



**CORN REFINERS
ASSOCIATION**

Questions & Answers About High Fructose Corn Syrup

Since its introduction in the 1970s, high fructose corn syrup has become a widely accepted American sweetener made from corn. This brochure offers answers to some frequently asked questions about this highly versatile, natural sweetener.

What is High Fructose Corn Syrup?

High fructose corn syrup (HFCS) is a sweetener made from corn and can be found in numerous foods and beverages on grocery store shelves in the United States. HFCS is composed of either 42 percent or 55 percent fructose, with the remaining sugars being primarily glucose and higher sugars. In terms of composition, HFCS is nearly identical to table sugar (sucrose), which is composed of 50 percent fructose and 50 percent glucose. Glucose is one of the simplest forms of sugar that serves as a building block for most carbohydrates. Fructose is a simple sugar commonly found in fruits and honey.

HFCS is used in foods and beverages because of the many benefits it offers. In addition to providing sweetness at a level equivalent to sugar,¹ HFCS makes foods such as bread and breakfast cereal “brown” better when baked, gives chewy breakfast bars their soft texture and also protects freshness. HFCS keeps products fresh by maintaining consistent moisture.² For more details, see *Facts About Caloric Sweeteners* on the back cover.

What is the difference between HFCS and sugar?

Sugar and HFCS have the same number of calories as most carbohydrates; both contribute 4 calories per gram. They are also equal in sweetness.²

Sugar and HFCS contain nearly the same one-to-one ratio of two sugars—fructose and glucose:

- ◆ *Sugar is 50 percent fructose and 50 percent glucose.*
- ◆ *HFCS is sold principally in two formulations—42 percent and 55 percent fructose—with the balance made up of primarily glucose and higher sugars.¹*

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High Fructose Corn Syrup Quick Facts

- ◆ Research confirms that high fructose corn syrup is safe and no different from other common sweeteners like table sugar and honey. All three sweeteners contain nearly the same one-to-one ratio of two sugars—fructose and glucose.
- ◆ High fructose corn syrup has the same number of calories as table sugar and is equal in sweetness. It contains no artificial or synthetic ingredients and is a natural sweetener.
- ◆ The U.S. Food and Drug Administration granted high fructose corn syrup “Generally Recognized as Safe” status for use in food, and reaffirmed that ruling in 1996 after thorough review.
- ◆ High fructose corn syrup offers numerous benefits. It keeps food fresh, enhances fruit and spice flavors, retains moisture in bran cereals, helps keep breakfast and energy bars moist, enables baked goods to brown better and keeps ingredients evenly dispersed in condiments.

Additional information and complete copies of peer-reviewed journal articles can be found at www.HFCSfacts.com.

Comparison of Caloric Sweetener Compositions¹

Component Percentage	HFCS-42	HFCS-55	Table Sugar	Invert Sugar*	Honey**
Fructose	42	55	50	45	49
Glucose	53	42	50	45	43
Other Sugars	5	3	0	10	5

* Hydrolyzed sugar comprised equally of free fructose and glucose

** Does not sum to 100 because honey also contains some proteins, amino acids, vitamins and minerals.

For more information on different types of sweeteners, see www.Sweet-Smarts.com.

Once the combination of glucose and fructose found in HFCS and sugar are absorbed into the blood stream, the two sweeteners appear to be metabolized similarly in the body.^{3,4}

In terms of chemical structure, table sugar and HFCS differ by the bonding of their sugars. Table sugar is a disaccharide, in which fructose and glucose are linked by a chemical bond.⁵ Fructose and glucose are not bonded in HFCS, and so are sometimes referred to as “free” sugars.

Is HFCS a “natural” sweetener?

Yes. HFCS, like table sugar and honey, is natural. HFCS is made from corn, a natural grain product. HFCS contains no artificial or synthetic ingredients or color additives and meets the Food and Drug Administration’s policy for use of the term “natural.”⁶

Is HFCS sweeter than sugar?

No. When HFCS was developed it was specifically formulated to provide sweetness equivalent to sugar. In order for food and beverage makers to use HFCS in place of sugar, it was important that it provide the same level of sweetness as sugar so that consumers would not perceive a difference in product sweetness and taste.

