Sugars, Sweeteners and Society revisited

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Fall 2015
Course Outline

Sept 17, 2015
1. Introduction: Photosynthesis, how plants make sugars, sugar cane & sugar beet, spread of sugar cane cultivation, chemistry & nomenclature of various sugars, sugar metabolism. Film “Sugar from cane a tour of Hawaii’s largest mill”

Sept 24, 2015

Oct 1, 2015
3. Sugar Barons: Drax, Beckford, Tate, Spreckels, Block-Bauer, Fanjul brothers and others. Effects of Sugar cultivation on the environment.

Oct 8, 2015
4. Taste: physiology and psychology. "Sugar substitutes" Alternative sweeteners: non-caloric high intensity sweeteners, such as acesulfame-K, aspartame, saccharin, sucralose. FDA acceptance and international use.
Course Outline

Oct 15, 2015
5. "Other caloric sweeteners” maple syrup, corn syrup, High Fructose Corn Syrup (HFCS), sugar alcohols.

Oct 22, 2015
6. “Is there reliable evidence that sugar causes or is associated with any disease(s)?” Heart disease, diabetes mellitus, and obesity. Fructose the arch criminal of metabolic syndrome?

Oct 29, 2015
Film: Fed Up  Produced and narrated by Katie Couric, the film takes us through interviews with more than 20 nutrition experts, basically a who’s who of New York Times Magazine nutrition articles in the last decade—Marion Nestle, Michael Pollan, Gary Taubes, Michael Moss, Michele Simon, David Ludwig—and others

Nov 5, 2015
7. “Sugar and dental caries” epidemiologic findings, interventional human studies, special population groups, non-interventional studies. Assessment of cariogenic potential of foodstuffs. Animal studies.

Nov 12, 2015  Make-up week
8. Attempts to limit consumption of sugar: Sin tax on sugary beverages, other ways to reduce sugar intake (weight watchers, school cafeterias)
“That Sugar Film?
Abbott, E. Sugar a bittersweet history, Duckworth Overlook, N.Y. 2008
Aykroyd, W.R. The Story of Sugar, Quadrangle Books, Chicago, 1967
Cohen, R. Sugar Love (A not so sweet story) National Geographic 224: 78-97, August 2013
Deer, N. Cane sugar. 2nd Ed. Norman Rodger, London. 1921
http://www.theatlantic.com/features/archive/2014/06/sugar-wars/372220/
Hochschild, A. Bury the chains, Houghton Miflin, 2005.
Lustig, R. Fat chance: beating the odds against sugar, processed food, obesity, and disease. Hudson Street Press, 2013.
References

Walvin, J. The Zong: a massacre, the law and the end of slavery. TJ International Ltd, Padstow, Cornwall. 2011
www.sugarscience.org/
www.youtube.com/watch?v=0z5X0i92OZQ  (Dr. Robert Lustig)
http://nyti.ms/1PbBL9N
Books for lay-readers about sugar

1998

SUGAR BUSTERS!
THE #1 NEW YORK TIMES BESTSELLER
CUT SUGAR TO TRIM FAT
- Lose weight
- Lower your cholesterol
- Achieve optimal wellness
- Increase your energy
- Help treat diabetes and other diseases

Featuring easy recipes from New Orleans’s top restaurants—and a 14-day meal plan!

H. LEIGHTON STEWARD MORRISON C. BETHEA, M.D. SAM S. ANDREWS, M.D. LUIS A. BALART, M.D.

2013

NEW YORK TIMES BESTSELLER
Robert H. Lustig, M.D., M.S.L.
author of THE FAT CHANCE COOKBOOK

FAT Chance
Beating the Odds Against SUGAR, PROCESSED FOOD, OBESITY, and DISEASE

“How no scientist has done more in the last fifty years to alert Americans to the potential dangers of sugar.”
—GARY TAUBES, author of WHY WE GET FAT AND WHAT TO DO ABOUT IT

2013

Salt Sugar Fat
How the Food Giants Hooked Us

MICHAEL MOSS
SONOMA COUNTY LIBRARY
37540 3077 482 1

Sonoma County Library
37540 3077 482 1
Photosynthesis for dummies

Where do sugars originate? In plants that trap the energy from sunlight and using CO$_2$ and water, make sugars.
Photosynthesis transfers electrons from water to energy-poor CO₂ molecules, forming energy-rich sugar molecules.
Sugar cane

