

Fructose: a high quality sweetener

Flavor enhancing, calorie-reduction and impact on glycemic load



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ABSTRACT: Fructose is a naturally occurring simple carbohydrate, which has successfully find its way into a myriad range of food and beverage applications. Its pleasant profile sweetness and potency make it ideal for applications where calorie reduction is required without compromising on flavor quality. Fructose exhibits synergy with many high-intensity artificial sweeteners as well as with bulk sweeteners. Its improved water holding capacity is translated to moisture retention helping in assuring quality and microbial stability. Moreover, its ability to reduce the glycemic load of food products & beverages makes it an ideal sweetener for development of finished products meeting health concerns.

It is almost of no surprise that fructose is such a common simple sweet sugar in so many fruits and vegetables. Fructose is characterized by an intense sweet taste, which probably assist in spreading around of seeds by birds as well as higher animals. Fructose can be found at relatively high concentrations in many fruits such as; apples, pears, peaches, bananas, kiwi, watermelon, different types of berries, dates, figs, in various types of nuts, in exotic fruits such as Chinese Lou Han Guo, in vegetables such as carrots, broccoli, chicory, onions, spinach, asparagus, artichokes, and in other foods consumed by humans such as honey. Fructose (β -D-fructopyranose) also known as Levulose or "fruit Sugar", is a naturally occurring, 6-carbon keto-type simple carbohydrate. It is a reducing monosaccharide, and is used as a bulk sweetener in foods and beverages. Fructose is commercially produced from natural agricultural resources such as starch (by an initial degradation step to obtain glucose followed by isomerisation and purification), and from sucrose (by inverting it to a mixture of glucose: fructose with additional steps of both glucose isomerisation and fructose enrichment). Technology also exists for the production of fructose from inulin by hydrolysis to its fructose monomeric building block (by either acidic or enzymatic process). Fructose produced from sucrose has the inherent advantage of being non-GMO. Fructose is a highly soluble sugar i.e. ~80 percent (20°C), and is characterized by a Relative Sweetening Value (RSV) of 1.1-1.7 (sweetness values are expressed relative to sucrose, where sucrose = 1.0 and tested at 5-10 percent d.s., in water). The sweetening potency of fructose depends highly on temperature and pH. The range in sweetening potency as affected by temperature is a result of changes in the relative ratio between the four tautomeric molecular existing in fructose solutions.

Fructose is a GRAS and non-allergenic sweetener (1), and its use is not restricted by

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official regulatory bodies. Despite some allegations aiming to uniquely attribute the global obesity problem to consumption of fructose containing sweeteners such as HFCS or sucrose, the only recommendations advised by official health stakeholders (based on cumulative sound scientific evidences) is to limit the addition of simple caloric added sugars to 10-25 percent of daily energy intake (2, 3). The sweetening profile of fructose is characterized by both a rapid

appearing onset of sweetening perception, as well as by the highest relative intensity peak existing for any bulk natural simple sugar. In terms of its potential application in food and beverage products, it is even more important to mention its

"non-lingering" sweetening profile, which is free from any perceived unpleasant taste. It is this quality of taste profile which makes fructose an excellent sweetener used in the new emerging markets for sweetened and flavored low-calorie (2-4 percent w/v) mineral waters. Fructose works well as a "masking agent" for bitterness and metallic tastes and aftertastes, which may be associated with artificial sweeteners such as saccharin and cyclamate. Moreover, combinations of fructose with HIS (aspartame, Ace-K, cyclamate, saccharin) allow a reduction in the caloric content up to 60 percent, while conserving high quality sweetening profiles. In addition, fructose synergistically enhances the sweetening potency making it suitable in preparation of lower calorie dietetic products and fruit preparations with excellent fruity flavors. Fructose exhibits sweetening synergy

effects with several bulk sugars. Surely, the most applicable effect in terms of range of use would be that with sucrose. For instance, a synergy of +30 percent relative sweetness was reported for blends of sucrose fructose in a ratio of 45:55 (4). In frozen yoghurt, ice creams and sorbets prepared with fructose, it is fructose's high freezing point depression ability which helps to formulate softer, "spoon able" and "creamy" ice creams suited for consumption in



