

# Ethnobotany. Lecture 10

Alexey Shipunov

Minot State University

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# Outline

- 1 Sugar plants
  - Sweeteners
  - Sugar cane
  - Sugar beet
  - Sugar maple
  - Sugar palms and other lesser sugar plants



# Results of Exam 1: statistic summary

Summary:

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
41.00	51.00	54.00	58.62	64.00	90.00

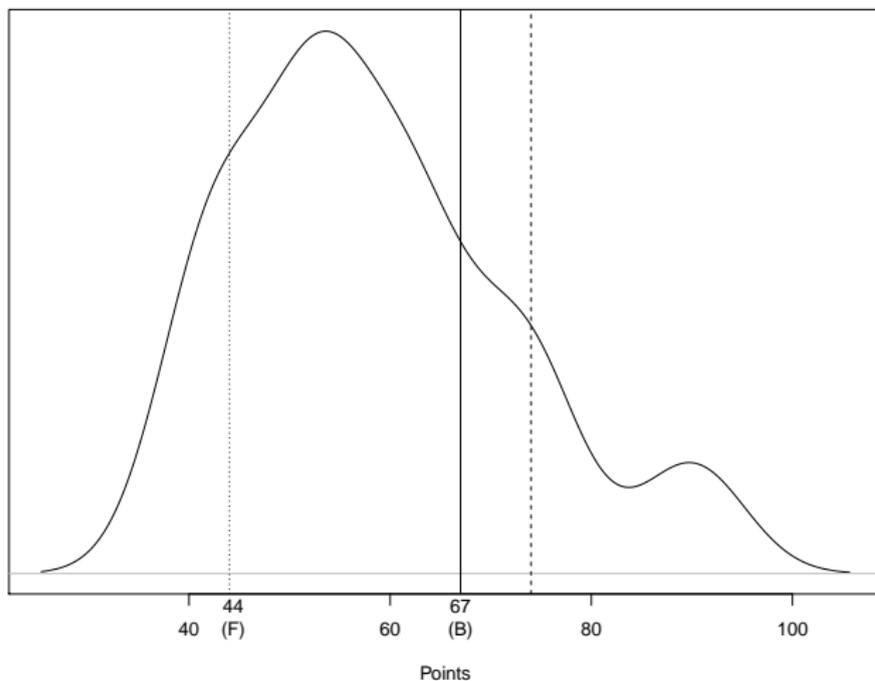
Grades:

F	D	C	B	max
44	52	59	67	74



# Results of Exam 1: the curve

Density estimation for Exam 1 (Biol 154)



# Sugar plants

## Sweeteners



# Our native natural sweeteners

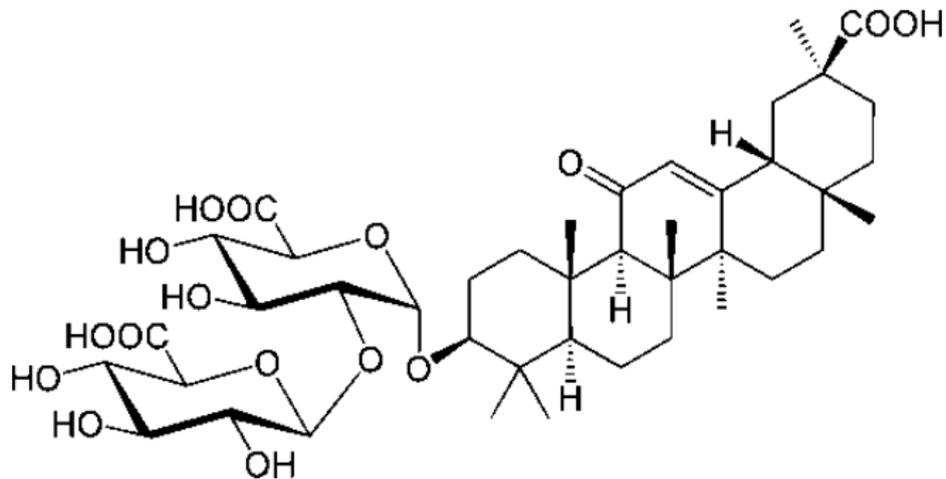
- North Dakotan wild licorice (*Glycyrrhiza lepidota*) belongs to legume family, Leguminosae
- Contains natural sweetener glycyrrhizin
- Side-effects are hypertension and lowering of testosterone level in males



