UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE „VICTOR BABEȘ" DIN TIMIȘOARA

CORINA DANCIU ȘTEFANA AVRAM
LARISA BORA

PHARMACOGNOSY LECTURE NOTES

PART I

HIPPOCRATE

EDITURA „VICTOR BABEȘ"
TIMIȘOARA
2025

Editura „Victor Babeş”
Piaţa Eftimie Murgu 2, cam. 316, 300041 Timişoara
Tel./Fax: 0256 495 210
E-mail: evb@umft.ro
www.umft.ro/ro/organizare-evb/

Director general: Prof. univ. dr. Sorin Ursoniu

Colecţia: HIPPOCRATE
Coordonator colecție: Prof. univ. dr. Andrei Motoc

Referent ştiinţific: Prof. univ. dr. farm. Cristina Dehelean

Cartea reprezintă traducerea în engleză după volumul
“Pharmacognosie. Notes de cours. Partie I”
ISBN 978-606-8456-77-5-

ISBN general: 978-606-786-452-6
ISBN vol. I: 978-606-786-451-9

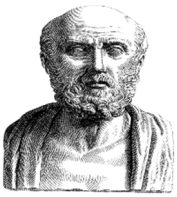
Table of Contents

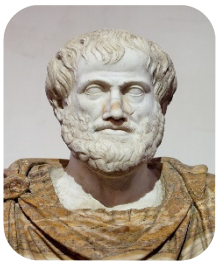
BRIEF HISTORY

After gaining knowledge about plants and animals of nutritive value, primitive people managed to distinguish useless, poisonous, and dangerous plants from others. By chance, they found that certain herbs, roots, leaves, fruits, or their juices cure certain diseases. The knowledge acquired has been passed down through the generations, first orally and then in writing. These types of documents were discovered in Mesopotamia, China, India, and Egypt, dating to the millennia IV-III BC. At first, medical practice was invaded by magic and mysticism, being attributed to sorcerers and priests.

The Ebers Papyrus, dates from the year 1500 BC. J-C, found in the tomb of a mummy, contains 870 prescriptions and 700 medicinal plants (University of Leipzig).

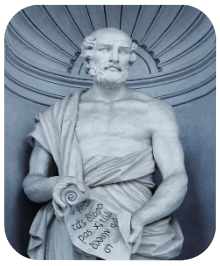
The Greek physician **Hippocrates** (460-370 BC), also known as the „father of medicine", in his work *Corpus Hippocraticum* described 236 medicinal plants.





Aristotle (384-322 BC), a Greek scientist and philosopher, disciple of Plato, separated superstition from reality in his works in the field of remedies of animal origin, being considered a landmark for almost 20 centuries.

Theophrastus (370-285 BC), an apprentice of Aristotle, used the scientific principles of his mentor, but he applied them to plants. He is the greatest botanist of ancient Greece, becoming famous due to his work *Historia plantarum*. He also wrote Causes of Plants and Research on Plants.



Dioscorides (50-100 AD), a Greek physician is considered the true father of Pharmacognosy; in his work *De Materia Medica* he described, in Latin, more than 600 plant products with therapeutic properties that are the basis of all treaties in this field.

Galenus (131-200 AD), a Greek pharmacist and physician, described methods of preparing some pharmaceutical formulations of plants and animal products.

The first pharmacopoeias were:

- Ricettario Fiorentino (Florence, Italy) – 1498;
- Pharmacopoeia of Nuremberg (Germany) – 1546;
- London Pharmacopoeia (England) – 1618.