Saccharum officinarum

Sugar beet

Beta vulgaris
Sugar cane originated as a grass in New Guinea.
Origin and dates of spread of sugar cane cultivation
Spread of sugar cane cultivation

- Origin in Papua-New Guinea 10,000-8,000 BCE
- Spread via East Indies now Indonesia (1000 BCE), to India (500-600 BCE), Philippines, China (286 CE) & Persia
- Arabs introduced sugar to Mediterranean countries (700 CE): Egypt, Syria, Malta, Cyprus, Sicily, Spain
- Spread to Morocco, Azores, Madeira, Canary & Cape Verde Islands ~(1440s)
- Spread to Hispaniola (Cuba), West Indies, South & North America (1500 CE)
Spread of sugar cane cultivation
From Spain and Morocco to Canary Islands, Madeira, and Azores
and in 1493 to West Indies
and in 1500s to Brazil, Florida and Louisiana
First European encounter with Sugar

Alexander the Great

• ~300 BCE on invading India encountered sugar cane which Alexander called: “the grass that gives honey without bees.”

• Nearchus, an officer in Alexander’s army, described sugar as looking like salt but tasting like honey.
How honey is made

Honey starts as flower nectar, which is collected by bees, naturally broken down by enzymes in the bees' stomach into simple sugars and stored in honeycombs. The unique design of the honeycomb, coupled with constant fanning by the bees' wings, causes evaporation to take place, creating the thick, sweet liquid we know as honey.
Composition of Honey (%)

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>~18%</td>
</tr>
<tr>
<td>Total Carbohydrates</td>
<td>~82%</td>
</tr>
<tr>
<td>Fructose</td>
<td>38.5%</td>
</tr>
<tr>
<td>Glucose</td>
<td>31.0%</td>
</tr>
<tr>
<td>Disaccharides</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

Composition depends on sources but is mostly an equal mixture of fructose and glucose with about 18% water. Honey contains traces of protein, amino acids, phenolics, & phytochemicals.
Honey Facts

- Used as a sweetener since prehistoric times
- Less convenient to use and store than sugar
- Less versatile in cooking and more expensive
- Increased demand not met by increased production

Honey seeker depicted in 8000 year old cave painting, Arana caves, Spain

Rock Painting, 500 BCE
Singanpur, India
Honey Myths

• Nutritional significant mineral content, untrue
• Will not rekindle sexual fire
• Will not cure asthma or respiratory ailments
• Not tolerated better than other sugars by diabetics
• Not safe for teeth
Global production now exceeds 120 Million tons a year
~70% produced from sugar cane (tropical climate)
~30% produced from sugar beet (temperate zone)
## Sugar cane production annually in USA (2012)

<table>
<thead>
<tr>
<th>State</th>
<th>Production (short tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florida</td>
<td>13.1 million</td>
</tr>
<tr>
<td>Louisiana</td>
<td>10.8 million</td>
</tr>
<tr>
<td>Hawaii</td>
<td>&lt; 1 million</td>
</tr>
<tr>
<td>Texas</td>
<td>&lt; 1 million</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>has declined</td>
</tr>
</tbody>
</table>

Government announces major plan to reactivate Puerto Rico's sugarcane production to help rum distilleries (2014)
Sugar beet

2000 BCE shown in Egyptian temple drawings
722 BCE catalogue of kitchen garden of Babylonian King
1747 Andreas Marggraf extracted sugar from beet
1799 Franz Archard developed practical method of extraction
King Frederick William III Prussia granted land for factory
1811 Benjamin Delessert presents sugar loaf from beets to Napoleon who saw it as a way to circumvent British blockade of French Caribbean Islands.
Beet sugar also appealed to Anti-Slavery Movement. Unlike cane, beet can be grown in temperate climates. Now accounts for 40% of total world sugar production.
E. H. Dyer established first successful sugar-beet processing in California. Followed by Claus Spreckels (1822-1903).
Sugar beet growing states in USA

- Arizona
- California
- Colorado
- Idaho
- Kansas
- Michigan
- Minnesota
- Montana
- Nebraska
- New Mexico
- North Dakota
- Ohio
- Oregon
- Texas
- Utah
- Washington
- Wyoming
Sugars 101: Nomenclature

**Carbohydrates** chemically consist of carbon, hydrogen and oxygen; nutritionally they are one of the basic food groups that includes sugars, starches, and fiber.

