Carbs, a lecture summary

Providing most energy consumed by the population (First nutritious food in developing countries).

D-Glucose: Aldoexode (an aldehyde) and D-Fructose: Ketohexose (a ketone) are the most renowned carbs. Carbs are poly-hydroxyl-aldehydes and ketones or substances that yield them along hydrolysis.

-Mono/Di/Tri/Tetra/and Polysaccharides are how foods are classified.

Monosaccharides

-As **D-Glucose** is reformed by a self-attack of oxygen onto the anomeric carbon, the products are α-D-Glucose and β-D-Glucose (which only differ regarding the direction of –OH on the primary carbon).
-Fructose undergoes the same process in producing its 5-carbon ring molecule. The Differences between α and β are the same as in glucose, the difference in the orientation of –OH on the primary carbon (C#2)

-D-**Glucose** (the most ready form for humans), and D-**Fructose** are the most common forms.
-D-**Galactose** is not found in free form in foods, it's usually combined with D-Glucose in the form of **Lactose**.

Oligosaccharides:

<u>1- Disaccharides</u>

(Maltose, Lactose, and Sucrose)

- **Maltose**: Carbon #1 (anomeric Hydroxyl) with Carbon #4 of another (**1,4 - alpha bond**) is produced **between two Glucose hexose rings**: Reducing Sugar, repeating unit in starch production.
- **Lactose**: Carbon #1 (anomeric Hydroxyl) of **Galactose with** Carbon #4 of a **Glucose** ring. The bond is between Beta Carbons and produces a **1,4-beta bond**, producing Lactose, as a reducing sugar.
- **Sucrose**: Linking Glucose and Fructose (**a-D-Glucose and B-D-Fructose**).
  (Water is removed as H2O and a glycosidic linkage is produced between an alpha and a beta this happens when both anomeric hydroxyls are involved in the linkage and no reducing end is produced):
  it is a Non-Reducing (either called alpha-1-2 or Beta-2-1). Most commonly consumed, found in all fruits. Equal amounts of glucose and fructose
  Sucrose is used to prepare Invert Sugar; it has different optical rotations (invertase=sucrose). **Sucrose reacts with acid in the presence of heat** (citric acid usually) **and is split into the two different molecules. Fructose (40%) is found in larger amounts than glucose(34%) and Sucrose(2.5%) in genuine Honey and the more, the better quality**.
  Invert sugar is **sweeter** than and **does not crystalize** as much as sucrose does, which makes it more economically available.
  In Jam-Making, the acid in the fruit plays an important role; **enough time given with heat while making jams ensures complete inversion of the sugar** (if not, the remaining sugars will crystalize after a while due to low amounts of acid left in the fruit).

2- Oligosaccharides (3 or 4 monosaccharaides)

- **Raffinose:**

(Trisaccharide) Galactose and Sucrose (Galactose/α–1-6 /Glucose/Fructose) produces Raffinose, which is a non-reducing sugar.

- **Stachyose**

A **Tetrasaccharide [Galactose/α-1-6/Galactose/α1-6/Glucose/Fructose]** containing contains Galactose & Raffinose.

Legumes produce Stachyose in high amounts. There is no enzyme in the human body that would separate the link between Galactose and Raffinose. They are indigestible. They are kept in carbonated water before cooking to limit Stachyose and Raffinose.

α-galactosidase is found in tablet form to limit flatulence.

Functional Properties of Sugar

-Ability to lower Water activity (**Humectancy**): Binds water by H-bonds and stabilizes them

- **Sweetness**: Fructose > Invert sugar > Sucrose > Xylitol (low cal. Sugar/alcohol found in plumbs) > Glucose > Lactose. Sweetness is a highly desirable taste by humans and lots of mammals

-**Visually:** Highly concentrated sugar solutions have a high refractive index; this produces a brighter color, reflected by the sugar.

-**Flavors and Colors**: sugars interact with other components.

-**Curing & Brines**: used to cure Cold-cut meat. Nitrates + Nitrites + Salt + Vit. C+ Sugar. (Nitrates and Nitrites are Carcinogenic, Vitamin C is added to lower the concentration of the produced carcinogens; Sugar is added to lower the "harshness" of the added salt and because of its reducing properties to prevent the discoloration of meat that usually produces brown patches).

3- Polysaccharides (4+ and chains of monosaccharaides)

- **Starch:** Starch is the standard energy storage in plant cells, stored in granules which are contained within the cells in a highly organized structure, characteristic shape and size for each plant (potato starch granules are the largest Elliptical shaped while rice has the smallest, confined by cellulose cell walls; starch is of two types:

  - **Amylose:** non-reducing end, reducing end, α-1-4 linkages usually **around 25%** of the starch present
    High Amylose Starch >50% - 100%, used to prepare Resistant starch which is indigestible in most individuals (the higher content of amylose means quick gel formation)

  - **Amylopectin:** α-1-4 linkages and α-1-6 linkages present, it **holds and binds water, usually around 75%** of the starch present.
    Under Heat conditions, starch granules are deformed and deflated
    A Gel consists of a **discontinuous liquid phase** (the trapped water in the gel) and a **continuous solid phase** (Made out of starch's components that organize under heat); it's **formed upon heating a starch suspension and subsequent cooling to room or lower temperatures**. The amylose chains that leach out of the granule and

into the solution, as the it's cooling, amylose forms a matrix both outside and inside the granules, water is trapped in the matrix which preserves the gel's integrity.

