The Journey of Fructose From Plant to Human

By Rex Mahnensmith | Submitted On July 11, 2016

Fructose is a basic carbohydrate component of virtually all fruits and most vegetables. Fructose appears in plants as a secondary product of photosynthesis. Glucose is the primary product of photosynthesis, but fructose and sucrose appear rapidly as glucose undergoes simple transformations in the plant. Fructose content varies from fruit to fruit and from vegetable to vegetable, but fructose is widely available for consumption and has always been present in our diet.

Fructose may be ingested from fruit and vegetables as a simple, resident sugar in the plant. Or, fructose may be ingested in the form of sucrose, which is simply a double-sugar molecule resulting from the union of glucose and fructose in the plant structure.

Ingested fructose is absorbed easily across the walls of our small intestine segments. A specific transport protein facilitates fructose absorption, and this transport protein does not require energy consumption or the presence of sodium. Ingested glucose on the other hand is transported across the walls of our small intestine segments by a different transport protein that requires dedicated energy and the presence of sodium, which serves as a co-transport partner. Ingested sucrose is not directly absorbable. Sucrose has no unique transport protein to facilitate its absorption. Ingested sucrose must be cleaved into its component monosaccharide sugars while still in the small intestinal cavity - fructose and glucose. Then and only then can sucrose yield its energy.

Glucose travels through the intestinal blood stream to enter the general blood stream to feed all tissues and cells, providing immediate energy release once transported into each tissue cell. However, unlike glucose, fructose cannot be directly used as an energy source by all cells of the human body, and though it may circulate through the general blood stream, it is utilized and stored dominantly and principally in the liver.

What is the fate of ingested fructose, then? It is absorbed from our intestines as an intact simple sugar molecule. It travels in our portal blood to the liver. Fructose is taken up by liver cells and enters a metabolic pathway driven by fructose-specific enzymes that first cleave the 6-carbon fructose molecule into 3-carbon chains, then direct these chains to form polysaccharides: starch and glycogen. A small amount of energy is consumed to convert fructose into these other large-molecule structures. In fact, the building of starch and glycogen "stores energy."

Glucose metabolism, on the other hand, generally releases energy to the cells that it enters for essential, vital purposes. Glucose contributes to glycogen and starch building only when glucose is present in excess of immediate tissue energy needs.

What is distinct between glucose and fructose is the fact that glucose metabolism principally yields energy as ATP for vital cell processes and ultimately ends as carbon dioxide (CO2) and water (H20), while fructose metabolism principally stores energy for future use by creating starch and glycogen. As well, importantly, fructose metabolism in the liver can divert into the production of fatty acids and fatty acid chains, or triglyceride molecules. These also are energy-storage, energy-reserve macromolecules.

Scientists have thusly discerned divergent purposes for glucose and fructose: glucose yields immediate energy through glycolysis for all cells; fructose yields stored energy through synthetic steps into starch, glycogen, and triglycerides. These larger compounds reside as energy reserves for eventual breakdown during periods of fasting - when glucose has not been ingested - and the product of their breakdown is principally glucose!

We have learned that the repetitive high intake of fructose is associated with body weight gains. The gains in body weight center in the liver as "fatty liver" and ultimately include visceral adipose, skeletal muscle adipose, and cutaneous adipose.

Nutritional scientists are not certain whether fructose-laden foods promote obesity more than "starchy" foods or "fatty foods." What is clear, with certainty, is that fructose develops fat and glycogen and starch storage, and frequent repetitive fructose ingestion will drive more and more such storage deposits.

Nutrition experts agree that even short-term high-fructose ingestion increases hepatic glucose production during fasting periods, increases blood triglyceride concentrations, and elevates intra-hepatic fat content. Thus, without question, high and frequent intake of fructose can generate fatty liver and general somatic obesity.

Common awareness of these facts is essential so that food consumption can be balanced, moderated, selective, and well-chosen.

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