INE INSTITUTE OF NUTRITIONAL ENDOCRINOLOGY

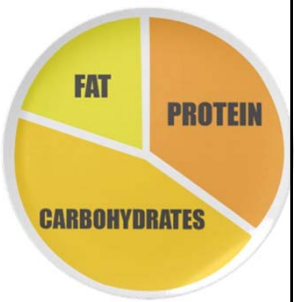
Macronutrients: Sugar Structure and Function

Dr. Ritamarie Loscalzo

Medical Disclaimer: The information in this presentation is not intended to replace a one-on-one relationship with a qualified health care professional, and is not intended as medical advice. It is intended as a sharing of knowledge and information from the research and experience of Dr. Ritamarie Loscalzo, drritamarie.com, and the experts who have contributed. We encourage you to make your own health care decisions based upon your research and in partnership with a qualified health care professional.

Primary Macronutrients

- ✓Water
- ✓Fat
- ✓Protein
- ✓Carbohydrate

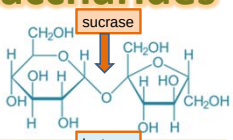


Review: Sugar on a Molecular Level

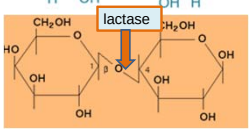
- ✓ Review: Sugar on a Molecular Level
  - ➢ Monosaccharides
  - ➢ Disaccharides
  - ➢ Oligosaccharides
- ✓ Why you need sugar
- ✓ Where sugar comes from in the diet
- ✓ What affects rate of absorption and uptake into cells
- ✓ How sugar is converted to energy
- ✓ What's needed for sugar to be efficiently utilized
- ✓ The negative effects of simple sugars
- ✓ Alternatives to sugar for satisfying your sweet tooth

Disaccharides

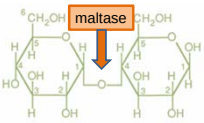
Sucrose



Lactose

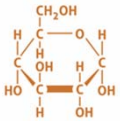


Maltose

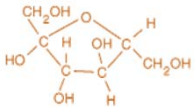


Monosaccharides

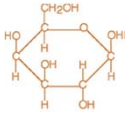
Glucose



Fructose

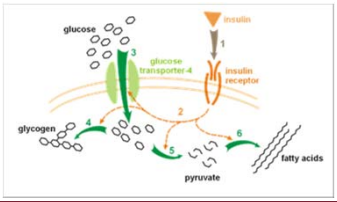


Galactose



Glucose

- ✓Transported across intestinal brush border by the sodium-dependent hexose transporter, SGLUT-1
  (http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/absorb_sugars.html)
- ✓Requires insulin to enter cells and be converted to ATP



Fructose

- ✓ Does not require insulin
- ✓ Only tiny amounts circulate in blood
- ✓ Requires GLUT5 transporter to enter cells
- ✓ Converted to triglycerides in the liver
- ✓ Consumption of high-fructose meals reduces 24-h plasma insulin and leptin concentrations, increases triglycerides, and does not suppress ghrelin; thus, does not turn off appetite
- ✓ Hepatic metabolism of fructose favors lipogenesis
- ✓ High fructose consumption correlated to smaller LDL particle size and increased cardiovascular risk

http://ajcn.nutrition.org/content/86/4/895.full

Fructose From Added Sugar

- ✓ Increases plasma uric acid
- ✓ Contributes to advanced glycation end products
- ✓ Can change metabolic hormonal response, possibly contributing to decreased satiety
- ✓ Highly lipogenic when consumed in high quantities
- ✓ Contributes to hepatic insulin insensitivity, chronically elevated insulin levels, increased cholesterol and triglycerides levels, and the development of a prediabetic state

http://www.ncbi.nlm.nih.gov/pubmed/20086073

Fructose In Whole Fruit

- ✓Fruits have lots of water, fiber, and a low energy density. They take a while to chew and are filling. It's **almost impossible** to overeat fructose by eating fruit.
- ✓When people add fruit to their diet, they reduce their calorie intake elsewhere to compensate.
- ✓Fructose from added sugars is bad, and it does NOT have the same effect if from real foods like fruits.

