Implications of nutritional recommendations on sugar for product development

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The debate on the nutritional role of sugar has been a long one and looks set to continue. There have been recommendations on sugar consumption made by groups in the health field, though many of these have not been quantitative. Probably the best known quantitative recommendation came from a discussion paper prepared by an *ad hoc* working party for the National Advisory Committee on Nutrition Education (1983). This recommended that total sugar consumption should be 20 kg/head per year, about half the present consumption. A limit of 10 kg/head per year was also suggested for foods like confectionery, soft drinks and snacks. By contrast, UK Government expert committees have made no quantitative recommendations on sugar consumption. The COMA report on diet and cardiovascular disease recommended that 'intake of simple sugars (sucrose, glucose and fructose) should not be increased further' (Department of Health and Social Security, 1984). It remains to be seen whether the COMA panel on sugar modifies this recommendation. It is noteworthy that both the US Food and Drug Administration (Glinsman *et al.* 1986) and the British Nutrition Foundation's Sugars Task Force (Clarke, 1987) have given sugars a relatively clean bill of health.

Whatever recommendations are made about sugar and sugar-containing products, the outcome will depend on the ways in which consumers modify their eating habits in the light of advice they receive. Ultimately it is consumers who determine which products are acceptable. It is for the food industry to make products which the public will want to buy. Recent changes in the formulation of manufactured foods to remove or replace certain classes of additives illustrates this, as does the increase in availability of low-fat products. However, only those products which are liked by consumers and serve their needs will survive.

ROLE OF SUGARS IN FOODS

Our liking for sweet foods is there when we are born and persists throughout life (Blass, 1987). The desirability of sweetness is mirrored in many aspects of life, from the role of sweet foods in festive occasions to the role they play in the social development of young children (James, 1979). Many everyday sayings testify to the positive regard with which we hold the sensation of sweetness.

Before discussing the opportunities for replacing sugars in manufactured foods, it is worth listing some of the sugars currently used by the food industry: sucrose, glucose, glucose syrup, fructose and lactose.

The dietary contributions of sugars in the UK, based on information on sugars entering the food supply (Clarke, 1987), are as follows (g/person per d): sucrose 104, glucose 19, honey 1; percentage of energy from all sugars 16·2, percentage of energy from all sucrose 14·0. Since there is wastage, actual consumption is rather less than this, by an estimated 10–30% (Glinsman *et al.* 1986; Clarke, 1987).

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In foods, sugars may act as sweeteners, flavour enhancers, texture modifiers, stabilizers, preservatives, bulking agents, fillers, solubilizing agents, flavour precursors, colour precursors and appearance modifiers. By using sugars singly or in mixtures it is possible to alter the organoleptic qualities of foods to meet the preference of the consumer (Street, 1986).

Over a wide variety of products, from confectionery to baked goods, canned to frozen foods and from cereals to pharmaceutical products, sugars are to be found contributing to products in ways which can significantly affect the acceptability of those products to the consumer.

Sugars not only provide sweetness but they also enhance flavour. This can be by either the masking of undesirable flavours, e.g. bitter or sour tastes, or by emphasizing desirable flavours, e.g. in stewed fruit.

Some key properties of sucrose hinge around its crystalline nature and, in solutions, its interaction with water. In crystalline form it has a low affinity for water, remaining dry at normal humidity. It is thus easily transported and handled and may be used in dry-mix products and in dustings.

Sugars contribute to the texture of many products. What is commonly known as 'mouthfeel' is as important a characteristic as the other properties that a food might have. An acceptable, pleasant 'mouthfeel' can turn a flavoured water into a soft drink. The body and texture of ice cream can be smoothed by the use of glucose syrups and the onset of lactose crystallization can effectively be delayed leading to the retention of smoothness on prolonged storage. In some products the recrystallization of sugars is required and it is necessary to control the manner in which this happens in order to produce the desired product. The confectionery industry provides an example of this in the production of fondants and fudges which have a grained texture. On the other hand, where crystallization of sugars is a serious quality defect, as in caramels and toffees, this can be overcome by the addition of glucose syrup or invert sugar syrup. The overall balance of all the sugars present is the key to an acceptable product.

Sugars also make a large contribution to the textural properties of baked products. The crisp texture of many sweet biscuits is due to the recrystallization of sugar after water has been driven off in the baking process and to the delay in the hydration of starch resulting from the presence of sugar. This enables the 'short' texture to be produced.