Isolates:

YEAR	COMPOUND	SOURCE
1804	**Morphine**	Latex from poppy capsules
1817	**Emetine**	*Carapichea ipecacuanha* (Brot.) L. Andersson, *Rubiaceae*
1817	**Strychnine**	*Strychnos nux-vomica* L., *Loganicaceae*
1820	**Quinine**	Cinchona bark
1821	**Caffeine**	Coffee seeds
1826	**Coniine**	*Conicum maculatum*
1833	**Atropine**	Belladonna leaves
1838	**Salicin**	Willow bark

PHARMACOGNOSY. GENERAL NOTIONS

The word Pharmacognosy comes from the Greek words *pharmacon* (remedy, substance, medicine) and *gnosis* (knowledge). This term was first used in 1815 by C.A. Seydler and referred to the science of knowledge of medicinal substances of plant, animal, and mineral origin. Previously, the term Materia Medica attributed to Dioscorides was used in the year 78 AD.

In recent years, the field of Pharmacognosy has been restricted to natural products of rather plant origin.

Pharmacognosy represents the connecting loop between several disciplines, more precisely: botany, biochemistry, genetics, pharmacology, toxicology, pharmaceutical technology, and pharmaceutical chemistry.

Branches of pharmacognosy

Pharmacobotany (descriptive pharmacognosy) which offers information about PLANT SPECIES (taxonomic position, spread, description) and about HERBAL MEDICINAL PRODUCTS (production, preservation, as well as their macro- and microscopic description).

Phytochemistry or ***plant chemistry*** reflects the biochemical mode of formation of ACTIVE COMPOUNDS, and their physicochemical properties, which are the basis for the methods of extraction, purification, identification (qualitative analysis of natural products), and dosage (quantitative analysis of natural products).

Phytotherapy is the branch of pharmacotherapy that deals with the treatment and prevention of a wide range of pathologies with the help of pharmaceutical preparations of natural origin and studies their biological activity (by *in vitro* and *in vivo* tests), their pharmacokinetics, pharmacodynamics, and bioavailability (clinical studies).

Medicinal plant. Herbal medicinal product. Active compounds

A ***medicinal*** plant is a plant species used in the curative and preventive treatment of certain human and veterinary ailments.

Medicinal plants may present monographs in the National or European Pharmacopoeia; in this case, they are called „officinals"; the „non-officinals" are regulated as description and quality by state standards, internal standards, or technical data sheets.

By ***herbal medicinal*** products, also called *drugs* (from the old Dutch word „droag" which means to dry) term that is frequently employed in English-speaking countries, it refers to the organ or a certain part of the plant, or metabolic product (volatile oils, fatty substances, resins, gums) used in the preparation of certain medicines in the pharmaceutical field, in pharmacies, as well as at the industrial level.

The chemical substances synthesized by the plant or animal organism, present in natural products with therapeutic action, are called ***active compounds, constituents, or phytocompounds.***

Metabolic transformations in medicinal plants

With the starting point of photosynthesis, plants are involved in a complex metabolic process, finally generating all the natural compounds. Two major types of metabolic pathways can be described:

a. primary metabolic pathways
b. secondary metabolic pathways.

a. The primary metabolism represents all of the metabolic processes that occur at the level of the different organs generating compounds that are essential to life and that are similar or identical for most organisms. Following this type of metabolism, *primary metabolites* are formed in the plant:
    - carbohydrates;

- lipids;
- amino acids, peptides, and proteins.

b. The secondary metabolism represents all of the metabolic processes by which an organism differs from other organisms of another species, generating secondary metabolites.

Metabolic pathways are genetically regulated and every process is controlled by enzymes. The *secondary metabolites* can be classified according to structural characteristics in phenolic compounds, terpenes, steroid structures, alkaloids, etc.

Secondary metabolites characteristics:

- tare widespread only in certain organisms, with variations between species;
- form only in certain organs and tissues;
- are not an energy source, nor are they essential for the survival of the cell from which they were synthesized;
- are formed in certain stages of organism development;
- are not subject to continuous turnover (parts are stored in certain organs; parts are excreted);
- transport from the place of formation to the place of storage or catabolism is carried out by phloem vessels; during translocation, a substance may suffer structural changes;
- the place of formation and the place of accumulation of a substance of secondary metabolism are not identical.

