

In Pursuit of Sweet Foods: Dr. Jagdish S. Pai

Stressed spelled backwards is Desserts!

Sweet taste is universally accepted as a pleasurable experience. Sweetness is accepted by humans to characterise foods as safe from substances that are bitter which are construed to be unsafe according to behavioural studies. Even babies like and accept sweet tasting foods readily as they are used to slightly sweet taste of mothers' milk which contains lactose. This taste is cultivated even more when children prefer sweet tasting mithais like pedha, burfi, jalebi, gulab jamun, laddu, etc. as well as candies, chocolates, ice cream, cakes, biscuits & cookies.

Sugar Consumption

Sugar consumption in India is estimated to be over 23.3 million tonnes in 2008-09 from 21.8 million tonnes in the previous year. This is the highest in the world. Consumption of sugar and other natural sweeteners like corn syrup, jaggery etc. in 2003 was around 160 million tonnes of which sugar alone was about 130 million tonnes. The consumption has been increasing in spite of steep increases in price recently as Indians love sweet foods. However, per capita consumption of sugar of Indians of about 24 kg per year is nothing compared to that of Americans, Canadians, Australians and many Europeans and West Indians. Africans normally consume quite low and so do Chinese and Nepalese.

Sugar & Sweeteners consumption by different countries in 2003

| | | | |
|-------------------------------|-------|--------------------------|-------|
| Argentina | 41.00 | Iceland | 56.00 |
| Australia | 47.00 | India | 24.00 |
| Barbados | 57.00 | Jamaica | 54.00 |
| Belgium | 55.00 | Japan | 28.00 |
| Brazil | 56.00 | Mexico | 48.00 |
| Canada | 63.00 | Nepal | 4.00 |
| China | 8.00 | Netherlands | 52.00 |
| Colombia | 49.00 | New Zealand | 60.00 |
| Congo, Democratic Republic of | 2.00 | Pakistan | 27.00 |
| Costa Rica | 57.00 | Sri Lanka | 31.00 |
| Croatia | 60.00 | Swaziland | 50.00 |
| Denmark | 58.00 | Sweden | 47.00 |
| France | 40.00 | Switzerland | 60.00 |
| Germany | 45.00 | Trinidad and Tobago | 57.00 |
| Grenada | 56.00 | United Kingdom | 41.00 |
| Hungary | 45.00 | United States of America | 70.00 |

Brazil is the largest sugar producer (30 million tonnes) followed by India (21), China (11) etc. Among the highest sugar-producing states in India are Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Gujarat. Besides sugar, other common sweeteners used are jaggery, palm sugar as well as corn syrup and dextrose all of which are used commonly in India.

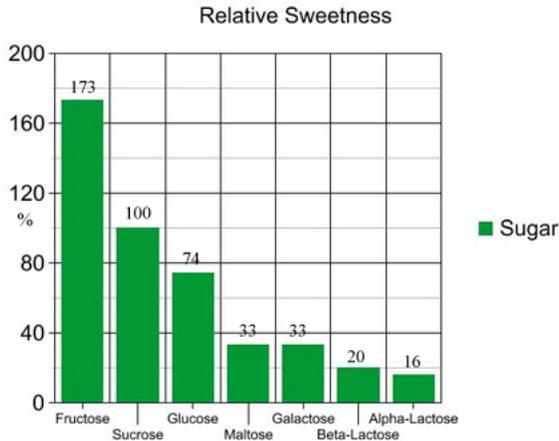
Different Sugars & Their Uses

There are many other sweeteners now available such as high fructose corn syrup, fructose, some sugar alcohols and many high-intensity low-calorie sweeteners like aspartame and sucralose. When one says sugar, it generally means sucrose, however, there are many sugars that are present naturally and those that are used commercially in preparation of sweet foods. There are monosaccharides like glucose, fructose, galactose and there are disaccharides which contain two monosaccharides combined e.g. sucrose (glucose & fructose), lactose (glucose & galactose) and maltose (glucose & glucose).

Early attempts to make alternative sugar source from corn starch by acid hydrolysis gave rise to corn syrup or dextrose and contained mostly glucose with some amounts of maltose and higher saccharides. Although it was sweet it was not as sweet as sugar. Relative sweetness of different sugars is compared in the graph below.

Since corn syrup is not very sweet when compared with sucrose attempts were made to make it sweeter by converting part of the glucose to fructose as glucose is less sweet and fructose is sweeter than sucrose. This conversion was successfully done using enzyme (glucose isomerase or xylose isomerase) and the resultant sugars contained somewhat equal proportions of glucose and fructose. This was named High Fructose Corn Syrup as corn starch was hydrolysed to glucose prior to conversion to fructose. Higher

fructose syrups can be prepared by separating part of the glucose from the mixture and reconverting it to fructose so one can get higher proportion of fructose in the final syrup that is very much sweeter compared to sucrose.