**Sugars** chemically are aldehyde or ketone derivative of polyhydric alcohols. They are sweet carbohydrates of various kinds of both animal and vegetable origin.

**Monosaccharides** $\text{C}_6\text{H}_{12}\text{O}_6$

- Glucose (blood sugar)
- Fructose (fruits)
- Galactose (dairy products)

**Disaccharides** $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

- Lactose (milk)
- Maltose (beer, vegetables)
- Sucrose (table sugar)
Sugar definitions

All sugars are carbohydrates, consist of monosaccharides, \((C_6H_{12}O_6)\) that contain 6 carbon atoms as well as hydrogen & oxygen, or disaccharides \((C_{12}H_{22}O_{11})\) made up of 2 monosaccharides less a water molecule.

**Sucrose**: disaccharide, nonreducing, consisting of glucose and fructose, “plant sugar” made by photosynthesis

**Glucose**: (dextrose) monosaccharide, reducing, “blood sugar”

**Fructose**: (levulose) monosaccharide, reducing, “fruit sugar”

**Lactose**: disaccharide, reducing, made up of glucose and galactose, “milk sugar”
Carbohydrate Nomenclature

Monosaccharides
- Glucose (dextrose)
- Fructose (fruit sugar)
- Galactose
- Invert sugar (1:1 glucose & fructose)

Disaccharides
- Sucrose (table sugar)
- Maltose
- Lactose (milk sugar)
- Trehalose (mushroom sugar)

Natural & Manufactured oligosaccharides (3-10 units)

Polysaccharides (>10 units)
- Starch
Metabolism of carbohydrates

• Poly- and disaccharides are hydrolyzed in the stomach to monosaccharides

• Glucose and galactose are actively transported across the small intestine to the venous blood

• Other sugars e.g. fructose diffuse passively across the intestine

• After transport in the blood, sugars are taken up by the cells and used either directly for energy, stored in the liver or muscles as glycogen or converted to fats
Sugar terminology

• Sugar from sanskrit *sarkara* meaning gravel, based on its appearance in small crystals. It is 99.95% sucrose.

• Candy from sanskrit *khanda* denoting a piece, referring to large crystals.

• Raw sugar, prepared directly from plant juice, consists of crystals of sucrose coated with a film of molasses. It is ~ 96-98 % sucrose.

• Molasses (treacle, black strap) brown liquid residue of uncrystallizable sugars as well as some sucrose, used in cooking, confectionery, manufacture of rum, cattle feed.
Sugar terminology (continued)

- **Turbinado**: almost completely refined cane sugar, just shy of last redissolving process. Crystals large & crunchy
- **Demerara**: Partially refined sugar from Guyana, generally sprinkled on baked goods for texture
- **Muscovado**: Minimally refined brown cane sugar with sticky candylke texture, bittersweet taste, Used in gingerbread, chutney, barbecue sauces
- **Powdered (confectioner’s) sugar**: granulated sugar that has been pulverized, mixed with corn starch to prevent clumping. Used for decorative purposes, icings, candy
- **Granulated white (table) sugar**: Highly purified to 99.95% sucrose. Good all purpose for baking, confectionery
Glucose is a 6 carbon sugar shown in the open chain form (Fischer projection on left) but mostly exists in cyclic pyranose form by nucleophilic addition between the aldehyde group on C-1 and the hydroxyl -OH at C-4.
Fructose (fruit sugar)

Fructose is a 6-carbon polyhydroxyketone shown in the open chain form (Fischer projection lower right). Crystalline fructose adopts a cyclic six-membered structure owing to the stability of its hemiketal and internal hydrogen-bonding. Found in many plants, where it is often bonded to glucose to form the disaccharide sucrose. Commercially, fructose is frequently derived from sugar cane, sugar beets, and corn. The primary reason that fructose is used commercially in foods and beverages, besides its low cost, is its high relative sweetness, being 1.73 times as sweet as sucrose. [\]
Sucrose, commonly named table sugar or sugar, is cane and beet sugar. The molecule is a disaccharide combination of the mono-saccharides glucose and fructose with the formula $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.

It is a white, odorless, crystalline powder with a sweet taste. ~ 175 million metric tons of sucrose were produced worldwide in 2013. The word "sucrose" was coined in 1857 by the English chemist William Miller from the French sucre ("sugar") and the generic chemical suffix for sugars -ose.
Crystals of Sugar magnified
My parents decriminalized sugar