

Dietary Fructose or Fructose Containing Sweeteners Negatively Impact Health

By William Misner, Ph.D.



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Consuming as little as 40-50 grams or slightly over 1.5-ounce fructose over a 10 hour period may increase blood pressure, blood triglycerides, reduced insulin binding & insulin sensitivity, and increase fat weight gain. The disturbing fact is that the general population has been consuming more than that amount every day for the past 34 years. Total fructose consumed per person from combined consumption of sucrose and high-fructose corn syrup has increased by +26%, from 64 g/d in 1970 to 81 g/d in 1997. As Body Mass Index increases (fat weight gain), the increased risk of insulin resistance, impaired glucose tolerance, hyperinsulinemia, hypertriacylglycerolemia, and hypertension may occur.

Fructose consumption as reported from animal studies (1) has been associated with:

INCREASED LACTATE

INSULIN RESISTANCE

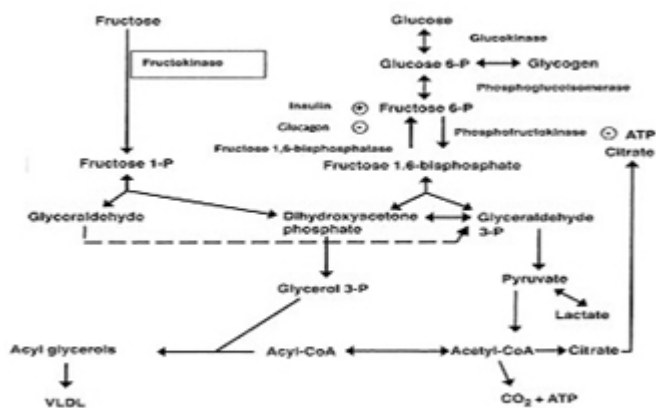
IMPAIRED GLUCOSE TOLERANCE

HYPERINSULINEMIA

HYPERTRIACYLGLYCEROLEMIA

HYPERTENSION

THE PATHWAY: HOW THE LIVER DISPOSES OF FRUCTOSE



Both plasma insulin and leptin act in the central nervous system in the long-term regulation of energy homeostasis. Because fructose does not stimulate insulin secretion from pancreatic β cells, the consumption of foods and beverages containing fructose produces smaller postprandial insulin excursions than does consumption of glucose-containing carbohydrate. Because leptin production is regulated by insulin responses to meals, fructose consumption also reduces circulating leptin concentrations. The combined effects of lowered circulating leptin and insulin in individuals who consume diets that are high in dietary fructose could therefore increase the likelihood of WEIGHT GAIN with its associated metabolic disorders. Fructose, compared with glucose, is preferentially metabolized to lipid in the liver.

Hepatic fructose metabolism begins with phosphorylation by fructokinase. Fructose carbon enters the glycolytic pathway at the triose phosphate level (dihydroxyacetone phosphate and glyceraldehyde-3-phosphate). Thus, fructose bypasses the major control point by which glucose carbon enters glycolysis (phosphofructokinase), where glucose metabolism is limited by feedback inhibition by citrate and ATP. This allows fructose to serve as an unregulated source of both glycerol-3-phosphate and acetyl-CoA for hepatic lipogenesis. P, phosphate.

The hepatic metabolism of fructose has important effects on both glucose and lipid metabolism. Absorbed fructose is delivered to the liver via the portal vein. Fructose is phosphorylated in the liver by adenosine triphosphate to form fructose-1-phosphate. The reaction is catalyzed by the enzyme fructokinase. Fructose-1-phosphate is split by aldolase B into glyceraldehyde and dihydroxyacetone phosphate. Both can be converted to glyceraldehyde-3-phosphate. Thus, the fructose molecule is metabolized into 2 triose phosphates that bypass the main rate-controlling step in glycolysis, 6-phosphofructokinase. By contrast, hepatic glucose metabolism is limited by the capacity to store glucose as glycogen and, more importantly, by the inhibition of glycolysis and further glucose uptake resulting from the effects of citrate and ATP to inhibit phosphofructokinase. The products of fructose metabolism in the glycolytic pathway of the liver are glucose, glycogen, lactate, and pyruvate. Because fructose uptake by the liver is not inhibited at the level of phosphofructokinase, fructose consumption results in LARGER INCREASES OF CIRCULATING LACTATE than does consumption of a comparable amount of glucose.