# American licorice, *Glycyrrhiza lepidota*



# Glycyrrhizin

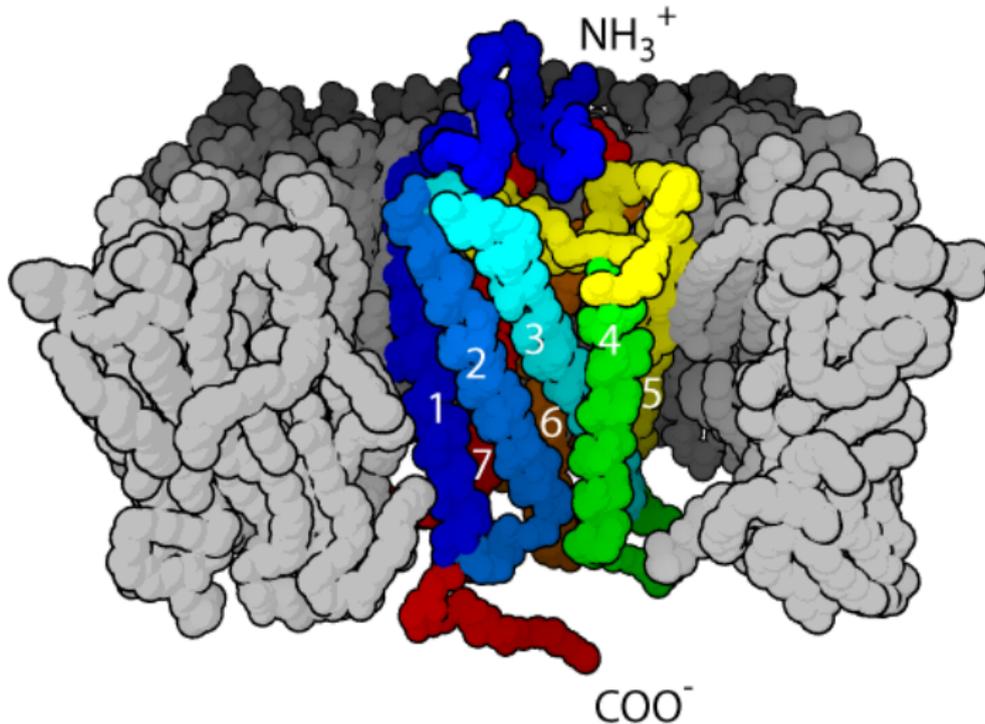


# What is sweetness?

- Nature of sweetness is not yet fully discovered
- Probably due to specific Van der Waals forces occurring in variety of molecules
- These molecules have an effect on sweet receptors—large proteins from G protein-coupled receptors (GPCRs) group



# GPCR, sweetness receptor



# Miracle fruit, *Synsepalum dulcificum*, the super-sweetener

- West African tree, belongs to tropical Sapotaceae family
- Berries convert sour tastes into sweet tastes (!), effect lasts for  $\approx 1$  hour
- The effect is due to glycoprotein miraculin which is binding to sweet receptors
- Cultivation is now starting in Florida, approval as food additive is pending—it is heat-resistant and may be used as a “sweetener”; there are genetically modified lettuce plants which produce miraculin
- Curculin from *Curculigo latifolia* (“lumbah-lumbah”), Malaysian herb from Hypoxidaceae family, has the same effect + it is also super-sweet by itself (500–2000 times sweeter than sucrose)



# Miracle fruit



# Miraculin glycoprotein



# Lumbah-lumbah



# Anti-sweeteners

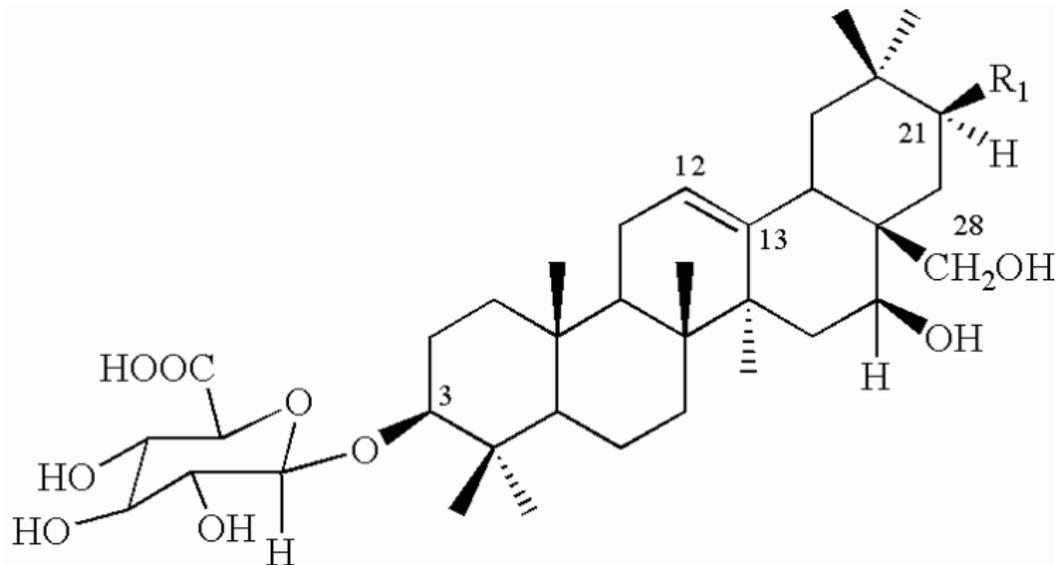
- Several plants contain chemicals which are able to suppress sweet receptors
- Indian herbaceous vine *Gymnema sylvestris* from a dogbane family (Apocynaceae) contain gymnemic acids which suppress sweet taste for  $\approx 10$  min
- In addition, plant has an unrelated (?) effect in lowering blood sugars
- Used as a drug for curing Type 2 diabetes and different forms of metabolic disorders



