Pharmacognosy II

Carbohydrates

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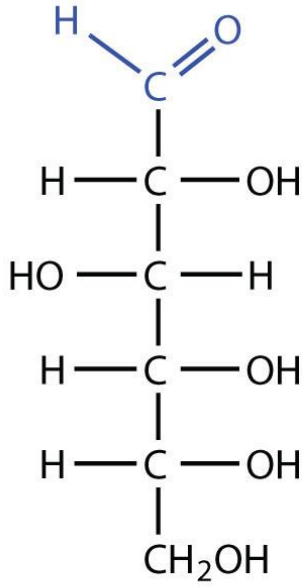
Lecture 2

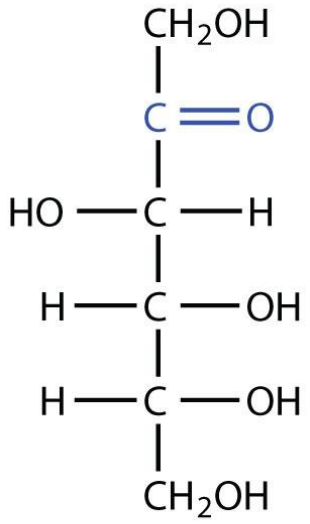
2024 / 09 /25-26

Introduction

- Carbohydrates are one of the three major macronutrients in our diet, along with proteins and fats
- Carbohydrates chemically are defined as polyhydroxy aldehyde or polyhydroxy ketones or compound that on hydrolyses produce either of the above



Glucose



Fructose

Cont.

Carbohydrates have various functions in the plant:

1. Cellulose, form the rigid cellular framework of plant cells
2. Starch, provid an important food reserve (energy storage)
3. Production of secondary metabolites
4. Mucilage act as water-retaining vehicles
5. Gums and mucilage are made in the plant by injury or stress

Cont.

- **Low molecular weight carbohydrates are**:

➢Crystalline

➢Soluble in water

➢Sweet in taste

➢e.g., glucose, fructose, sucrose

- **High molecular weight carbohydrates (polymers) are**:

➢Amorphous

➢Tasteless

➢Relatively less soluble in water

➢e.g., starch, cellulose, inulin

Cont.

- In green plant, photosynthesis consists of two type of reactions:

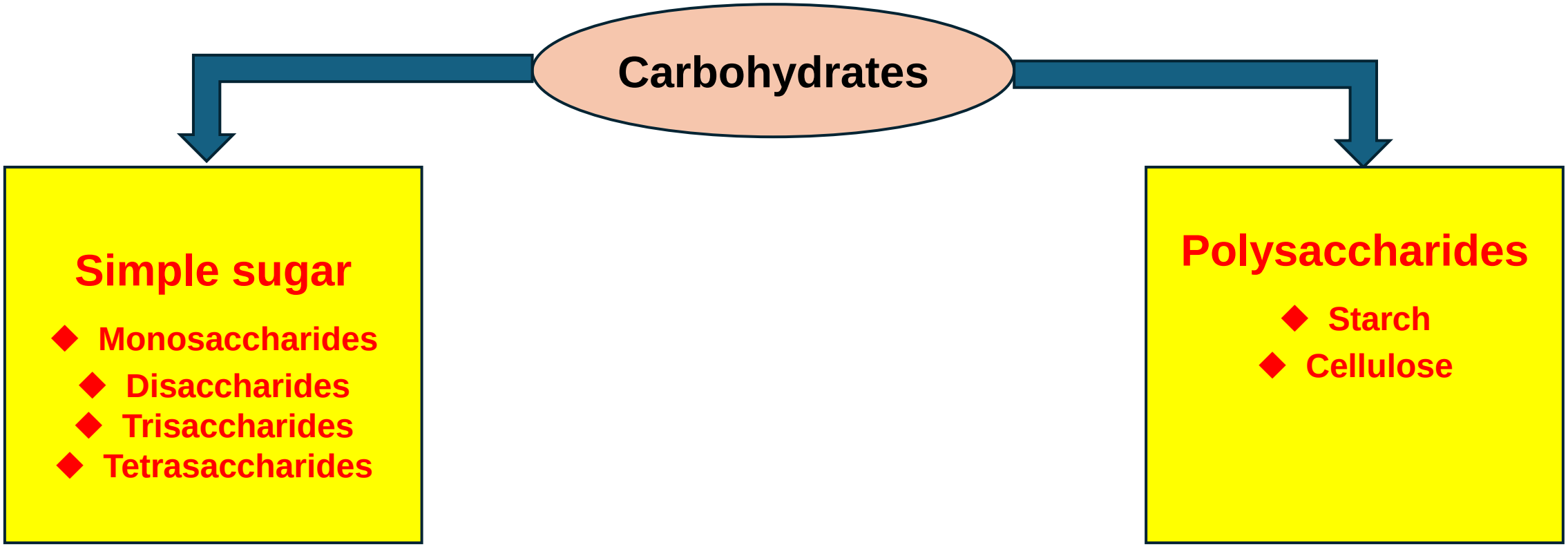
1. Light reactions that convert electromagnetic energy into chemical potential.
2. Dark reactions (Enzymatic reactions) that utilize the energy from the light reactions to fix carbon dioxide into sugar.