Elliott et al., (1) hallmark review of the literature reported several harmful effects from habitual consuming of processed fructose-containing sweetener agents. They report that regular consumption of processed fructose negatively impacts blood pressure, blood lipid triglycerides, insulin resistance and glucose metabolism, with fat weight gain proportionate to time and total dose:

DIETARY FRUCTOSE OR FRUCTOSE-CONTAINING SWEETENERS NEGATIVELY EFFECT BLOOD PRESSURE

Species	Amount fed	Study Length	Effects on blood pressure	Reference
Rats	35% of energy as fructose and 35% as starch or 70% starch or 59% fat	4 wk	Increased mean arterial pressure with fructose	(2)
Rats	5%, 10%, or 20% fructose in drinking water	1 wk	Fructose-induced hypertension with 10% solution by end of 1 wk	(3)
Rats	66% of energy as fructose with or without sodium chloride	3 wk	Systolic BP increased in fructose-fed rats receiving the high-salt diet	(4)
Dogs	60% of energy as fructose or dextrose	20-28 d	Mean arterial pressure increased with fructose	(5)
Humans (males with or without hyperinsulinemia)	0%, 7.5%, or 15% of energy as fructose	5 wk each	Systolic BP slightly higher with 0% fructose; no difference in diastolic BP	(6)

1BP, blood pressure.

DIETARY FRUCTOSE OR FRUCTOSE-CONTAINING SWEETENERS NEGATIVELY EFFECT TRIGLYCERIDES

Species	Amount fed	Study Length	Effects on lipids	Reference
Rats	68% fructose	100 d	Increased TGs that were reversed when a chow diet was reintroduced	(7)
Rats (copper-replete or -deficient)	Fructose or starch as the sole carbohydrate source	4 wk	Increased TGs with fructose; increased total cholesterol with fructose plus copper	(8)
Dogs	60% of energy as fructose or dextrose	20-28 d	Increased fasting TGs with fructose	(9)
Humans (males with or without hyperinsulinemia)	0%, 7.5%, or 15% of energy as fructose	5 wk each	TGs in hyperinsulinemic men increased as fructose increased	(10)
Humans (males with or without hyperinsulinemia)	20% of energy as fructose or cornstarch	5 wk each	TGs increased in both groups with fructose but not with cornstarch	(11)
Humans (males and females aged 13-55 y)	Consumed either sucrose, fructose, or xylitol	2 y	No differences in plasma cholesterol or TGs	(12)
Humans (males and females)	40 g fat with or without 50 g fructose	Only 10 hours	Fat plus fructose led to higher postprandial TGs; increased TGs correlated with baseline TGs	(13)
Humans (males and females with or without type 2 diabetes)	1 g fat/kg body wt plus 0.75 g/kg body wt of either fructose or starch	Only 6 hours	TGs rose more slowly but were higher after fructose than after starch 4-6 h after the meal; increased TGs positively correlated with fasting insulin	(14)

Humans (males and females)	17% of energy as either fructose or glucose	6 wk	Higher fasting and postprandial TGs in older men with fructose	(15)
Humans (females)	30% of energy as fructose or glucose with 3 meals	24 hours	Higher postprandial TGs with fructose and higher fasting TGs the following day	(16)

1TG, triacylglycerol.

DIETARY FRUCTOSE OR FRUCTOSE-CONTAINING SWEETENERS NEGATIVELY EFFECT FAT WEIGHT GAIN

Species	Amount fed	Length study	Effects on weight	Reference
Rats	15% of energy as fructose or cornstarch	15 mo	No differences in body weight or relative food intake	(26)
Hamsters	60% fructose or sucrose	2 wk	Increased energy intake, weight gain, and adiposity with fructose	(27)
Humans (males and females)	1150 g soda sweetened with HFCS (80 g fructose) or artificial sweetener	3 wk	Increased energy intake and body weight with soda sweetened with HFCS	(28)
Humans (middle-aged males)	50-60 g fructose/d	24 wk	Increased body weight	(29)
Humans (overweight males and females)	28% of energy as sucrose or artificial sweetener	10 wk	Increased energy intake, body weight, and fat mass with sucrose intake	(30)

1HFCS, high-fructose corn syrup.

CONCLUSION

Only a modest amount of processed fructose sugar is associated with harmful consequences to human subjects and more precarious interventions imposed in animal research. Healthy normal athletes should NOT therefore impose a known health risk during exercise or during sedentary mealtimes by consuming a processed fructose-sugar sweetener.

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There is no intention implied condemning natural unprocessed fructose sugar found in whole fruit.