Basic steps in obtaining a herbal medicinal product:

1. Choice of plant study material which is made on the basis of information from standard medicine (pharmacognosy), folk medicine (ethnopharmacology), and chemotaxonomy research.

2. Realization of plant extracts of different types: liquid (aqueous, hydro-alcoholic, hydro-glycero-alcoholic) or dry (using as an intermediate organic solvent: ether, chloroform, acetone, etc. for extraction, concentration, analysis of active ingredients and other plant substances present in the extract).
3. Qualitative and quantitative determination of the chemical composition of plant extracts.
4. Pharmacodynamic analysis of plant extracts.
5. Identification and dosage of the active pharmacodynamic compounds. Obtaining the purified plant extract.
6. The study of the therapeutic action, toxicity, teratogenic, and carcinogenic effects of the purified extract.
7. Identification of the pharmaceutical form of administration.
8. The study of stability and bioavailability of the pharmaceutical product.
9. Transferring of the extraction and conditioning method to the pilot scale.
10. Preclinical and clinical pharmacological research (pharmacodynamics and toxicological screening).
11. Identification of technology for industrial scale-up.
12. Obtaining the manufacturing notice.

I. HERBAL MEDICINAL PRODUCTS CONTAINING CARBOHYDRATES

PART I – MONOSACCHARIDES, OLIGOSACCHARIDES, HOMOGENEOUS POLYSACCHARIDES

Carbohydrates (gr. glykós = sweet), also called sugars or saccharides, represent a class of fundamental natural substances, widespread in nature, in the plant kingdom, as well as in the animal kingdom. They are of particular biological importance. Normally, they are ternary natural substances (consisting of C, H, and O → $C_n(H_2O)_n$). They are formed as a result of the process of photosynthesis, being the result of the primary metabolism of chlorophyll plants. Below we present the equation for the formation of one of the most common monosaccharides of nature, glucose.

$$6\ CO_2 + 6\ H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

Do you remember that…Photosynthesis is the process by which green plants (chlorophyll), in the presence of solar radiation, fix carbon dioxide from the atmosphere, remove oxygen, and form very varied organic components (carbohydrates, lipids, proteins).

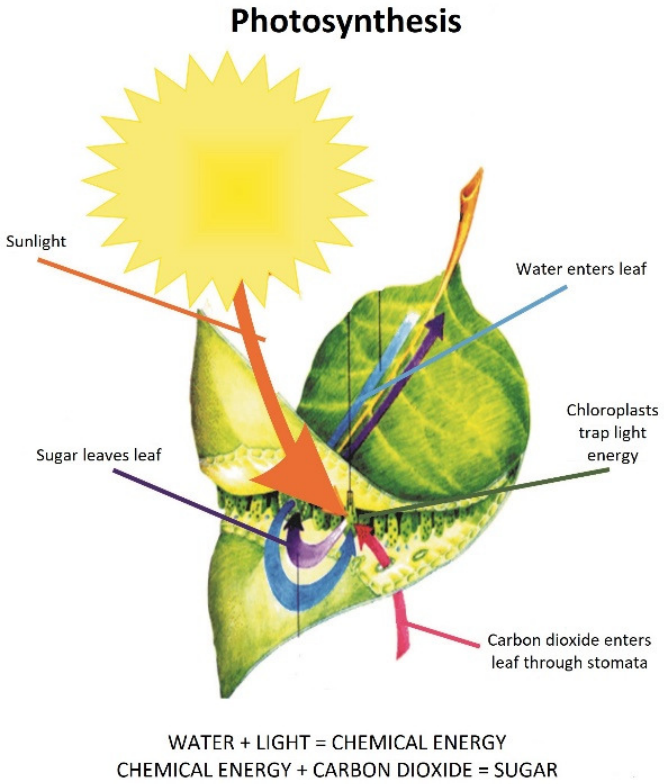


Figure 1. Photosynthesis process.