Sugar in India is mostly produced from sugar cane. Many of the other sugar producing countries in South America like Brazil, Mexico etc. also use sugar cane as the source. European countries produce good amounts of sugar from sugar beet. The juice from cane or beet is clarified and concentrated to prepare raw crystallised sugar (also referred to as brown sugar) that may be refined to remove colour and other impurities to give white refined sugar that is over 99% sucrose. The mother liquor from which sugar crystals are prepared is molasses that may be used for fermentative production of ethanol. If the cane juice after clarification using lime is simply concentrated without refining the solidified mass is jaggery. Jaggery has good proportions of minerals including calcium and iron and has brown colour and typical flavour. Lesser colour product may be prepared by using bleaching agents like sulphites. It has fairly good amounts of glucose and fructose as some sucrose gets hydrolysed during its preparation. This also makes the products softer than sugar. Small amounts of sugar or jaggery are also prepared from date palm, sorghum and sugar maple.

| Sugars, brown | |
|---|----------|
| Nutritional value per 100 g (3.5 oz) | |
| Thiamine (Vit. B1) | 0.008 mg |
| Riboflavin (Vit. B2) | 0.007 mg |
| Niacin (Vit. B3) | 0.082 mg |
| Vitamin B6 | 0.026 mg |
| Folate (Vit. B9) | 1 µg |
| Calcium | 85 mg |
| Iron | 1.91 mg |
| Magnesium | 29 mg |
| Phosphorus | 22 mg |
| Potassium | 346 mg |
| Sodium | 39 mg |
| Zinc | 0.18 mg |

Source: USDA Nutrient database

Sugars not only provide energy and sweetness to the food products but have many other useful functions in foods. They act as preservatives in jams, jellies etc. They control crystallisation in confectionery products. They provide texture in many frozen desserts. They balance acidity and enhance flavour in many non-sweet foods like sauces and condiments. They provide nourishment to yeast in fermented products like breads. However, sugars are commonly considered negatively as it is felt that since it tastes pleasant, more quantity of food is consumed when it is sweet contributing to overeating.

Metabolism & Concerns about Sugars

Sucrose when consumed is digested to glucose and fructose and absorbed in small intestine going into the blood. Starch also is digested to glucose that is absorbed there. Glucose metabolism is facilitated by insulin. Glucose level in blood is controlled by several hormones including insulin so it will not keep on rising indefinitely nor fall too low as brain needs constant supply of glucose. Fructose does not require insulin for its metabolism. When adequate amounts of insulin are not produced glucose levels rise very high and remain high for a long time leading to diabetes. Sometimes insulin resistance is developed wherein in spite of adequate amounts of insulin glucose level is not controlled adequately. Diabetes gives rise to many other problems.

Sugars have been blamed for all kinds of ailments including obesity, diabetes type 2, cardiovascular diseases etc. as well as dental caries. There are many epidemiological studies suggesting possible link between obesity and certain lifestyle diseases and the sugar consumption. There are also dietary guidelines recommending restriction of sugars in the diet but there is still ambiguity about the causality of these diseases.

Bacteria in mouth can grow very well and cause tooth decay when sugary substances are available. They produce plaques that progressively deteriorate tooth hygiene resulting in cavities and toothache. It has been found that beverages that allow sugar to remain in mouth transiently do not affect as much as sticky or hard substances like candies that allow sugar to remain in mouth much longer allowing prolific growth of bacteria.

Refined sugars provide calories but are not sources of micronutrients. This led health professionals to ask whether sugars intake negatively affect nutrient quality of diets. Current research does not conclusively correlate sugar intake and micronutrient intake. Some research has found that effect of sugars on micronutrient intakes can depend on the nutritional quality of sugar containing foods consumed. Sweetened milk products would correlate well with sugar and calcium intakes but high consumption of sugar-sweetened soft drinks has lower intake of calcium.

Some researchers believe that consuming high energy density and low nutrient density foods displaces needed nutrients in a diet, but others disagree and suggest that nutrient rich foods intake is independent of intake of high energy density foods.

Institute of Medicine found that very high and very low intakes of added sugars were associated with lower micronutrient intakes and recommends calories from sugars to be not more than 25% in the daily diets. WHO recommends not more than 10%. However, as per American Dietetic Association, these recommendations had impact of epidemiologic, economic, social and political factors and are not based solely on scientific evidence.

As many favourite foods are sweet it is natural to think of their role in contributing to overconsumption and obesity. However, many epidemiological studies find inverse relation between sucrose intake and body weight or BMI. Institute of Medicine found no clear and consistent association between intake of added sugars and BMI.