- The results of these reactions are summarized in the following equation:

$$2H_2O + CO_2 + \text{Light} \xrightarrow{\text{chlorophyll}} (CH_2O) + H_2O + O_2$$

Classification of carbohydrates

- Carbohydrates can be classified into several categories based on their chemical structure and the number of sugar units they contain:

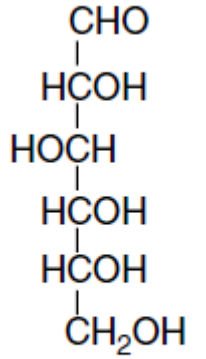


1. Simple sugars

- **Monosaccharides** are sugars that contain from **three to nine carbon atoms**
- If they have aldehyde group, they called an aldose or ‘aldo’ sugar (e.g., glucose). While if they have a ketone group, they called a ketose (e.g., fructose).
- Monosaccharides can’t be hydrolyzed to simpler sugars
- The general formula of monosaccharides is [C_n H_{2n} O_n]
- Monosaccharides are subdivided into trioses [3C], tetroses [4C], pentoses [5C], hexoses [6C], heptoses [7C], depending upon the number of carbon atoms they possess

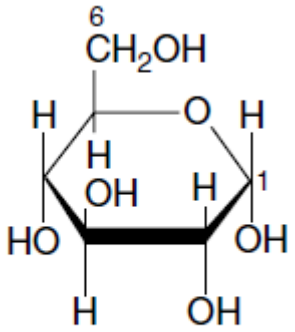
Cont.

- The formulae of sugars and other carbohydrates are written in several different ways

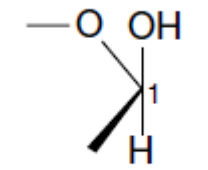


Aldohexose
(D-glucose)

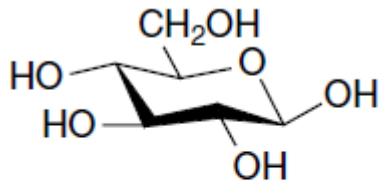
Open chain form



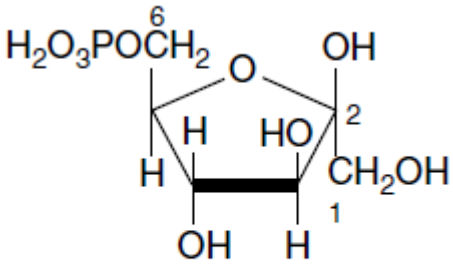
α-D-Glucose
(pyranose ring)



β-D-Glucose



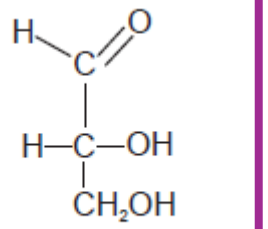
β-D-Glucose
(another representation)



D-Fructose-6-phosphate
(furanose ring)

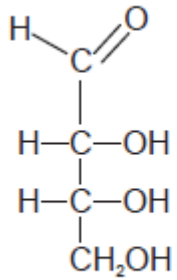
Cont.