# *Gymnema sylvestre*



# Gymnemic acid



# Sugar plants

## Sugar cane



# Sugar cane, *Saccharum officinarum*

- Belongs to grass family, Gramineae; it is a C<sub>4</sub> grass
- The oldest cultivated sugar plant
- Contains sugars in stem



# Sugar cane



# Sugar cane biology

- Extremely tall grass, up to 6 m tall (!)
- Stem phloem\* juice contains 12–20% of sucrose in lower parts of stem
- Juice is pressed, filtrated, evaporated, centrifuged (to separate syrup from sugar crystals) and dried



# Sugar cane agriculture

- Grafted culture, it is not recommended to wait until flowering
- Short-day, sun-loving plant, optimal temperatures should be  $> 20^{\circ}\text{C}$
- Requires irrigation even in humid tropics (!) and significant amounts of phosphorous
- Vegetation period is up to 250 days



# Sugar cane history

- The culture started in Indian center, then moved to China and with Arabs—to Europe (Spain, 1150 AD)
- Arabs first invented white, filtrated sugar
- Went to Central and South America in XVI century (Europe needs sugar but it was not growing well there!).
- Now cultivated in tropical America, Africa and Asia (top producers are Brazil and India) but culture is declining under the pressure of competition with sugar beet
- Etymological dictionary says that:

**sugar:** late 13c., from O.Fr. sucre “sugar” (12c.), from M.L. succarum, from Arabic sukkar, from Pers. shakar, from Sanskrit sharkara “ground or candied sugar,” originally “grit, gravel”

# Sugar plants

## Sugar beet



# Sugar beet, *Beta vulgaris* var. *saccharifera*

- Amaranth family, Amaranthaceae (or Chenopodiaceae in older classifications)
- Same species with vegetable beet
- Has been selected from leaf and root beets for only 300 years: one of the youngest cultures
- Root contains up to 20% of sucrose



# Sugar beet from North Dakota! (that's a joke photo)



# Sugar beet biology

- Biennial plant: first year with rosellate leaves, second year forms stem with non-showy flowers
- The “root” is actually intermediate structure between stem and root in strict sense—hypocotyl
- Has anomalous secondary growth (layers of tissues)
- Roots are “white”: do not contain betalain (red pigment which probably helps red beet to protect tissues from fungi and animals)



# Sugar beet agriculture

- Hardy plant: North Dakota is one of the leading states in sugar beet cultivation
- Yield is typically  $\approx 70$  ton/hectare (wet mass), and 12 ton/hectare (pure sugar): compare with  $\approx 100$  and  $\approx 10$  for sugar cane
- Some plants should be left for seeds (second year)
- Susceptible for weeds (needs herbicides)



# Sugar beet history

- In 1747, the sucrose content was discovered
- In 1810s, due to continental blockade of France, sugar mills were established across all Europe
- In XX century, sugar production was almost doubled
- Leading countries now are France, Germany and U.S.; one of biggest research centers is NDSU



# Sugar plants

## Sugar maple



# Sugar maple, *Acer saccharum*

- Tree from Sapindaceae (*Aceraceae* in older classifications) family
- Old semi-cultivated plant of eastern tribes of Native Americans
- Spring sap is the main source of sugar



# Sugar maple



# Native sugar-making



# Sugar maple features and history

- Sap contains 2–5 % of sucrose, the season starts in early spring and continues 4–8 weeks
- In total one tree could produce up to 50 liters of sap per season for 60–70 years (from 30–40 to 100 years old)
- Production increased during Civil War
- Leading producer is Canada (Quebec)
- Analogous birch syrup from *Betula* is more poor, only 1–2% of sugars



# Sugar collection



# Sugar evaporation



# Sugar plants

## Sugar palms and other lesser sugar plants



# Sweet sorghum, *Sorghum saccharatum*

- Grass, selection started in 1940s
- Similar in agriculture, but much less demanding plant than sugar cane
- 10–20% of sucrose in stems
- Now cultivated mostly in U.S. and Argentine