Scientists have also found that sucrose contributes to satiety and if taken before meals reduces food intake. Evidence available to date shows no direct relation between sugar intake and obesity. Although many older children and adults that are overweight or obese have insulin resistance, the notion that insulin resistance leads to obesity is unproven yet. These individuals however should not overeat or markedly decrease their physical activity.

Researchers at Harvard School of Public Health found a positive association between greater intake of sugar-sweetened beverages and weight gain and obesity in children and adults after review of many studies. They also acknowledge the multifactorial nature of obesity and that the studies do not establish causality. There are other studies that have produced different results and found no statistical association between consumption of sugar sweetened beverages and fruits drinks and BMI. Obesity is a major public health issue. A report by American Institute for Cancer Research and the World Cancer Research Foundation stated that excess weight and obesity can increase the risk for several types of cancers and recommended that intake of energy-dense foods including sugar-sweetened beverages be limited.

Concepts of glycemic index (GI) and glycemic load (GL) were developed as useful tools in management of diets of people with impaired glucose tolerance. It was hypothesised that slowly absorbed, high-fibre foods with low GI would be beneficial in diabetes, GI being a measure of rise in blood glucose caused by consuming a carbohydrate. Glucose has been given a GI of 100. Since the amount of carbohydrate consumed would also affect the rise of blood glucose, GL described both quality and quantity of carbohydrate in a meal. Although a nice and useful concept, it has too many variables that affect the consistency and reproducibility of GI calculations like ripeness, physical form of food, its processing and preparation. Researchers also found variability among individual response to the foods.

There are guidelines and advises that GI is a useful concept for management of blood glucose in diabetics. American Diabetes Association however, states that there is not sufficient, consistent information to conclude that low-GL diets reduce the risk for diabetes although both GI and GL may provide additional benefit over consideration of total carbohydrates alone.

There have been some studies indicating that people who consume diets with high GI or GL may be more likely to develop type II diabetes than those at lower levels. Results from Nurses' Health Study and Health Professionals' Follow-Up Study showed a positive association between GI and diabetes risk. However, recent studies found no such relationship. American Diabetes Association states that current information is not sufficient or consistent enough to conclude that low-GL diets reduce risk for diabetes. It also cautions about use of added fructose as a sweetening agent in diabetic diet due to evidence that fructose may adversely affect plasma lipids. Research is still continuing as there are many other factors such as less physical activity, smoking, high caloric intake, lower intake of protein etc. also come into play.

Although sugars themselves may not have been proven harmful, just like any other energy-dense substance, more one consumes sugar-sweetened foods more calories are consumed and more weight may be put on. This may lead to obesity which might lead to various ailments related to it including type II diabetes, cardiovascular diseases etc. when it is combined with lack of exercise. There are some studies that have shown some relationship of excessive sugar consumption with some of the lifestyle problems although causality has not been shown because of many other factors. It is too early to give a clean chit to very high sugar consumption. Hence it is advisable not to completely avoid sugars but limit sugar-sweetened food consumption and also select nutrient containing sweet foods and to have a physically active life.

Alternative Sweeteners

There are many alternative sweeteners now available some with calories and others either very low or no calories. There is a wide choice of sweeteners for those who want to restrict their caloric intake and those who are diabetic or have difficulty controlling blood glucose levels. Some are natural e.g. sugar alcohols exist in nature and some have been used for long e.g. sorbitol. Stevia leaves and their preparations have been used in some countries for quite long. There are many low-calorie artificial sweeteners that are several hundred times as sweet as sugar and their usage has grown over the years.

Sugar Alcohols or Polyols

A group of sweeteners called sugar alcohols or polyols have been approved in many countries. Many of them are naturally present in fruits and vegetables. The commercially they are prepared from sugars by hydrogenation. Following table gives a list of these with their caloric contents and their sweetness compared to sucrose.

Sugar Alcohols or Polyols

| | Calories per g | Approx. sweetness (sucrose =100%) | Typical Food Applications |
|--|----------------|-----------------------------------|--|
| Sorbitol | 2.6 | 50 - 70% | Sugar-free candies, chewing gums, frozen desserts and baked goods |
| Xylitol | 2.4 | 100% | Chewing gum, gum drops and hard candy, pharmaceuticals and oral health products, such as throat lozenges, cough syrups, children's chewable multivitamins, toothpastes and mouthwashes; used in foods for special dietary purposes |
| Maltitol | 2.1 | 75% | Hard candies, chewing gum, chocolates, baked goods and ice cream |
| Isomalt | 2.0 | 45 - 65% | Candies, toffee, lollipops, fudge, wafers, cough drops, throat lozenges |
| Lactitol | 2.0 | 30 - 40% | Chocolate, some baked goods (cookies and cakes), hard and soft candy and frozen dairy desserts |
| Mannitol | 1.6 | 50 - 70% | Dusting powder for chewing gum, ingredient in chocolate-flavored coating agents for ice cream and confections |
| Erythritol | 0 - 0.2* | 60 - 80% | Bulk sweetener in low calorie foods |
| Hydrogenated Starch Hydrolysates (HSH) | 3 | 25 - 50% | Bulk sweetener in low calorie foods, provide sweetness, texture and bulk to a variety of sugarless products |