HFCS-55 has sweetness equivalent to sugar and is used in many carbonated soft drinks in the United States. HFCS-42 is somewhat less sweet and is used in many fruit-flavored noncarbonated beverages, baked goods and other products in which its special characteristics such as fermentability, lower freezing point, surface browning or flavor enhancement add value to the product.² See *Facts About Caloric Sweeteners* on the back cover.

Is there a correlation between the introduction of HFCS and the rise of obesity in the past 30 years?

Many factors contribute to the development of obesity, yet nutritionists, health experts and researchers generally agree that the chief cause is an imbalance between calories consumed and calories burned. Excessive calories can be consumed as fats, proteins, alcohol or carbohydrates. The American Dietetic Association notes, “Excess body fat [obesity] arises from the energy imbalance caused by taking in too much energy and expending too little energy...Obesity is a complex problem and its cause cannot be simply

attributed to any one component of the food supply such as sweeteners.”⁷

Further, the prevalence of obesity is increasing around the world, according to the International Obesity Task Force—even though use of HFCS outside of the United States is limited or nonexistent.⁸ In fact, sugar accounts for about 92 percent of caloric sweeteners consumed worldwide.⁹

Scientific studies continue to find that HFCS does not contribute to obesity any differently than sugar.

An expert panel, led by Richard Forshee, Ph.D. of the University of Maryland Center for Food, Nutrition and Agriculture Policy, concluded that “the currently available evidence is insufficient to implicate HFCS per se as a causal factor in the overweight and obesity problem in the United States.” The panel’s report was published in the August 2007 issue of *Critical Reviews in Food Science and Nutrition*.¹⁰

The report found that there are many other “plausible explanations for rising overweight and obesity rates” in the United States, listing such factors as “a decrease in smoking; an increase in sedentary occupations; an increase in two-income households and single-parent households; transportation and infrastructure changes that discourage physical activity; a decrease in PE classes and extracurricular sports programs in schools; an increase in sedentary forms of entertainment (i.e. TV/movie viewing, video games, etc.); demographic changes (i.e. aging population, immigration, etc.); a decrease in food costs with increase in food availability; and changes in food consumption patterns.”

Another peer-reviewed study has found that those who frequently consume sweetened soft drinks do not have a higher obesity rate than those who rarely drink them. The study found higher obesity rates correlated with several other factors, such as the amount of time in front of the computer or TV, or the consumption of high amounts of dietary fat.¹¹

Further, the November/December 2005 issue of *Nutrition Today* includes a report from the Center for Food, Nutrition and Agriculture Policy and its Ceres Workshop, which was compiled by scientists who reviewed a number of critical commentaries about HFCS. Their analysis found that HFCS is not a unique contributor to obesity, concluding “there is currently no convincing evidence to support a link between HFCS consumption and overweight/obesity.”¹²

Is HFCS known to cause diabetes?

No. Many parts of the world, including Australia, Mexico and Europe, have rising rates of obesity and diabetes despite having little or no HFCS in their foods and beverages,^{8,9} which supports findings by the U.S. Centers for Disease Control and the American Diabetes Association that the primary causes of diabetes are obesity, advancing age and heredity.

U.S. Department of Agriculture data show that per capita consumption of HFCS has been declining in recent years, yet the incidence of obesity and diabetes in the United States remains on the rise.¹³

Has the use of HFCS in the food supply increased the amount of fructose in the diet?

No. Many press reports note the dramatic increase in HFCS in the food supply since its introduction in the 1970s. However, it is important to note that as HFCS consumption increased, sugar consumption decreased. USDA data show that the per capita use of HFCS in the U.S. food supply was matched with an almost equal decline, on a one-to-one basis, in the per capita use of sugar. In fact, consumption of HFCS has declined since its peak in 1999. The USDA estimates per capita sugar consumption in 2006 was 44.5 lbs per year¹⁴ and 41.5 lbs per year for HFCS.¹⁵

As HFCS use increased in the United States, it replaced sugar in various foods and beverages on a nearly one-for-one basis, as the chart (lower right) illustrates. Yet because sugar and HFCS share a common composition, the ratio of fructose-to-glucose in the diet has remained relatively unchanged over time. This confirms that the approximate overall sugars mixture in the foods and beverages we consume—principally glucose and fructose—is nearly the same today as it was 30 years ago, before HFCS was introduced.