In crystalline form sucrose, glucose and lactose can all be used as base material for tablets to provide yet another type of texture. By contrast, in boiled sweets, the sugar is in the form of a 'glass' which is a supersaturated solution of sugar.

In many products, sugars are an important provider of bulk, which is, moreover, soluble, a factor which also contributes vitally to eating quality. Sugar has a preservative action which is utilized, for example, in canning, freezing, preserves and glacé fruits. In canning, sugar enters the 'fruit' cells to preserve texture and minimize oxidation changes when the container is opened to the air. In bakery products sugar retards loss of moisture giving these products longer shelf-life (Junk & Pancoast, 1973).

Sugars can also inhibit microbiological spoilage, the basis of which is the reduction of the water activity. A water activity of less than 0·86 is sufficiently low as to inhibit the growth of many micro-organisms. The addition of monosaccharides to sucrose solutions will maximize the total soluble solids and lower the water activity, and hence combinations of sucrose with invert or glucose syrups, or both, are often used in jams and preserves (Herson & Hallard, 1980).

Table 1. *Function of sucrose and sugars in foods*

	Sweetness	Bulk	Texture/structure	Low hygroscopicity	Preservative	Freezing point depression	Crystallizing	Colour
Cakes	X	X	X				X	X
Biscuits	X	X	X	X			X	X
Boiled/pressed sweets	X	X	X	X	X			
Chocolate	X	X	X	X			X	
Caramels/toffees	X	X	X	X	X			X
Jams	X	X			X			
Pie fillings	X	X	X		X			
Canned fruit	X		X					
Ice cream	X	X	X			X		
Starch/gelatin desserts	X	X	X					

In many cooking processes the Maillard reaction takes place, involving the reaction of reducing sugars like glucose and fructose with amino acids and proteins. This is a non-enzymic browning reaction, the products of which impart both colour and flavour to the product. Caramelization is another manner by which sugars can contribute to the colour of products, as in toffees.

Honey has been used to sweeten foods since time immemorial. Nowadays it is used essentially for its flavour properties. At one time it also served the purpose of a humectant as well as contributing to the recipe as a non-crystallizing sugar and a means of raising the soluble solids. Invert sugar, where sucrose is partially broken down into glucose and fructose, is now more often used. These monosaccharides are better humectants than sucrose.

Sugars, therefore, have various functional roles in food, the majority of which are not performed singly, as can be seen in Table 1. The development of products without sugars, therefore, usually requires the use of more than one alternative ingredient to give the functional properties supplied by the sugars, one of which will be needed to supply sweetness.

SUBSTITUTION OF SUGARS BY ALTERNATIVE SWEETENERS

The alternative sweeteners permitted in the UK are of two main types: bulk sweeteners and intense sweeteners. Bulk sweeteners include hydrogenated glucose syrup, isomalt, mannitol, sorbitol and xylitol, and intense sweeteners comprise acesulfame K, aspartame, saccharin and thaumatin.

Straight substitution of sugar by an alternative sweetener is feasible where the main property needed is sweetness. A notable example is soft drinks, where there has been a major expansion in the availability of low-calorie products. This has happened with the advent of aspartame, a sweetener which lacks the bitterness associated with saccharin, and which is therefore more acceptable. Other foods where sugar is used to impart sweetness and where substitution is technically possible include canned fruit, yoghurt, baked beans, sauces and pickles. The choice may be circumscribed by factors such as

taste, stability or cost. For example, aspartame is not stable at high temperatures and care needs to be used in foods subjected to cooking at any stage. The bitterness of saccharin has already been alluded to, and may not be acceptable in products where sweetness is being used to 'mask' the bitterness inherent in an ingredient, e.g. tomatoes in tomato sauce or in baked beans. Similarly, the alternative sweeteners themselves may mask desired flavour characteristics, making the product less acceptable than the standard version.

The crystallinity of sugar can be substituted in some foods. Chocolate consists of a fat phase filled with small sugar crystals, the range and size of which determine texture and snap. The use of alternative sweeteners like sorbitol, xylitol or isomalt is technically feasible, although with some loss of eating quality. However, sugar alcohols have a laxative effect which places limitations on the quantity which may be eaten. For example, a limit of 30 g sorbitol/d has been suggested (Anon., 1977), which is about the quantity that would be found in a standard chocolate bar.

The crystallinity of sugars is also exploited in the manufacture of fondants for confectionery products, where a concentrated solution of sugar is cooled, causing it to become supersaturated. On aeration crystallization is produced to form an opaque fondant. If the enzyme invertase is incorporated, the fondant subsequently liquefies as the sucrose is hydrolysed by the enzyme, a technique used in the manufacture of chocolate creams and soft-centred chocolate mints. These products cannot be made with most alternative sweeteners.