Triose

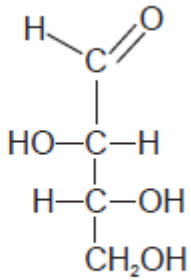


D -(+)-glyceraldehyde

Tetroses

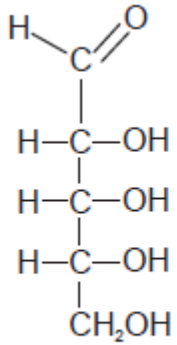


D -(-)-erythrose

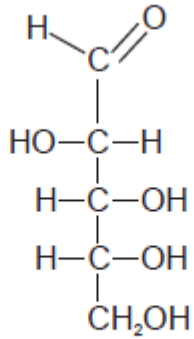


D -(-)-threose

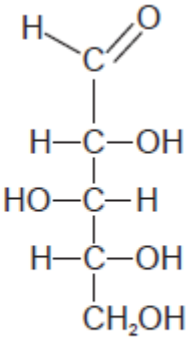
Pentoses



D -(-)-ribose

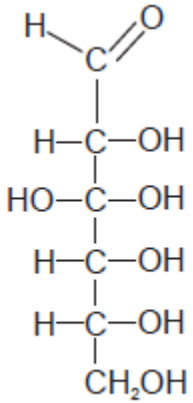


D -(-)-arabinose

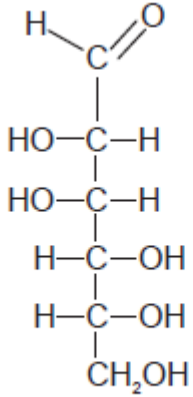


D -(+)-xylose

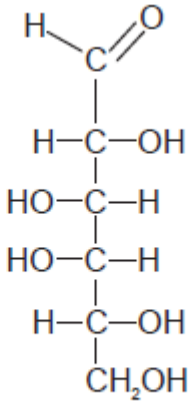
Hexoses



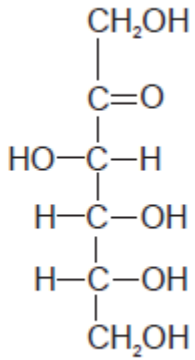
D -(+)-glucose



D -(+)-mannose



D -(+)-galactose



D -(-)-fructose

- Pentoses are very common in plants and are the products of hydrolysis of polysaccharides mucilages and gums
- Hexoses are abundantly available carbohydrates of plant kingdom. They can be obtained by hydrolysis of polysaccharides like starch

Cont.

- **Disaccharides** are carbohydrates, which on hydrolysis yield two molecules of monosaccharides
- They have the molecular formula $C_{11}H_{22}O_{11}$

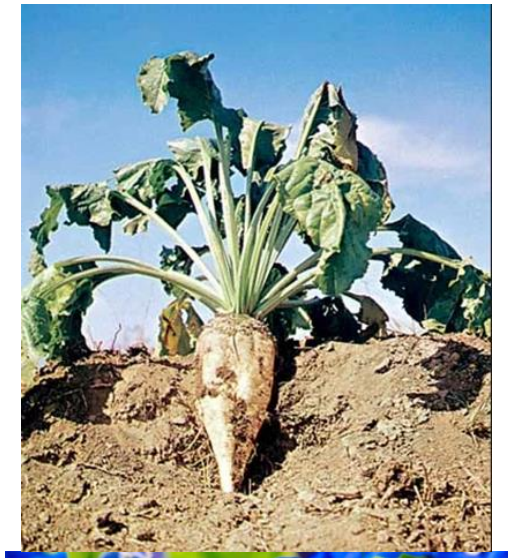
Sucrose $\xrightarrow{\text{Hydrolysis}}$ Glucose + fructose (sugarcane)

Maltose $\xrightarrow{\text{Hydrolysis}}$ Glucose + Glucose (malt sugar)

Lactose $\xrightarrow{\text{Hydrolysis}}$ Glucose + Galactose (cow's milk)

Cont.

- **Trisaccharides** are carbohydrates that liberate three molecules of monosaccharides on hydrolysis



Raffinose	Hydrolysis ⟶	Glucose + fructose + galactose (in beet) (sugarcane)
Gentianose	Hydrolysis ⟶	Glucose + Glucose + fructose (gentian roots)

Cont.

Tetrasaccharides

- Stachyose, a tetrasaccharide, yields on hydrolysis, four molecules of monosaccharide, found in manna.