Is HFCS considered a safe food ingredient?

Yes. In 1983, the U.S. Food and Drug Administration listed HFCS as “Generally Recognized as Safe” (known as GRAS status) for use in food, and reaffirmed that ruling in 1996. In its 1996 GRAS ruling, the FDA noted that “the saccharide composition (glucose to fructose ratio) of HFCS is approximately the same as that of honey, invert sugar and the disaccharide sucrose” (or table sugar).¹⁶ GRAS recognition by FDA is important because it is only assigned to food ingredients that are recognized by experts as having a long history of safe use or as having their safety shown through adequate scientific studies.

According to the American Dietetic Association, “Consumers can safely enjoy a range of nutritive and nonnutritive sweeteners when consumed in a diet that is guided by current federal nutrition recommendations ... as well as individual health goals.”¹⁷

Does consumption of HFCS, as compared to sugar, reduce the ability of the body to produce insulin?

No. Both have largely the same effect on insulin production.

Insulin is essentially responsible for the uptake of glucose into cells and the lowering of blood sugar. All caloric sweeteners trigger an insulin response to a greater or lesser extent. Among common sweeteners, pure glucose triggers the greatest insulin release, while pure fructose triggers the least. Both table sugar and HFCS trigger about the same intermediate insulin release because they contain nearly equal amounts of glucose and fructose.¹⁸

It is extremely rare for pure fructose to be consumed alone in the diet. Fructose is usually consumed together with glucose, as it is in HFCS, table sugar and honey. It is important to remember that no matter the source of the ingredients—whether from sugar or HFCS—the human body produces insulin in response to the whole meal consumed.

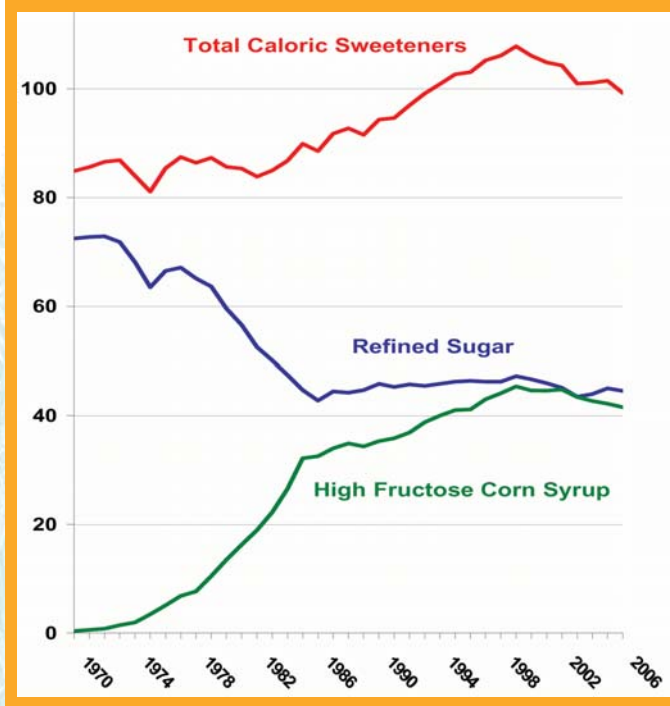
Kathleen J. Melanson, *et al.*, at the University of Rhode Island reviewed the effects of HFCS and sugar on circulating levels of glucose, leptin, insulin and ghrelin in a study group of lean women. All four tested substances have been hypothesized to play a role in metabolism and obesity. The study found “no differences in the metabolic effects” of HFCS and sugar in this short-term study, and called for additional studies of obese individuals and males.¹⁹

Does the body process HFCS differently than other sugars?

No. HFCS contains approximately equal ratios of fructose and glucose, as does table sugar, honey and many fruits.