# Sweet sorghum



# Arenga sugar palm, *Arenga pinnata*

- Belongs to palm family, Palmae
- The source of “gur” sugar and also wine
- Inflorescences are used for taking sap (17–20% of sucrose)



# Arenga sugar palm



# Arenga sugar palm features and history

- Syrup are very easily inverted (hydrolyzed into glucose and fructose) and should be evaporated as soon as possible
- Every day, palm tree gives 5–7 liters of sap; the season is up to 8 weeks
- Old Indian culture spread into south-east Asia



# Collection of palm sap



# Toddy, *Caryota urens*

- African sugar palm, one of the largest palms
- Monocarpic tree, dies after flowering
- Since the sap is fermented fast, it mostly used as a source of palm wine ( $\approx 1\%$  of alcohol)
- Starred in groundbreaking novel “The Palm Wine Drinkard” by Nigerian author Amos Tutuola



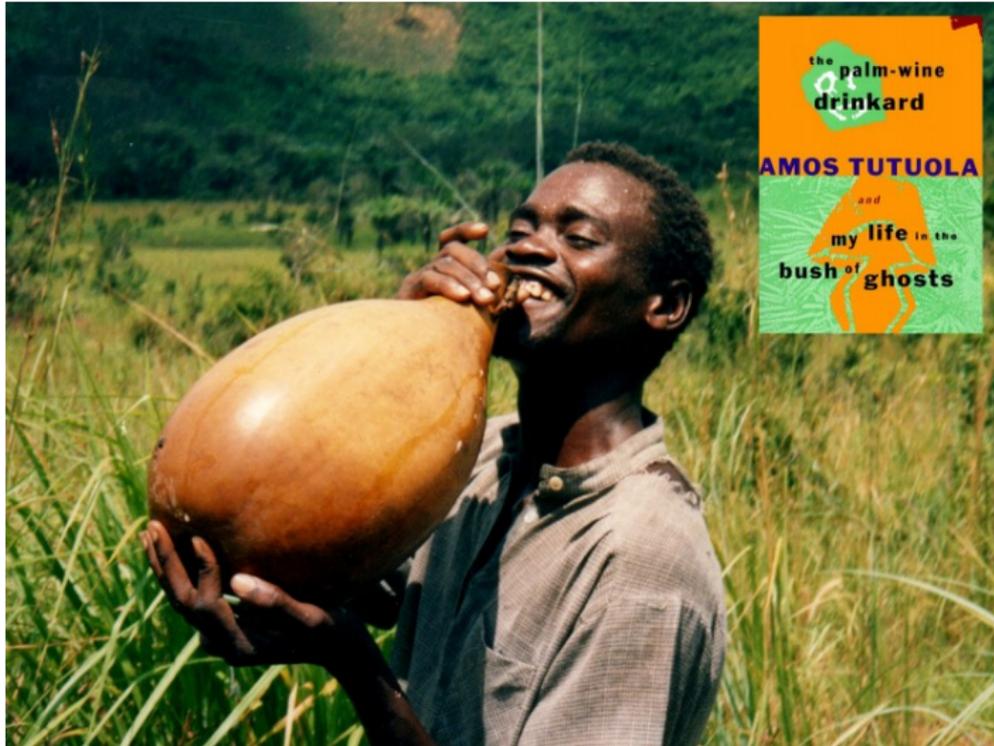
# Toddy palm



# Toddy palm on flowering stage



# Palm-wine drinkard



# Mezcal, tequila agave, *Agave tequilana*

- Monocarpic Mexican plant from asparagus family (Asparagaceae)
- The sap is rich of sugars, mostly fructose
- Used mostly for alcohols like mezcal, pulque and tequila



# Mezcal



# Summary

- Sugar is highly used but controversial source of energy
- Sweet taste still has undiscovered nature
- Two plants produce more than 2/3 of sugars: sugar beet (production is increasing) and sugar cane (decreasing)
- Many tropical sugar plants are used mostly for alcohol production



# For Further Reading



A. Shipunov.

*Ethnobotany* [Electronic resource].

2011—onwards.

Mode of access:

[http://ashipunov.info/shipunov/school/biol\\_310](http://ashipunov.info/shipunov/school/biol_310)



P. M. Zhukovskij.

*Cultivated plants and their wild relatives* [Electronic resource].

Commonwealth Agricultural Bureaux, 1962.

Mode of access:

[http://ashipunov.info/shipunov/school/biol\\_310/  
zhukovskij1962\\_cultivated\\_plants.pdf](http://ashipunov.info/shipunov/school/biol_310/zhukovskij1962_cultivated_plants.pdf)

**Pages 23–27.**