2. Polysaccharides

- Polysaccharides are formed from condensation products of **more than ten monosaccharide units**.
- If only one type of monosaccharide unit is present, the polysaccharide is a "homoglycan" but a "heteroglycan" if more than one kind on monosaccharide is involved.
- Depending upon the type of product of polysaccharide hydrolysis these are further classified as Pentosans and Hexosans. Xylan is pentosan, whereas starch and cellulose are the examples of hexosans.
- Oligosaccharide are saccharides containing from 2 to 10 units of sugar.

Cont.

Examples of Homoglycans

1. Starch: composed of glucose.
2. Inulin: composed of fructose
3. Dextran: formed from sucrose.
4. Cellulose: consist of several hundred of D-glucose

Cont.

Examples of Heteroglycans

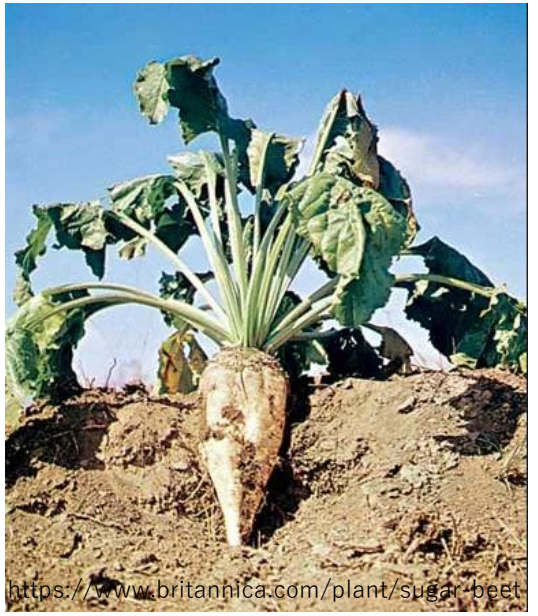
1. Gum and mucilage
2. Agar
3. Tragacanth
4. Acacia

Miscellaneous carbohydrate containing plants

Sucrose

- **Sucrose, commonly known as saccharum or sugar, is derived from various sources, including sugarcane (*Saccharum officinarum*), sugar beets (*Beta vulgaris* subsp. *vulgaris Altissima* Group), and other plants. It is the only disaccharide that occurs abundantly in free state in plants.**

Sugarcane (*Saccharum officinarum*)



sugar beets (*Beta vulgaris* subsp. *vulgaris Altissima* Group),

Sucrose

- It is called invert sugar because upon hydrolysis; sucrose yields equimolar quantities of glucose and fructose
- Sucrose is a non-reducing sugar.
- The process of obtaining sugar involves crushing, boiling (with lime; calcium oxide to neutralize the acid and prevent sugar hydrolysis), decolorization (with sulfur dioxide), filtering, and crystallization. Molasses is a by-product of this process and has various uses.

Cont.

Pharmaceutical uses of sucrose

1- Syrup base (conc. 85% w/v in USP)

2- Demulcent

3- Mask unpleasant tastes in pharmaceutical products

4- Nutrient

5- Preservative by inhibiting microbial activity

6- Slowing down oxidation process.

Maltose

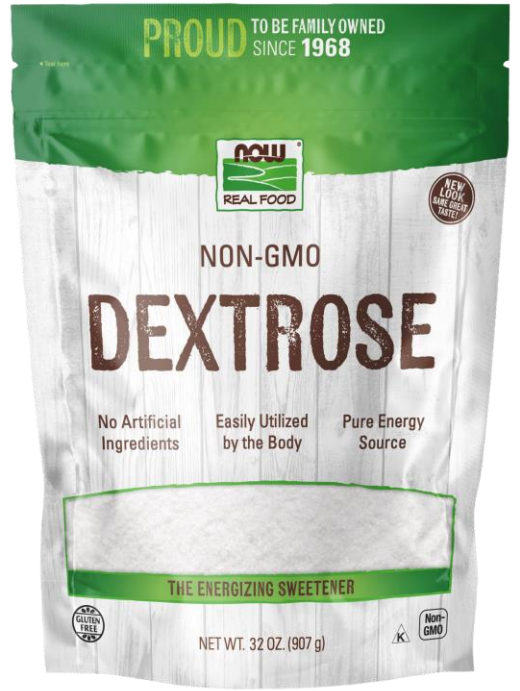
- Maltose although rarely occurring in free state in nature and is produced in large quantities by the hydrolysis of starch. Upon hydrolysis, yields two molecules of glucose. It is a reducing sugar
- Reducing sugars :if the hydroxyl group on the anomeric carbon is not linked to another compound by a glycosidic bond, the ring of carbohydrates can open. The sugar can act as a reducing agent, and it called a reducing sugar.