Once the combination of glucose and fructose found in HFCS and sugar are absorbed into the blood stream, the two sweeteners appear to be metabolized similarly in the body.^{3,4}

Per capita consumption (pounds) of selected sweeteners, 1970–2006.^{14, 15, 20}





Leptin and Ghrelin

Kathleen J. Melanson, *et al.*, at the University of Rhode Island reviewed the effects of HFCS and sugar on circulating levels of glucose, leptin, insulin and ghrelin in a study group of lean women. The study found “no differences in the metabolic effects” of HFCS and sugar.¹⁹

Triglycerides

A study by Linda M. Zukley, *et al.*, at the Rippe Lifestyle Institute reviewed the effects of HFCS and sugar on triglycerides in a study group of lean women. This short-term study found “no differences in the metabolic effects in lean women [of HFCS] compared to sucrose,” and called for additional studies of obese individuals or individuals at risk for the metabolic syndrome.²¹

The metabolic syndrome is a collection of metabolic risk factors including abdominal obesity, atherogenic dyslipidemia, raised blood pressure, insulin resistance, prothrombotic state and proinflammatory state, which increase the chance of developing vascular disease.²²

Uric Acid

Joshua Lowndes, *et al.*, at the Rippe Lifestyle Institute reviewed the effects of HFCS and sugar on circulating levels of uric acid in a study group of lean women. Uric acid is believed to play a role in the development of the metabolic syndrome. This short-term study found “no differences in the metabolic effects in lean women [of HFCS] compared to sucrose,” and called for additional studies of obese individuals and males.²³

Does HFCS affect feelings of fullness?

No credible research has demonstrated that HFCS affects calorie control differently than sugar. A study by Pablo Monsivais, *et al.*, at the University of Washington found that beverages sweetened with sugar and HFCS, as well as 1% milk, all have similar effects on feelings of fullness.²⁴

Stijn Soenen and Margriet S. Westerterp-Plantenga, researchers at the Department of Human Biology at Maastricht University in The Netherlands, studied the effects of milk and beverages sweetened with sugar and HFCS on feelings of fullness. The researchers found “no differences in

satiety, compensation or overconsumption” between the three beverages.²⁵

Tina Akhavan and G. Harvey Anderson at the Department of Nutritional Sciences, Faculty of Medicine, University of Toronto studied the effect of solutions containing sugar, high fructose corn syrup and various ratios of glucose to fructose on food intake, average appetite, blood glucose, plasma insulin, ghrelin and uric acid in men. The researchers found that sugar, HFCS, and 1:1 glucose/fructose solutions do not differ significantly in their short-term effects on subjective and physiologic measures of satiety, uric acid and food intake at a subsequent meal.²⁶

Further, research by Almiron-Roig and co-workers in 2003 showed that a regular soft drink, orange juice and low-fat milk were not significantly different in their effects on hunger or satiety ratings, or in calories consumed at a subsequent meal.²⁷

Does HFCS have a high Glycemic Index?

The Glycemic Index (GI) is a ranking of foods, beverages and ingredients based on their immediate effect on blood glucose levels. The GI measures how much blood sugar increases over a period of two or three hours after a meal. Some scientists believe that selecting foods with a low GI helps in diabetes management.

Carbohydrate foods that break down quickly during digestion have the highest GI. The benchmark in many indexes is glucose, with a GI of 100. Compared with glucose, the GI of fructose is very low with a value of 20. Sugar and honey, both with similar compositions to HFCS, have moderate GI values that range from 55 to 60.²⁸ Although it has not yet been specifically measured, HFCS would be expected to have a moderate GI because of its similarity in composition to honey and sugar.

It must be kept in mind that the body does not respond to the GI of individual ingredients, but rather to the GI of the entire meal. Since *added sugars* (principally sugar and HFCS) typically contribute less than 20 percent of calories,²⁹ it is clear that HFCS is a minor contributor to the overall GI in a normal diet.

Is HFCS allergenic?

A number of cereal grains are known to cause allergic reactions (e.g., wheat, rye, barley), but corn is not among them.³⁰ In fact, the prevalence of corn allergy in the U.S. is extremely low—estimated to affect no more than 0.016 percent of the general population.³¹ Food allergies are caused by certain proteins in foods. Nearly all of the corn protein is removed during the production of HFCS. Moreover, the trace protein remaining in HFCS likely bears little immunological resemblance to allergens in the original kernel.