Carbohydrates represent an important class of compounds with a structural and energetic role. Compared to the dry matter, they account for a total of more than 50% of the chemical composition of plant organisms. Carbohydrates are constituents of different metabolites, being precursors of several organic compounds of the living world. In plants they are widespread in all organs, being frequently encountered in reserve organs.

Carbohydrate classification

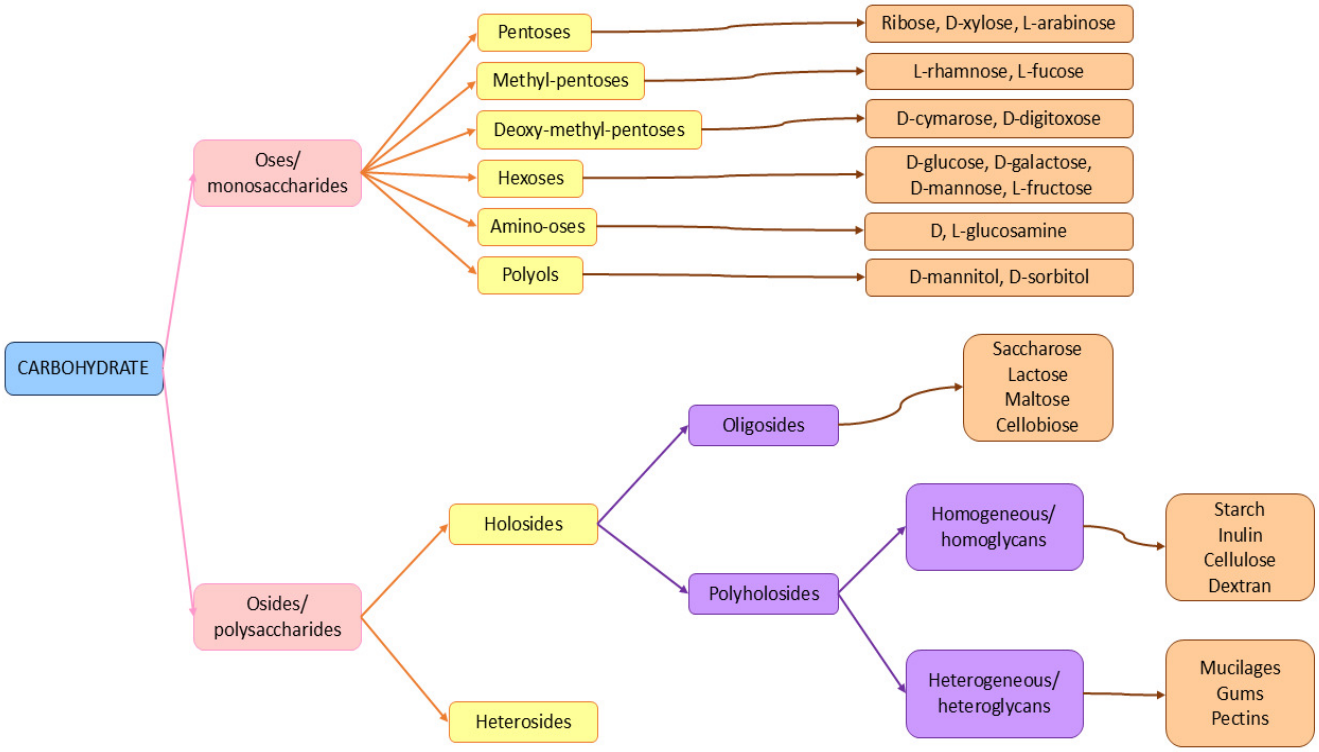


Figure 2. Classification of carbohydrates.

The simplest structures, monosaccharides, have been classified as polyhydroxyaldehydes, polyhydroxyketones, and their derivatives. In the case of these structures, the carbonyl group is transformed in a glycosidic hydroxyl, by a combination of hemi-acetylic type, with the formation of a furanic or pyranic heterocycle.