Dextrose or D-glucose

- A sugar that occurs naturally in grapes and other fruits. It is obtained by controlled enzymatic hydrolysis of starch.
- The product rigorously purified to yield crystalline dextrose that is 100% pure and suitable for parenteral use (drugs given by injection or infusion).
- It is used commercially in the manufacture of candy, carbonated beverages, ice creams, bakery and canning industry

Pharmaceutical uses of Dextrose

1. A nutrient given by mouth, or by intravenous injection.
2. An anticoagulant for the storage of whole blood (Citrate dextrose solution).
3. Sweetener, binder, and coating agent.



Fructose

- Fructose, D-fructose or fruit sugar is a ketone sugar that occurs naturally in most sweet fruits (hence, the name fruit sugar) and in honey. Fructose occurs as colorless crystals that is freely soluble in water.

Pharmaceutical uses of fructose

1. Fructose used as nutrient for diabetic people especially in diabetic acidosis.
2. Infant feeding formula usually contain fructose.
3. It is also ingredient in some parenteral fluids.

Lactose

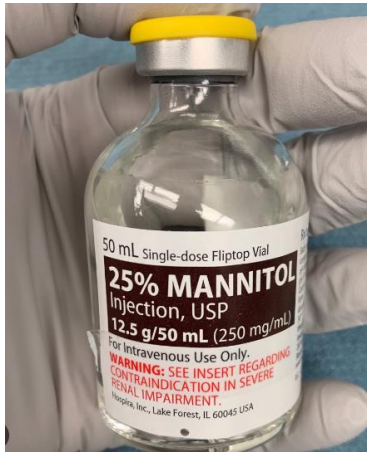
- Lactose possesses a free functional aldehyde group, and it is a reducing sugar.
- Commercially known as milk sugar. Its natural sources is cow's milk which contain casein, albumin, lactose, vitamins, and inorganic salts

Pharmaceutical uses of Lactose

1. Lactose is a tablet diluent.
2. Nutrient in infants' food.
3. Lactulose a semisynthetic sugar poorly absorbed form GIT is used as laxative
4. It has role in establishing the intestinal microflora because it provides the preferred substrate for lactobacilli.

Mannitol

- Mannitol is directly formed from fructose by the activity of mannitol dehydrogenase.
- Mannitol is a white, crystalline powder, which is freely soluble in water.
- When administered parenterally, it is not metabolized and is eliminated readily by glomerular filtration. This led to the use of mannitol as a diagnostic aid and as an osmotic diuretic.



Starch

- Starch is widely distributed organic compound in plants. It is produced in large quantities in green leaves as a temporary storage.
- It is obtained from maize (*Zea mays*), rice (*Oryza sativa*), wheat (*Triticum aestivum*), potato (*Solanum tuberosum*), and Tapioca (*Manihot utilissima*)
- Starch is generally a mixture of two structurally different polysaccharides: amylose (β-amylose) and amylopectin (more than 80 % of most starch) (α-amylose)

Cont.

- Amylose, although water-soluble, gives an unstable solution, which irreversibly precipitates. It is mainly responsible for the deep blue coloration given by starch and iodine
- Solutions of amylopectin are relatively stable, the color given with iodine is purple, and the iodine-binding is low

Pharmaceutical uses of Starch

1. It is used as absorbent, emollient in ointment.
2. Tablet filler, binder and disintegrant.
3. Antidote for iodine poisoning.
4. In sweetener manufacturing
5. In plastics industry for biodegradable products
6. As a lubricant for surgeons’ gloves

Dextran

- Dextran is a polyglucan that is formed from sucrose.
- It is used in intravenous solutions as plasma expanders in cases of shock caused by hemorrhage and burns.
- Iron dextran injection is used as i.m or i.v.