How is HFCS made?

The corn wet milling industry makes HFCS from corn starch using a series of unit processes that include steeping corn to soften the hard kernel; physical separation of the kernel into its separate components—starch, corn hull, protein and oil; breakdown of the starch to glucose; use of enzymes to invert glucose to fructose; removal of impurities; and blending of glucose and fructose to make HFCS-42 and HFCS-55.²

Endnotes

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Facts About Caloric Sweeteners 1, 2, 32, 33

Sweeteners that contribute calories to the diet are called caloric or nutritive sweeteners. All common caloric sweeteners have the same composition: they contain fructose and glucose in essentially equal proportions. All caloric sweeteners require processing to produce a food-grade product.

Fructose	a simple sugar commonly found in fruits and honey
Glucose	a simple sugar that serves as a building block for most carbohydrates
High fructose corn syrup (HFCS)	free (unbonded) fructose and glucose in liquid (syrup) form; produced from corn
Sucrose	crystalline white table sugar; produced from sugar cane or sugar beets; fructose and glucose bonded together
Invert sugar	free fructose and glucose in liquid (syrup) form; produced from the breakdown of sugar
Hydrolyzed cane juice	free fructose and glucose in liquid (syrup) form; produced from the breakdown of cane juice
Honey	liquid (syrup) product; principally free fructose and glucose with minor levels of other sugars and some trace minerals
Fruit juice concentrate	concentrated, filtered, clarified fruit juice; fructose-to-glucose ratio varies by fruit source, but generally equivalent to other nutritive sweeteners (orange juice and grape juice have a fructose to glucose ratio of 1 to 1, while apple juice has a ratio of 2 to 1)

For more information on different types of sweeteners, see www.Sweet-Smarts.com.

Nutritional Characteristics

Common caloric sweeteners share the same general nutritional characteristics:

- each has roughly the same composition—equal proportions of the simple sugars fructose and glucose;
- each offers approximately the same sweetness on a per-gram basis;
- one gram (dry basis) of each adds 4 calories to foods and beverages;
- each is absorbed from the gut at about the same rate;
- similar ratios of fructose and glucose arrive in the bloodstream after a meal, which are indistinguishable in the body.

Since caloric sweeteners also are nutritionally equivalent, they are interchangeable in foods and beverages with no measurable change in metabolism.

What if caloric sweeteners are removed from foods?

To replace one caloric sweetener with another provides no change in nutritional value. To remove sweeteners entirely from their commonly used applications and replace them with high intensity sweeteners would drastically alter product flavor and sweetness, require the use of chemical preservatives to ensure product quality and freshness, result in a reduction in perceived food quality (bran cereal with the caloric sweeteners removed would have the consistency of sawdust), and would likely require the addition of bulking agents to provide the expected texture, mouth feel or volume for most baked goods.

Why is HFCS used in specific applications?

If consumers are sometimes surprised to find HFCS in particular foods or beverages, it may be because they do not have a full appreciation of its versatility and value. HFCS often plays a key role in the integrity of food and beverage products that has little to do with sweetening. Here are some examples in popular products:

Baked goods	HFCS gives a pleasing brown crust to breads and cakes; contributes fermentable sugars to yeast-raised products; reduces sugar crystallization during baking for soft-moist textures; enhances flavors of fruit fillings
Yogurt	HFCS provides fermentable sugars; enhances fruit and spice flavors; controls moisture to prevent separation; regulates tartness
Spaghetti sauces, ketchup and condiments	HFCS enhances flavor and balance – replaces the “pinch of table sugar grandma added” to enhance spice flavors; balances the variable tartness of tomatoes
Beverages	HFCS provides greater stability in acidic carbonated sodas than sucrose; flavors remain consistent and stable over the entire shelf-life of the product
Granola, breakfast and energy bars	HFCS enhances moisture control, retards spoilage and extends product freshness; provides soft texture; enhances spice and fruit flavors

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