Physical and chemical properties:

They are solid, colorless, odorless, crystallized substances and most of them have a sweet taste. They are easily soluble in water, poorly soluble in methanol, pyridine, difficult to soluble in ethanol, and insoluble in chloroform, ether, and carbohydrates. They are active substances from the optical point of view, thanks to the presence in the molecule of asymmetric carbon atoms. In addition, they have reducing properties that help in their

identification. Oligosaccharides generally have the same properties as simple monosaccharides. Polysaccharides, polymeric structures with a larger molecular weight, form colloidal solutions with water and are insoluble in nonpolar organic solvents.

I.1. REPRESENTATIVE NATURAL PRODUCTS WITH MONOSACCHARIDES

1. *GLUCOSUM*. GLUCOSE (Ph.Eur.)

Glucose is found in a free state in sweet fruits, in honey, or in a form bound in monosaccharides.

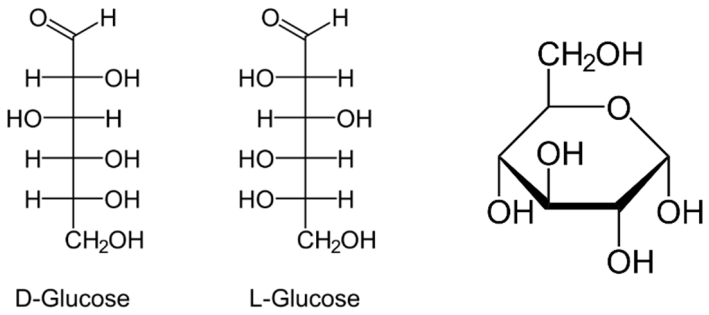


Figure 3. Linear forms (left) and cyclic form (right) of glucose.

Methods of obtaining

A. By natural means:
   - Glucose is one of the products that result from the photosynthesis of chlorophyll plants and certain prokaryotes.
   - It can also be obtained by breaking down starch (in plants) or glycogen – a process called glycogenolysis (in animals and fungi).
   - In animals, it can be synthesized in the liver and kidneys from intermediates such as pyruvate and glycerol (these compounds are not carbohydrates). This process is called gluconeogenesis.

B. Industrial route:
   - On an industrial scale, glucose is obtained by the hydrolysis of starch in an acidic medium: $(C_6H_{10}O_5)_n + nH_2O \rightarrow C_6H_{12}O_6$.
   - Another method of obtaining glucose on an industrial scale is enzymatic hydrolysis of starch. As a source of starch can be used: maize, rice, wheat, and potatoes.

Effects and uses:

- ✓ Energizing action (caloric intake) and sweetening properties; triggers insulin secretion.
- ✓ States of malnutrition, for the prevention of dehydration, as a vehicle for therapeutic intake in surgical interventions.
- ✓ Glucose can be used in the form of solutions of 3.3%, 5%, 5%, 10%, 20%, 33%, and 40%.
- ✓ Solutions with a concentration < 5% are used for dilution of certain drugs, for hydration, and as an energy substitute; the 5% glucose solution is isotonic and has the same indications, being the most used
- ✓ Solutions with a concentration > 5% (10%, 20%, 33%, and 40%) are hypertonic; they are frequently used as osmotic diuretics (for tissue dehydration, frequently used in case of edema)

2. *FRUCTOSUM*. FRUCTOSE. LEVULOSE. D-FRUCTOPYRANOSE

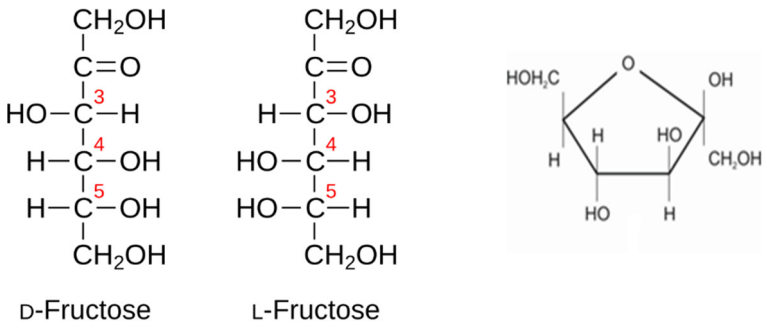


Figure 4. Linear forms (left) and cyclic form (right) of fructose.

