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Facts about Fructose

What is Fructose?

Carbohydrates have been an important component of the human diet since Man's earliest times. Cereal grains and tubers provided starchy glucose, while honey, fruits and vegetables supplied simple sugars like glucose and fructose. As methods for refining sucrose (table sugar) from sugar cane and beets developed, glucose and fructose assumed a somewhat increased prominence in the diet relative to starch.

Pure crystalline fructose was first made available for food and beverage use 20 years ago, having been marketed previously primarily as a health supplement. Pure **crystalline fructose** has had a negligible effect on the carbohydrate composition of the diet because of the small volume of this sugar produced relative to all other naturally occurring and added starches, syrups and sweeteners.

Food scientists and technologists favor pure crystalline fructose because it possesses functional properties beyond their inherent sweetness, which extend its usefulness in a wide variety of foods and beverages.

Production

Pure crystalline fructose is a product of both the corn wet milling and sucrose industries. In the former, cornstarch is extracted from corn kernels and, in a series of processing steps, glucose is enzymatically transformed to fructose. In the latter, the disaccharide bond in sucrose is enzymatically hydrolyzed to liberate glucose and fructose. In both processes, the fructose is then crystallized, dried, milled to desired particle size and packaged. The crystalline product is brilliant white and very high purity.

Crystalline fructose and High Fructose Corn Syrup are not the same

The public, the press and even scientists have confused crystalline fructose with high fructose syrups (HFS) [also known as **high fructose corn syrup (HFCS)**, and isoglucose]. They are not the same product. While most would correctly expect that pure crystalline fructose contains fructose alone, many are surprised to learn that HFS contains nearly equal

amounts of glucose and fructose (similar to sucrose). This difference in composition is chemically significant, and leads to differences in certain food applications and specific physiological responses.

Contrary to contemporary reports, the introduction of HFS in the latter quarter of the 20th century really did very little to change the ratio of simple sugars to starch, or the ratio of glucose to fructose. Why? Because sucrose has nearly the same composition, and HFS simply replaced sucrose in many applications on a one-for-one basis. Specifically, HFCS is made from corn while HFS encompasses High Fructose Syrups made from corn, wheat, rice and other starch sources.

(More about [high fructose corn syrup](#))

Safety

Sucrose and HFS have long been considered Generally Recognized As Safe (GRAS). As a significant component of these two sweeteners, the safety of fructose has been thoroughly documented in several authoritative scientific reviews:

- GRAS status of HFS established (1983)⁴ — reviewed by FDA primarily as a component of HFS
- Report of the Sugars Task Force (1986)⁵ — reviewed by FDA from all natural and added sources
- Health Effects of Dietary Fructose (1993)⁶ — reviewed by an ILSI-convened Expert Panel from all natural and added dietary sources
- GRAS status of sugars reaffirmed (1996)⁷ — reviewed by FDA from all added sources

The FDA concluded, "high fructose [corn] syrup is as safe for use in food as sucrose, corn syrup and invert sugar."¹ The ILSI Expert Panel concluded, "fructose is a valuable, traditional source of food energy, and there is no basis for recommending increases or decreases in its use in the general food supply or in special dietary use products."⁸

A Joint Consultation of the World Health Organization and the United Nations Food and Agriculture Organization⁹ found that consumption of sugars is not a causative factor in any disease, including obesity. Specifically stating:

- "Much controversy surrounds the extent to which sugars and starch promote obesity. There is no direct evidence to implicate either of these groups of carbohydrates in the etiology of obesity, based on data derived from studies in affluent societies."

and

- Sucrose and other sugars have not been directly implicated in the etiology of diabetes and recommendations concerning intake relate primarily to the avoidance of all energy-dense foods in order to reduce obesity.

Unfounded allegations

Recent unfounded allegations suggest that fructose is uniquely responsible for the current obesity crisis in the U.S. These allegations - such as increased fat production or increased appetite - are based on poorly conceived experimentation of little relevance to the human diet, which tests unphysiologically high levels of fructose as the sole carbohydrate, often in animals that are poor models for human metabolism. The consequences of such exaggerated diets are predictably extreme, and are thoroughly reviewed by Forbes, et.al.⁶

Meeting consumer demand

A recent consumer survey conducted for the Calorie Control Council shows that more than 180 million adult Americans are incorporating **low calorie foods**, sugar-free foods and beverages into their meal plan as part of a healthy lifestyle.¹⁰ People will continue to demand a greater variety of **low calorie foods** and beverages as they strive to make healthier food choices. Fructose can help meet this demand because of its unique sweetness and functionality.