Sugars can also remain as a supersaturated solution which when cooled makes a 'glass', as is found in clear, hard-boiled sweets. By varying the strength of the sugar solution various textures can be made. Various alternative sweeteners can be used for particular applications.

A very important property of sucrose and other sugars in solution is their interaction with water and hydrophilic polymers. This is of central importance in making cakes and biscuits. These interactions control the hydration of starch and the denaturation of protein in such a way as to allow the development of texture.

It is not possible to replace sugars in the manufacture of sweet biscuits at the present time, and without sugar these products would disappear from the food supply. In cakes, some replacement by polymeric bulking agents is possible together with the use of high-intensity sweeteners, but at the expense of shelf-life and palatability and also at increased cost. To match the keeping qualities of existing cakes, quite high levels of preservatives would need to be used.

The action of sugars in lowering the water activity is the basis of their preservative function at high concentrations, which is important in foods like jams and pie fillings. Reduced-sugar jams which would be subject to microbial spoilage, need to be stored in the refrigerator, or have preservatives added. The caramelization and Maillard reactions which sugars undergo to modify flavour or impart colour are not imitated by alternative sweeteners. The use of food colours may be necessary for some products.

One important factor limiting the use of intense sweeteners is that they lack bulk. In products such as jams, confectionery and cakes, the removal of sugar would require the use of an alternative bulking agent. At present, there is no single satisfactory alternative, although solutions to this problem have been found for some foods, for example the use of polymeric bulking agents in cakes.

Table 2. *Summary of Food Advisory Committee (1988) proposals to control nutritional claims about sugar(s)*

Claim	Condition
'Low in'	5 g/100 g (100 ml) *and* per serving
'Free'	0·1 g/100 g (100 ml) *and* per serving
'No added'	None added to food or ingredient nor use of ingredient which is primarily sugar(s)
'Reduced'	75% compared with similar food

PRODUCT DEVELOPMENT, MARKETING AND LABELLING

Product development does not only entail overcoming technical obstacles which allow the product to be manufactured, but also includes the development of a product philosophy which allows the product to be successfully marketed to the consumer. It may relate to concerns that the consumer has over diet and health issues, for example additives or fat. Quality factors of importance to consumers include whether the product is perceived as being 'wholesome' or made of 'natural' ingredients.

There exist, or are proposed, legal constraints on the types of claims which may be made for food products, for example, The Food Labelling Regulations (1984), and the proposals from the Food Advisory Committee (FAC) to control nutritional claims (Ministry of Agriculture, Fisheries and Food, 1988) (Table 2). There are legal restraints on composition of some foods, such as the standards laid down by the Cocoa and Chocolate Products Regulations (1976). It is within these various frameworks that any products containing alternative sweeteners or changes in sugar content will be launched.

An important factor in marketing products made with alternative sweeteners is likely to be the extra cost of many of these products compared with the standard products. This will be partly due to increased cost of the ingredients in many cases, but also increased complexity in manufacturing the product. The consumer is cost conscious and will need to be convinced of the other virtues of the product.

There is also the problem that the claims made within the framework proposed by the FAC will not necessarily convey to the consumer the relevant nutritional or health message, and there is scope for misunderstanding. Products 'free' or 'low in' sugars would in no way imply, for example, that they are low in energy, as many of the alternative sweeteners have appreciable energy values. Some sugar-free products might even have more energy than equivalent sugar-containing products, since removal of sugar often incurs a quality penalty and it is conceivable that these products might contain more fat, used in the formulation to make a sufficiently attractive product.

THE TARGET CONSUMERS

One target group for sugar-reduced products would be the weight conscious. There is, however, no evidence that the diets of the obese are rich in sweet foods, although there is some evidence that the obese have a liking for fatty foods if they are sweet (Drewnowski, 1987). It is unlikely that the use of alternative sweeteners will, on their own, solve the problems of the obese, since foods made with them will be palatable and will still

contribute to the basic problem of over-eating. The results of research on the effects of sweeteners in the treatment of obesity seem to be contradictory (Rolls, 1987).

Foods containing sweeteners such as sorbitol are often recommended for diabetics. The benefit of these is now regarded as questionable, although foods containing intense sweeteners may be of value to non-insulin-dependent diabetics in assisting control of blood sugar levels (Clarke, 1987).