Methods of obtaining. Effects and uses:

- Fructose is found in a free state in fruit juice, in flower nectar, in honey, or bound in the form of sucrose or inulin. It is 1.7 times sweeter than sucrose. After glucose, it is the most common monosaccharide. It is an epimer of glucose.

- It is obtained by the hydrolysis of inulin, a characteristic polymer of the *Asteraceae* family, a reserve substance in the root of chicory, dandelion, *etc.*
- It has an energizing action (caloric intake) and sweetening properties. Intestinal resorption is slow and it does not trigger insulin secretion, its metabolism being hepatic.
- It is used in undernutrition, for the prevention of dehydration. It is also used by diabetics, but paying attention to the dose, because at the hepatic level it is converted into glucose.

3. *SORBITOLUM*. D-SORBITOL

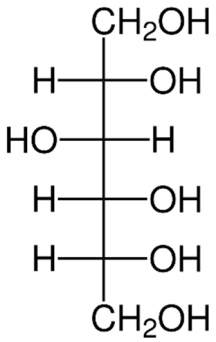


Figure 5. Linear structure of sorbitol.

Methods of obtaining. Effects and uses:

- It is obtained by reduction of D-glucose.
- It is present in the fruits of various species – some examples: mountain ash - *Sorbus aucuparia* L., apple tree - *Malus domestica* (Suckow) Borkh., pear - *Pyrus sativa* (Duhamel ex DC.) Holandre, plum - *Prunus avium* L ., (*Rosaceae*).
- Laxative, cholagogue, energizing action.
- Used in the treatment of dyspeptic disorders and constipation.

- In the form of injectable solutions or infusions (conc. 5–10%), it is used as a vehicle for the administration of other drugs, a vehicle for therapeutic delivery and rehydration.
- It is raw material for obtaining ascorbic acid and esters of type: span, tween (amphiphilic constituents, emulsifiers, and stabilizers in pharmaceutical technology).
- Moisture regulator in powders.
- Used as a sweetener for diabetics (it is converted to fructose).
- Used in various dental preparations for its fresh effect.

4. *MANNITOLUM*. D-MANNITOL

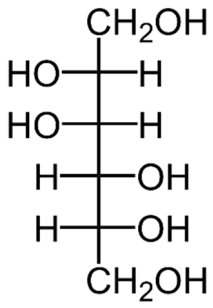


Figure 6. Linear structure of mannitol.

Methods of obtaining. Effects and uses:

- The polyol that corresponds to D-mannose (C2 epimer of glucose).
- It is present in some brown algae, lichens, fungi, or plants of the families: *Apiaceae, Fabaceae, Oleaceae.*
- It is obtained by alkaline epimerization of D-glucose and reduction of D-fructose.
- Diuretic, cholecystokinetic, and laxative action.
- It is used in dyspeptic disorders, constipation, in foods for diabetics.
- In the form of solutions for injection in oliguria, anuria.
- Used as a sweetener in foods for diabetics, chewing gum.

5. *MEL* (honey). *MEL DEPURATUM* (pharmaceutical honey)

Natural product, of animal origin, produced by bees, *Apis mellifica* L., *Apis ligustica* L. (*Hymenoptere*). Bees use as a plant source the nectar of flowers and the exudate of certain leaf shoots.