- **Stage I swelling**: **hydrogen bonds break, Amylose starts migrating outwards** due to the heat conducted by water, partial cooking of starchy foods occurs, the cellulose cell walls soften and the starch granules swell and begin to gelatinize while the pectin remains insoluble. Amylose outside the granules creates a gelatinized structure

- **Stage II swelling**: As the foods are fully cooked, fatty acids also break, the starch granules completely gelatinize, pectin becomes soluble, amylose completely escapes the granule and gelatinizes around them while the **amylopectin remains in the expanded, pasted granules**, cells separate easily.

The gel becomes a paste and when cooled, the sample is gel.

Viscosity increases due to gelatinization and so does the their digestibility
Cold water obviously plays no role on starches (heat always required)
(Unlike intracellular water, water around the food does not play a role in the swelling; it's merely a medium of heat transfer)

I. Pectic Substances

Pectin is a soluble gelatinous polysaccharide, which is present in ripe fruits and is used as a setting agent in jams and jellies. **Polymers of D-galacturonic acid units** of varying degrees of esterification linked by **α (1→ 4) linkages**

$$\textbf{Degree of Esterification} = \frac{\textbf{\# of Esterified D-Galacturonic Acid Units}}{\textbf{Total \# of D-Galacturonic Acid Units}} \times 100$$

Esterification is a typical process by which fruits ripen
Commercial sources of Pectin: Apples, Citrus peel…

a. High Methoxy Pectin Gels (DE>50%)

Works under Acidic pH and is dependent on sugar concentration
Pectin gelatinizes at Low/Acidic pH (at low pH, the negatively charged Oxygen bound at the side chains of pectin are neutralized in the acidic medium by H^+ **and with more than 65% Sugar** (which esterifies by having glucose solubilized by the present water and creating Hydrogen bonds between side chains of different pectin molecules meaning that pectin would create a sheet with sugar and water trapped within)

Slow Set Esterification is used in Jams, where the degree of Esterification is 50-70%
Rapid Set Esterification is used as a method of Fruit Preservation with DE> 70%

b. Low Methoxy Pectin Gels (DE<50%)

Works under Neutral pH and is independent of sugar concentration
Pectin backbone is stabilized by Ca2+ ions, which form ionic bonds between the side chains of different pectin molecules, this process, produces a pectin sheet

II. Cellulose

Present primarily in the cell wall of plants.
In acidic mediums and with the presence of a strong base (NaOH), cellulose loses a proton from its Carboxylic group and becomes **Carboxy Methyl Cellulose (CMC) with functionality similar to that of gums**

III. Hemicellulose

Plant polymers characterized by their high content of pentoses notably xylose and L–arabinose.

IV. Lignin

Amorphous substance laid down in the middle lamella and cell wall; has a stiffening effect and increases rigidity; renders tissues unpalatable.

Dietary Fiber = Cellulose + Hemicellulose + Pectin + Lignin

Gums

A gum is any water-soluble polysaccharide that is extractable from land or marine plants or from microorganisms and that possesses the ability to contribute viscosity or gelling ability to their dispersions. They serve as thickeners of water, they trap it and immobilizes the structure

Guar Gum: Man: Gal 2:1, ½ the chain is substituted
Locust Bean Gum: Man: Hal 4:1, ¼ of the chain is substituted
Gum Arabic: Arabinose is the main ingredient, extracted from trees in Sudan, milled into a powder and sold
Agar: Red Sea Weed
Carrageenan: Sea Weed
Alginates: Brown Algae
Xanthan: Xanthomonas Compestris, exhibits sheer thinning behavior and is used for the thickening of fruit drinks

Types of Colloidal Systems in Foods

Type	Discontinuous Phase	Continuous Phase
Emulsion	Liquid	Liquid
Dispersion	Solid	Liquid
Gel	Liquid	Solid
Foam	Gas	Liquid (Solid)

Functions of Gums
- Thickeners
- Flavor Fixatives
- Binders

Odors and flavors are volatile and often evaporate. When incorporating gum, it binds to those proteins and creates a mush with pores that allows the evaporation of water and prevents their evaporation.

Binders are usually used in sausage production, since meat contains a lot of water and the other components mentioned, films of proteins align around, creating an emulsion (Oil in Water) and a dispersion (Protein disbursed in water and because of solid fat in water).
The protein layers created are not strong enough to hold the system, which is why the intestine is cleaned and filled with the meat emulsion.
A gum is incorporated instead of the intestine into the meat which layers around the fragile protein and enforces it to hold the system and together and replaces the intestine in holding the emulsion (this creates skinless sausages)

Ice Cream
Ice cream is an emulsion (and somewhat a foam) of a continuous frozen liquid phase and discontinuous oil and air phases.
After storage: the previously separated ice crystals melt and refreeze into larger ice crystals.
In ice creams, **gums**: Decrease mobility of water and thereby contribute to good body and smooth texture, they retard enlargement of ice crystals during storage especially those arising from temperature fluctuations.
Prebiotics
Inulin and fructo-oligosaccharides are termed 'prebiotics" because they are non-digestible food carbohydrates that selectively stimulate the growth and/or activity of a number of potentially health-stimulating intestinal bacteria.
Chicory Root and Artichoke notably contain high amounts of prebiotics.

Possible Health Effects
- Relief of constipation.
- Inhibition of diarrhea.
- Increase in calcium absorption and deposition in bones.
- Decrease in total and LDL cholesterol levels of blood.
- Decrease in blood triglyceride levels.
- Reduction of the risk of colon carcinogenesis