Table 1. Sugar content of selected common plant foods (g/100g)[28]

Food Item	Total Carbohydrate[A] including "dietary fibre"	Total Sugars	Free Fructose	Free Glucose	Sucrose	Fructose/ Glucose Ratio	Sucrose as a % of Total Sugars
Fruits							
Apple	13.8	10.4	5.9	2.4	2.1	2.0	19.9
Apricot	11.1	9.2	0.9	2.4	5.9	0.7	63.5
Banana	22.8	12.2	4.9	5.0	2.4	1.0	20.0
Fig, dried	63.9	47.9	22.9	24.8	0.9	0.93	0.15
Grapes	18.1	15.5	8.1	7.2	0.2	1.1	1
Navel orange	12.5	8.5	2.25	2.0	4.3	1.1	50.4
Peach	9.5	8.4	1.5	2.0	4.8	0.9	56.7
Pear	15.5	9.8	6.2	2.8	0.8	2.1	8.0
Pineapple	13.1	9.9	2.1	1.7	6.0	1.1	60.8
Plum	11.4	9.9	3.1	5.1	1.6	0.66	16.2
Vegetables							
Beet, Red	9.6	6.8	0.1	0.1	6.5	1.0	96.2
Carrot	9.6	4.7	0.6	0.6	3.6	1.0	77
Corn, Sweet	19.0	6.2	1.9	3.4	0.9	0.61	15.0
Red Pepper, Sweet	6.0	4.2	2.3	1.9	0.0	1.2	0.0
Onion, Sweet	7.6	5.0	2.0	2.3	0.7	0.9	14.3
Sweet Potato	20.1	4.2	0.7	1.0	2.5	0.9	60.3
Yam	27.9	0.5	tr	tr	tr	na	tr
Sugar Cane		13 - 18	0.2 – 1.0	0.2 – 1.0	11 - 16	1.0	high
Sugar Beet		17 - 18	0.1 – 0.5	0.1 – 0.5	16 - 17	1.0	high

http://en.wikipedia.org/wiki/Fructose

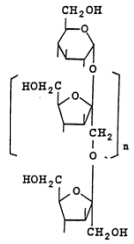
Galactose

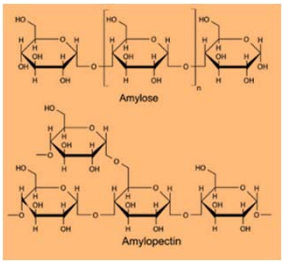
- ✓ Transported across intestinal brush border by the sodium-dependent hexose transporter, SGLUT-1
- ✓ Can be converted to glucose-6-phosphate *https://www.inkling.com/read/marks-medical-biochemistry-lieberman-marks-4th/chapter-29/ii--galactose-metabolismmetaboli*
- ✓ Some studies show correlation with ovarian cancer
- ✓ Galactose is a component within the ABO blood group system. O and A have two galactose, whereas there are three galactose in B.
- ✓ Alpha-1,3-galactose, or Alpha-Gal for short, has been recognized as a delayed allergy to mammal meat

http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/absorb_sugars.html

Oligosaccharides

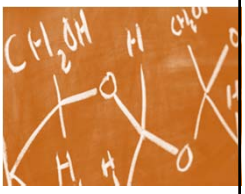
Fructooligosaccharides





Why You Need Sugar

- ✓ Energy
  - ➢ For optimal cellular growth and repair
  - ➢ For gland and organ function
  - ➢ For mental clarity, attention, and focus
  - ➢ For steady moods
  - ➢ For having fun
  - ➢ For meaningful relationships
  - ➢ For achieving success in your chosen career



Where Sugar Comes From In Foods

Best Sources (Complex)

- ✓ Green leafy vegetables
- ✓ Rainbow-colored vegetables
- ✓ Root vegetables and tubers
- ✓ Fruit
- ✓ Whole, non-gluten grains
- ✓ Legumes
- ✓ Nuts and seeds

