severely condemned, and the lavish 'splashing in' of crude and unnatural flavours is also objectionable, but otherwise there can be no question of disapproving of any step that can add to the attractiveness and palatability of our food, an object which has been one of man's prime concerns throughout the ages.

The author wishes to thank the Directors of J. Lyons and Co. for permission to make this communication.

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Nutritional Aspects of the Chemical Preservation, Colouring and Flavouring of Fruit and Vegetables

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I propose to deal briefly with the nutritional aspects of the chemical preservation, colouring and flavouring of fruit and vegetable products.

Use of preservatives in fruit pulp and fruit drinks

Fruit preserved for jam-making and other purposes by means of sulphur dioxide is known as fruit pulp; for technical reasons it is necessary to add a little water as well as preservative. The amounts of water and preservative added are limited by Government Order S.R. and O. 1944 to: (1) 3 pt. of preservative and 1.25 gal. of water/cwt. of cooked pulp of black currant, red currant, white currant, gooseberry, plum and apple; (2) 3 pt. of preservative and 1 gal. of water/cwt. of raw pulped strawberry;