It is often suggested that the use of alternative sweeteners would eliminate dental caries. Most alternative sweeteners are not utilized by oral bacteria, which otherwise ferment sugars to produce acid at the tooth surface to demineralize the enamel. It might, therefore, be thought that they are particularly appropriate for use in confectionery. However, confectionery contributes only about 16% of the sugar in the diet, and it is unlikely that replacement of sugars in a single category of food would make much impact. A trial of sweets containing Lycasin (hydrogenated glucose syrup) failed to demonstrate a significant reduction in caries (Frostell *et al.* 1974), presumably for this very reason. Partial replacement of sugars in a food product is unlikely to alter its cariogenicity significantly, as the evidence strongly suggests that even relatively low quantities of sugars are sufficient to produce enough acid to demineralize the teeth (Bibby *et al.* 1983; Michalek *et al.* 1977). Limited replacement of sugars is therefore unlikely to have much impact on dental caries, particularly when, as at present, caries rates are falling substantially, probably as a result of the use of fluoride (Downer, 1987). It is also now becoming clear that cooked starches can be broken down in the mouth to sugars which are utilized by oral bacteria to produce acid at the tooth surface. Cooked starches, like sugars, are therefore likely to contribute to the overall cariogenicity of the diet. Removal of sugars might be balanced by an increase in the intake of starches.

Sugars are often accused of contributing nothing to the diet except 'empty calories'. Sugars are, however, rarely eaten on their own, but usually form part of a total food which as a whole will contribute a variety of nutrients. Sugars contribute about 20% of our energy intake in the UK (Clarke, 1987) and it is unlikely that their total replacement would, on its own, have such an effect on total nutrient intake as to be a major factor in correcting nutritional deficiencies, even if such deficiencies existed. Replacement of sugars by alternative sweeteners will not in itself have a dramatic effect on the intake of nutrients. This is because in practice most replacement of sugars will be by bulk sweeteners which do not themselves have a nutrient value over and above energy, and the augmentation of nutrients will only come from foods filling any energy gap left by the loss of sugar. This energy gap may be quite small, however, because many alternative bulk sweeteners have a significant energy value.

OUTLOOK FOR PRODUCTS MADE WITH ALTERNATIVE SWEETENERS

The British Nutrition Foundation Sugar Task Force (Clarke, 1987) and the US Federal Department of Agriculture (Glinsman *et al.* 1986) have both thoroughly examined the relationship between sugars intake and health. No important health problems were seen to exist, although a relationship between frequency of intake of sugars (and other carbohydrates) and dental caries was acknowledged. The overall health benefits of replacing sugars with alternative sweeteners are, therefore, unlikely to be profound. The replacement of sugars may prove difficult for other reasons. Sugars are seen as 'natural' by many consumers whilst many alternative sweeteners, being manufactured by chemical

processes, may be seen as 'unnatural'. All the alternative sweeteners are classed as food additives.

There is also the problem that some sugar alcohols, like sorbitol or xylitol, are incompletely absorbed by the body, leading to osmotic diarrhoea. Although the body of the regular user can become adapted to these sweeteners to some extent, the casual eater on a binge may well suffer laxative effects. These effects can occur at relatively low levels. For example, if the sugar in a typical chocolate bar were replaced by sugar alcohols, then an adult is likely to have problems, with a child being even more severely affected.

Sugars are very versatile in the way that they can be used in food products. This is particularly true of sucrose which would probably be in demand for its functional properties even if it were not sweet. By contrast, no alternative sweeteners have this range of properties, so that in replacing sugars this functionality has to be bestowed by more than one extra ingredient. It is, thus, often difficult to make an alternative-sugar product with eating qualities as good as its sugar-containing counterpart. Also, they usually cost more. These are crucial factors in determining the acceptability of these products to the consumer. Products containing alternative sweeteners will, however, widen the consumer's choice and assist those motivated to reduce their intake of sugars.

Replacement of sugar-containing foods from the diet may have unwanted implications for health. It has been found in two studies that those who come closest to achieving the COMA panel's recommendations for fat in the diet (Department of Health and Social Security, 1984) tend to be the highest consumers of sugars (Nelson, 1985; Gibney *et al.* 1987). Removal of sugar-containing foods without their replacement by suitable alternatives might raise intakes for fat and requires careful consideration of the benefits and risks.

Given that sugars taste good, do not have important negative health implications besides dental caries (which has declined and is continuing to do so) and are otherwise safe and versatile in the way they can be used, it is difficult to see the need for products containing alternative sweeteners.

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