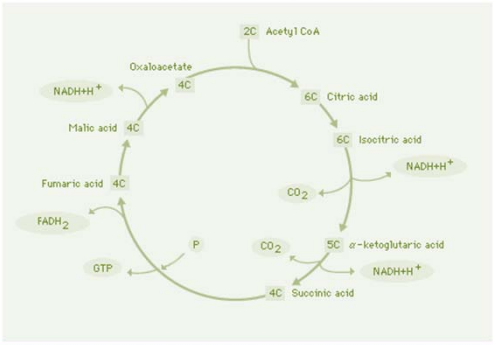
Less Desirable Sources (Simple)

- ✓ Table sugar (sucrose)
- ✓ Fructose
- ✓ Glucose syrup
- ✓ High fructose corn syrup
- ✓ Maple syrup
- ✓ Agave nectar
- ✓ Coconut nectar
- ✓ Palm sugar
- ✓ Honey
- ✓ Refined grains

Getting Sugar Into Cells

- ✓ Insulin
- ✓ Healthy Insulin Receptors
- ✓ Nutrients

Converting Sugar into Energy



Negative Effects of Simple Sugars

- ✓ **Blood sugar imbalances** leading to insulin resistance, diabetes
- ✓ Dental cavities
- ✓ **Decreased immunity**
- ✓ Accelerated **cancer cell growth**
- ✓ **Premature aging**
- ✓ Hostility and aggressiveness
- ✓ **Decreased libido**
- Mental decline – **Alzheimer's**

- ✓ **Depletion of** B vitamins and other nutrients **required for energy production**
- ✓ Intestinal distress
- ✓ **Candida overgrowth**
- ✓ Mood swings
- ✓ **Depression**
- ✓ Addiction
- ✓ **Inflammation**
- ✓ …many, many more

Assessing Tolerance To Various Sugars

- ✓Home Testing
  Check blood sugar for several hours after eating a variety of foods
- ✓Lab Testing
  - ➢Fasting blood glucose
  - ➢Hemoglobin A1C
  - ➢Fructosamine
  - ➢Insulin

Best Alternatives To Sugar For Satisfying Your Sweet Tooth

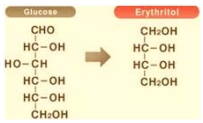
- ✓**Stevia:** Green plant
  - ➢**fresh is best,**
  - ➢*then* green powder,
  - ➢*then* SweetLeaf concentrate
- ✓**Lo Han:** Chinese herb
- ✓**Erythritol:** Sugar alcohol
- ✓**Chicory root inulin:** Maybe – test
- ✓**Yacon:** Maybe – test

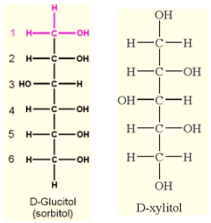
Alternatives To Sugar: Products

- ✓***Zero:***
  Organic erythritol
- ✓***Lakanto:***
  Lo Han and erythritol
- ✓***Just Like Sugar:***
  Chicory root

Sugar Alcohols

- ✓Also known as polyols
- ✓Do not contain ethanol
- ✓Sweetness similar to sucrose
- ✓Fewer calories than sugar
- ✓Naturally occurring and chemically derived
- ✓Do not raise blood sugar





Sugar Alcohols Compared

Name	Sweetness relative to sucrose	Energy (kcal/g)	Sweetness per food energy, relative to sucrose
Erythritol* (4 carbon)	0.812	0.213	15
Mannitol (6 carbon)	0.5	1.6	1.2
Sorbitol (6 carbon)	0.6	2.6	0.92
Xylitol (5 carbon)	1.0	2.4	1.6
Compare with: **Sucrose**	1.0	4.0	1.0

** Erythritol is by far the best choice, sorbitol the worst*

Erythritol

- ✓ Most absorbed in the small intestine and excreted unchanged in the urine and feces
- ✓ About 10% enters the colon - does not normally cause laxative effects
- ✓ Free of side effects in regular use
- ✓ Doses over 50 grams (1.8 oz) can cause nausea and stomach rumbling
- ✓ More difficult for intestinal bacteria to digest than other sugar alcohols, so it's less likely to cause gas or bloating
- ✓ Naturally occurring in pears, melons, grapes, mushrooms, wine, soy sauce, and cheese

Resources for Deeper Understanding

Advanced Nutrition and Human Metabolism Chapter 4

Sugar Shock – Connie Bennett