Although they are carbohydrates, polyols are partially absorbed in the small intestine and so they have less calories than sugars and starches. Also they do not need insulin for their metabolism and do not affect blood glucose levels greatly. So they can be consumed by diabetics. However, if they are consumed in large quantities they have laxative effects. American Dietetic Association advises that more than 50g of sorbitol or over 20g mannitol may cause diarrhea. This is because as they are partially absorbed a good amount goes to large intestine and microbes there thrive on them and produce gases resulting in laxative effect. Exception is erythritol which is almost completely absorbed and is excreted as such almost completely in urine.

PFA recently allowed sorbitol, mannitol, xylitol, isomalt, lactitol and maltitol in many products including chewing and bubble gums, sugar-based and sugar-free confectionery like candies, chocolate, lozenges etc. while the first three are also permitted in Indian sweets like halwa, Mysore pak, laddoo, jalebi, burfi, peda, gulab jamun, rasogolla etc. Besides lower calories and being safe for diabetics, another advantage of these polyols is that bacteria in mouth cannot use them so they are useful in preventing dental caries.

Low-calorie Sweeteners

There are many low-calorie sweeteners available for use. As more and more people all over the world are facing the problem of obesity and the diabetes, these sweeteners are becoming very popular. They have been tested rigorously and have been found to be safe. As they are extremely sweet, they are required in very small amounts and their normal intake levels have been found to be

adequately safe in all individuals except those with extremely rare genetic disease, phenylketoneuria who must restrict phenylalanine content from all sources of food including aspartame. Although neotame also releases phenylalanine, the fact that it is several thousand times sweeter than sugar, the amounts that would be consumed even by phenylketoneurics would be safe.

Although stevia is natural and not new as its leaves and other preparations have been used in Japan and in some South American countries for long, there was some hesitation in approving it in many countries since it was indicated that certain preparations from stevia leaves may affect fertility and genes. Highly purified steviosides have been proved safe and without any side-effects by several studies so US FDA has recently permitted stevioside and rebaudioside A from stevia to be used in foods although they were permitted in dietary supplements earlier.

| Sweetener | No. of Times Sweeter Than Sugar |
|-------------------|---------------------------------|
| Acesulfame-K | 200 |
| Aspartame | 180 |
| Neotame | 7,000 |
| Saccharin | 300 |
| Stevia sweeteners | 200 |
| Sucralose | 600 |

Saccharin, aspartame, acesulfame K and sucralose have been permitted in India in many food products including soft drinks, chocolates, Indian traditional sweets, sugar confectionery, chewing and bubble gums etc. Neotame has been permitted recently in soft drinks. Thus recently there have been a surge in low calories, sugar-free products in the market and Indians have been enjoying the traditional products at festive occasions without the fear of gaining too many calories and also diabetics can enjoy the sweets at such occasions. Here also, even though one may avoid calories from sugars from such artificially sweetened food products, they are by no means devoid of calories. There are calories in sugarless sweets from fats and proteins and also from carbohydrates like starch. In dairy products, there might also be lactose. All these contribute to calories. Although consumed in restricted amounts these products may be safe for diabetics, if large quantities are consumed, the starch, lactose etc. might contribute to glucose being produced in intestine and absorbed to increase its levels in blood. If such foods have good fibre contents, then the problems would be minimised.

Finally

Sweet foods give a lot of pleasure to all, young and old. However, overindulgence may cause certain problems and afflictions and if neglected might produce certain dangerous diseases like obesity, diabetes and cardiovascular disease. Indians have large number of diabetics and the numbers of obese is rising alarmingly even in children. The problem is not just because of eating sweet foods but overeating and lack of physical exercise. There is not need to avoid sweets but the key is moderation. Dietary fibres also help maintain glucose levels in blood by controlling sugar absorption in blood. Diabetics should consult medical doctors while controlling their carbohydrate including sugar intake. There are many alternative sweeteners available that are shown to be safe at the levels consumed in foods so they may also help satisfy a person's sweet tooth and also not unduly elevate glucose levels in diabetics. Regular physical activity is very essential especially in today's lifestyle which saves a lot of activity and offers a tremendous choice of calorie laden foods.