Fructose has been used in whole new categories of food and beverage products, such as shelf-stable nutrition bars, soft moist cookies, pourable frozen juice concentrates and energy-reduced products.

Some are even suggesting the application of fructose for those with special dietary or nutritional needs, like endurance athletes.

Benefits

- *Sweetness*
Fructose is the sweetest of all nutritive sweeteners. It has roughly 1.2 to 1.8 times the sweetness of sucrose in most food applications.^{11, 12}
- *Flavor Enhancement*
Its sweetness perception peaks and falls earlier than glucose and sucrose, "unmasking" fruit and spice flavors.
- *Ingredient Synergy*
The interaction of fructose with other sweeteners and starches results in a synergy that boosts the sweetness, cake height

(baked goods) and viscosity of foods and beverages.

- *Shelf-stability*
Fructose does not hydrolyze in acidic conditions like sucrose does; so finished product sweetness and flavor are stable over extended storage times.
- *Solubility/Resistance to Crystallization*
While sold in crystalline form, fructose recrystallizes with difficulty once it is solubilized in foods. This property made possible the development of soft moist cookies.
- *Humectancy*
Fructose binds and retains moisture so well that it can replace sorbitol and glycerin in foods, thereby improving taste. Used in low-moisture granola-type bars.
- *Surface Browning*
A major appeal of baked and roasted foods is the pleasing brown surface color and alluring aroma, produced by a chemical reaction between reducing sugars and amino acids. Fructose is the most highly reactive simple sugar.
- *Frozen Applications*
Fructose maintains the integrity of frozen fruit by controlling water and preventing damaging ice crystal formation that can destroy fragile fruit tissue.
- *Glycemic Index/Insulin Release*
Glycemic index has been advocated as a means to gauge the compatibility of foods with the special **diet needs of people with diabetes**. Fructose has a low glycemic index and results in moderate release of insulin to the bloodstream relative to glucose and sucrose.
- *Dental Caries*
The only proven health risk of nutritive sweeteners at typical consumption levels is dental caries. Fructose is among the least cariogenic of the nutritive sugars.

Primary applications areas for crystalline fructose include dry mix beverages, low calorie products, flavored water, still and carbonated beverages, sports and energy drinks, chocolate milk, breakfast cereals, baked goods, yogurt, fruit packs and confections.

Summary

Fructose and HFS are not the same. Fructose is sweeter than sucrose so less is needed to achieve the same sweetness, offering calorie savings. Fructose has a low glycemic index and does not cause surges and dips in blood glucose levels. Pure crystalline fructose offers many functional benefits when added to a wide range of foods and beverages, improving product palatability and stability.

¹Office of the Federal Register, National Archives and Records Administration, US Government Printing Office. Fed Regist, 1983; 48(27):5715.

²Glinsmann WH, Irausquin H, Park YK. Evaluation of health aspects of sugars contained in carbohydrate sweeteners. Report of Sugars Task Force, 1986. J Nutr, 1986; 116:1/S.

³Forbes AL, Bowman BA, Filer LJ, Glinsmann WH, White JS. Health effects of dietary fructose. AJCN, 1993; 58(5S).

⁴Food and Drug Administration. **High fructose corn syrup**. Code of Federal Regulations. Washington, DC: US Government Printing Office; Fed Regist, 1996; 61(165):43447 (21CFR 184.1866).

⁵Glinsmann WH, Bowman BA. The public health significance of **crystalline fructose**. AJCN, 1993; 58(5S):820S.

⁶Joint FAO/WHO Expert Consultation. Carbohydrates in Human Nutrition (FAO Food and Nutrition Paper - 66). Chapter 3 - Dietary Carbohydrate & Disease. Report of a Joint FAO/WHO Expert Consultation, Rome, April 14-18, 1997.

⁷Dieting and Low-Calorie Products Survey, Conducted by Booth Research Services, Inc. for the Calorie Control Council, May 2004.

⁸Hanover, LM and JS White. 1993. Manufacturing, composition and applications of fructose. *Am J Clin Nutr.* 58:724S-732S.

⁹Schallenberger, R.S. and T.E. Acree. 1971. Nutritional and metabolic aspects of sugars. In E.L. Hirst, ed., *Sugar Chemistry*. AVI Publishing Company, Westport, CT.