winter times (the Freezing Point Depression Factor of sucrose (FPDF) is 1.0, while that of fructose is 1.9). The above mentioned trait is due to its increased ability to immobilize water molecules around it, i.e. amount of unfrozen water in various solution systems (W_g). Fructose is characterized by a W_g of 0.96gr. unfrozen water/gr./solids, while sucrose by a W_g value of =0.56gr. unfrozen water/gr./solids (5). The above mentioned ability of fructose also affects values of Water-Activity (A_w). For example the A_w of saturated fructose solutions at 25°C is 0.634 while that of sucrose at the same conditions is 0.844 (5). We have tested and found that in products such as cakes and cookies A_w decreases by up to 0.05 by replacing 30 percent of the sugar with fructose. Lowering of A_w values may also assist in assuring shelf life by reducing microbial susceptibility. In terms of its contribution to both sweetening potency, quality and calorie reduction, the best potential uses for fructose would be in products consumed at refrigeration temperatures and acid pH's (~ 2.5-4.5). In view of the above, products such as CSD's (carbonated soft drinks), fruit beverages and yogurts would be most benefited with potential calorie reductions of 15-20 percent. In addition to its fruity flavoring-enhancing properties fructose also shows special flavor enhancing interactions i.e. with cinnamon and cocoa, helping to formulate flavored cocoa milk beverages with high quality taste. Additional unique interactions of fructose include partial replacement of sucrose in sweetened starch-containing dairy desserts. In the above mentioned applications, starch gelatinization temperature is reduced by ~ 1.5-2.0°C allowing processing at lower temperatures. As a reducing sugar, fructose provides excellent caramelization ability resulting in nice brownish coloration of bakery products. One of the best possible applications for fructose is its use in production of fruit preparations added to the "white mass" of yogurts. Using fructose, in this case, works in two ways: first a better "fruity flavor" is achieved, and secondly a reduction in "added sugar" is gained. For example a 35 Brix fruit mass consisting of 30 percent added sucrose can be replaced while having an improved flavor with only 15 percent added sucrose, and 5.5-9 percent added fructose. While tested in the production of the "white mass" of yogurts, fructose in comparison with sucrose resulted in better flavor-enhancing contributing power (at additions levels of 3.0-3.5 percent to milks prior to incubation). Moreover, even when the addition of the sugars was done after the fermentation, fructose still resulted in better taste profiles. Another beneficial trait of fructose as a sweetener in food and beverage products includes its ability to contribute to a reduction in glycemic loads of foods.



required (since fructose is typically 1.5 times as sweet as sucrose). Therefore, formulating with fructose works in two ways: (a) fructose has a higher RSV, and (b) fructose is characterized by a low GI. For instance, ice-tea beverage sweetened with 100 grams of sugar/liter will require only ~ 66 grams fructose! The GL of 250cc of that ice-tea sweetened with sucrose would be ~ 15, while replacing it with fructose will result a GL value of only 3.3. There is a variety of products for infant and baby foods in Europe which contain fructose such as: baby milk formulae, baby cereal, fruit puree and more. According to the European Union Legislation Of Foodstuffs directive (91/321/EEC) on infant formulae, annex 2(4/3), it is allowed to add fructose, at the same amount as sucrose and honey, in dosage of 20 percent of the total carbohydrate content. Moreover, according to directive (96/5/EC) on processed cereal based foods and baby foods for infants and young children, it is

allowed to add fructose up to 2.5 g/100 Kcal. In conclusion, there are many applications and opportunities where fructose may be formulated while benefiting from its various special functional, flavoring and energy/GL promising characteristics.

In terms of its contribution to both sweetening potency, quality and calorie reduction, the best potential uses for fructose would be in products consumed at refrigeration temperatures and acid pH's

CONCLUSIONS

This article outlaid the chemical, physical, sensorial and some physiological aspects of fructose, a natural occurring simple carbohydrate sweetener. The above traits were explained viewing in mind their possible contribution to food and beverage formulation. Its sweetening profile, its ability to reduce calorie content, its synergistic behavior with both artificial intensive sweeteners and bulk sweeteners, its water holding capacity, its colegative traits, and lastly its low glycemic index which affects the glycemic load of foods and beverages makes it an ideal sweetener for product development meeting both high quality demands and health concerns.

Another beneficial trait of fructose as a sweetener in food and beverage products includes its ability to contribute to a reduction in glyceamic loads of foods

Carbohydrate	GI
Glucose	100
HFCS 42	69
Sucrose	60
HFCS 55	60
Isomaltulose	55
Lactose	50
Fructose	20

Table 1. Glycemic index (GI) of some carbohydrates

As shown in table 1 fructose is characterized by a GI of ~20 while that of sucrose is ~ 60. In addition, in order to gain equivalent sweetening power with fructose, only ~ 60 percent of the amount of material is

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