Methods of obtaining. Effects and uses:

- The separation of honey from the combs can be carried out in three processes: centrifugation, pressing, and free flow.
- *Mel depuratum* is the purified honey, having a density of 1.39–1.44. Purification is carried out by the removal of pollen and wax by washing with water, filtration or centrifugation, and distillation at reduced pressure, under 40 °C.
- Honey has a complex composition, having a predominant content of water and sugars (99%) and a residue of 1% unsweetened substances
- It contains 70–80% inverted sugar (mixture of glucose and fructose), 5–10% sucrose, non-reducing saccharides, gums, dextrins, nitrogenous substances, enzymes, amino acids, vitamins (B, A, PP, folic acid), mineral salts (Fe, Cu, Mn, Mg, Ca, K), and water.
- It has an energizing, mineralizing, immunostimulating, anti-inflammatory, sedative, antibacterial, laxative, and expectorant action.
- Used in the treatment of sinusitis, rhinitis, pharyngitis, laryngitis, stomatitis, constipation.
- External use in wounds.

I.2. REPRESENTATIVE NATURAL PRODUCTS WITH DISACCHARIDES

1. *SACCHARUM*. SUCROSE. SUGAR

Sucrose, O-α-D-glucopyranosyl-(1-2)-β-D-fructofuranose is a non-reducing disaccharide, formed of a molecule of α-glucose condensed (12) with β-fructose. It is the main form of transport and a temporary reserve of energy in plants.

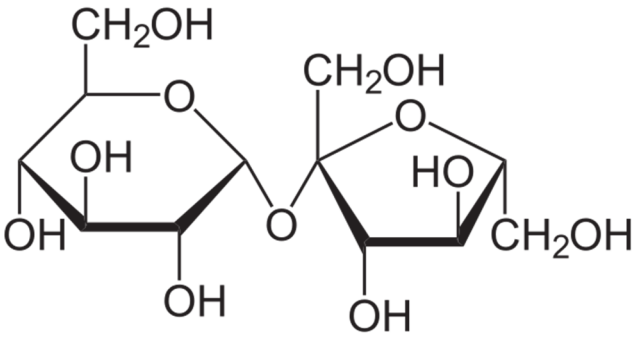


Figure 7. Sucrose chemical structure.

It is accumulated in **large quantities** in:

- sugar beet roots – *Beta vulgaris* L. (*Amaranthaceae)*
- the juice of a species of maple – *Acer saccharum* Marshall (*Sapindaceae*)
- fruits of a palm tree – *Phoenix dactylifera* L. (*Arecaceae*)
- sugar cane stems – *Saccharum officinarum* L. (*Poaceae)*

Methods of obtaining. Effects and uses

- The sugar beet roots are washed, cut into noodles, and then the sucrose is extracted by diffusion in hot water.
- The resulting juice is like a syrup, brown-pasty (molasses); for refined sugar recrystallizations and purifications are made.
- Invert sugar is formed by prolonged boiling in water and in the presence of acids or invertase. Sucrose, strongly dextro-rotatory, is hydrolyzed to

α-D-glucose and β-D-fructose. The resulting mixture becomes levo-rotatory. It is called inverted sugar because it has changed its optical activity.

- It is used as a taste corrector, in hypoglycemic states, in the form of hypertonic solutes in edema, preservative in pharmaceutical technology. The aqueous solution 64% (*Sirupus simplex*) inhibits the development of microorganisms, it is excipient for tablets and syrups.
- Heated to 200 °C it caramelizes, while at 160 °C it melts.

2. *SACCHARUM LACTIS* (Ph.Eur.). LACTOSE

It is a reducing disaccharide present in mammalian milk (cow's milk 5%, breast milk 7%). It consists of a galactose molecule and a glucose molecule, having the chemical structure of type β-D-Galactopyranosyl-(1→4)-D-glucose.