Gums and mucilages

- They have similar constitutions and on hydrolysis yield a mixture of sugars and uronic acids.
- Gums are considered to be pathological products formed upon injury of the plant or owing to unfavorable conditions, such as drought, by a breakdown of cell walls (extracellular formation; gummosis).
- Conversely, mucilages are generally normal products of metabolism formed within the cell (intracellular formation) and may represent storage material, a water-storage reservoir or a protection for germinating seeds.
- They are often found in quantity in the epidermal cells of leaves, e.g. senna, in seed coats (linseed, psyllium etc.), roots (marshmallow) and barks (slippery elm).

Cont.

Commercial sources of gums

- **Shrub or tree exudates**: acacia, tragacanth
- **Marine gums**: agar, algin
- **Seed gums**: guar, locust bean
- **Plant extracts**: pectin
- **Starch and cellulose derivatives**: carboxymethylcellulose, ethylcellulose, methylcellulose;
- **Microbial gums**: dextrans, xanthan

Pharmaceutical uses of Gum and Mucilage

1. Used as tablet binders, emulsifiers, suspending agents, stabilizers, and thickeners.
2. They are ingredients in dental paste and other adhesives and in bulk laxatives.
3. Used as thickening and gelling agents.

Tragacanth

- Tragacanth is the dried, gummy exudate obtained by incisions from the stem of *Astragalus gummifer,* and certain other species of Astragalus genus
- It is commonly known as gum tragacanth.
- The gum is produced physiologically in the plant cells. When a one- or two years old plant is injured, the gum exudates immediately after injury

Pharmaceutical uses of Tragacanth

1. Tragacanth is used to suspend heavy insoluble powders and as an excipient for tablets
2. As an emulsifying agent for oils and resins.
3. As a binding agent in tablets and pills
4. In cosmetics (hand lotions) as a demulcent and an emollient
5. Food additive

Acacia

- Acacia is the dried, gummy exudate from the stems and branches of *Acacia Senegal,* other African species of Acacia and *Acacia seyal* Del. (Family Leguminosae). It is known as Arabic gum.
- The gum is produced by physiologically active living cells of the phloem. The tears of gum are formed on the exposed surface due to bacterial action, which flow gradually on its own and are collected in bags.

Pharmaceutical uses of Acacia

1. Demulcent, emollient
2. As emulsifying and suspending agent for the administration of insoluble drugs.
3. As an adhesive and binder in tablet granulations.
4. Used in various formulations for cough and throat problems.
5. Used to cover inflamed surfaces such as burns.
6. Pharmaceutical necessity in lozenges
7. It is used extensively in making of candy and other food products.
8. Gum acacia solution has consistency similar to blood and is administered intravenously in haemodialysis

Sodium Alginate

- Sodium alginate is the sodium salt of alginic acid.
- It is obtained from the algal growth of the species of family Phaeophyceae.
- Sodium alginate occurs as a nearly odorless and tasteless coarse or fine powder and is yellowish white in color. It is readily soluble in water, forming a viscous, colloidal solution

Pharmaceutical uses of Alginate

1. Used in the preparation of paste, creams and for thickening and stabilizing emulsions.
2. As a suspending and thickening agent
3. As binding and disintegrating agent in tablets and lozenges.
4. In food industry, it is used for the preparation of jellies, ice-cream
5. Cosmetics and pharmaceutical industries
6. Capsules containing sodium alginate and calcium carbonate are used to protect inflamed areas near the entrance to the stomach

Agar

- Agar is the dried, hydrophilic, colloidal polysaccharide complex extracted from the agarocytes of algae known as *Gelidium cartilagineum* (Family: Gelidiaceae), and related red algae.

- It occurs in the form of a transparent or translucent bundles, yellowish-white slender, lustrous, flattened strips or as coarse powder or flakes

- It consist of agarose and agaropectin. Agarose is a neutral galactose polymer, which is responsible for the gel strength of agar. The structure of agaropectin, responsible for the viscosity of agar solutions

Pharmaceutical uses of Agar

1. Treat chronic constipation, as a laxative
2. As suspending and emulsifier agent.
3. As gelling agent for suppositories
4. As tablet excipient and disintegrant.
5. Nutrient media for bacteriologic culture
6. As emulsifying agent

Pectin

- Pectin is a purified carbohydrate product obtained from the dilute acid extract of the inner portion of the rind of citrus fruits or from apple.
- Pectin is classified as a protectant and a suspending agent and is an ingredient in many antidiarrheal formulations

Thank you for listening