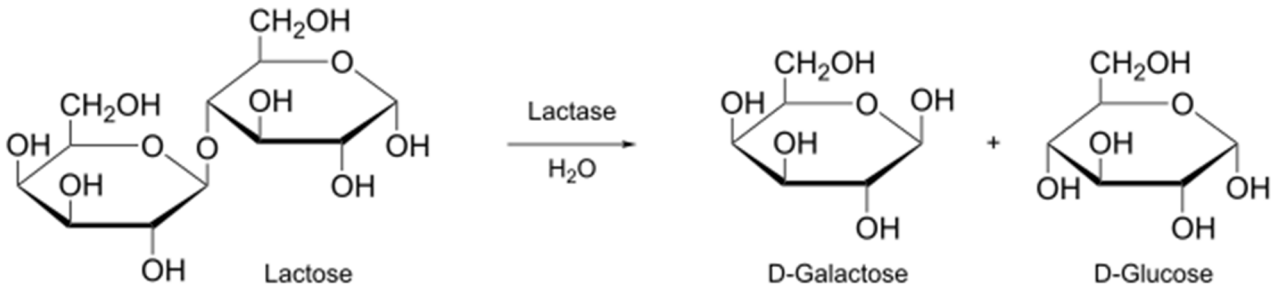


Figure 8. Lactose. Lactose hydrolysis.

Methods of obtaining. Effects and uses:

- Extracted from the milk, from the whey left after obtaining the cheese.
- Has a nutritional role and it is used in the diet of infants in the first months, being the only carbohydrate from the diet.
- Stimulates intestinal peristalsis.
- Helps maintain normal intestinal flora.
- Helps in obtaining lactulose; this is not metabolized in the intestines; it is an osmotic laxative.
- Excipient for tablets. In the case of intravaginal preparations, it stimulates the formation of lactic acid in contact with the lactobacilli of normal vaginal flora.

I.3. REPRESENTATIVE NATURAL PRODUCTS WITH OLIGOSACCHARIDES

CYCLODEXTRINS

Methods of obtaining. Effects and uses:

- They are cyclic oligosaccharides, obtained by enzymatic degradation of starch in the presence of the enzyme cyclodextrin glycosyl transferase, from *Bacillus macerans* and *Bacillus circulans*. There are several types, α-, β-, and γ-cyclodextrins which correspond to 6, 7, and 8 glucose units bound by α-(1-4) type bonds.
- These molecules are highly soluble and resistant to hydrolysis.
- They have a hydrophobic part inside and a hydrophilic part outside, which gives them the ability to form inclusion, non-covalent compounds with many molecules of compatible size.
- This results in molecular encapsulation that leads to:
  - increased chemical and physical stability,
  - modification of solubility and dissolution rate,
  - improving bioavailability,
  - prevention of chemical interactions,
  - prevention of gastric and ocular degradation,
  - masking of taste and unpleasant smell.
- Cyclodextrins have many applications in the complexation of active ingredients, detergents, dyes, and flavorings.

I.4. REPRESENTATIVE NATURAL PRODUCTS WITH POLYSACCHARIDES

1. *CELLULOSUM* (Ph.Eur.). CELLULOSE

Cellulose is a basic substance in the plant kingdom; a linear polymer consisting of D-glucopyranose units bonded β-(1→4). It exists in:

- the hairs of several species of cotton;
- cellulosic fibers of flax, hemp, jute;
- the wood of resins and hardwoods contains 40–60% cellulose.

Semi-synthetic derivatives of cellulose are used in pharmaceutical technology:

- carboxymethylcellulose (CMC): emulsion agent, excipient, disintegrant;
- cellulose acetophthalate: coating agent for enteric-coated pills;
- cellulose di-nitrate: contains active substances used in the treatment of warts and corns in film form.

2. *AMYLUM*. STARCH (Ph.Eur.)

Starch is the main reserve substance of the plant kingdom. It is present in all plant organs, especially tubers, fruits, and seeds. It is a polymer of glucopyranose, consisting of a mixture of two components: amylopectin (more than 80%) and amylose (about 20%).

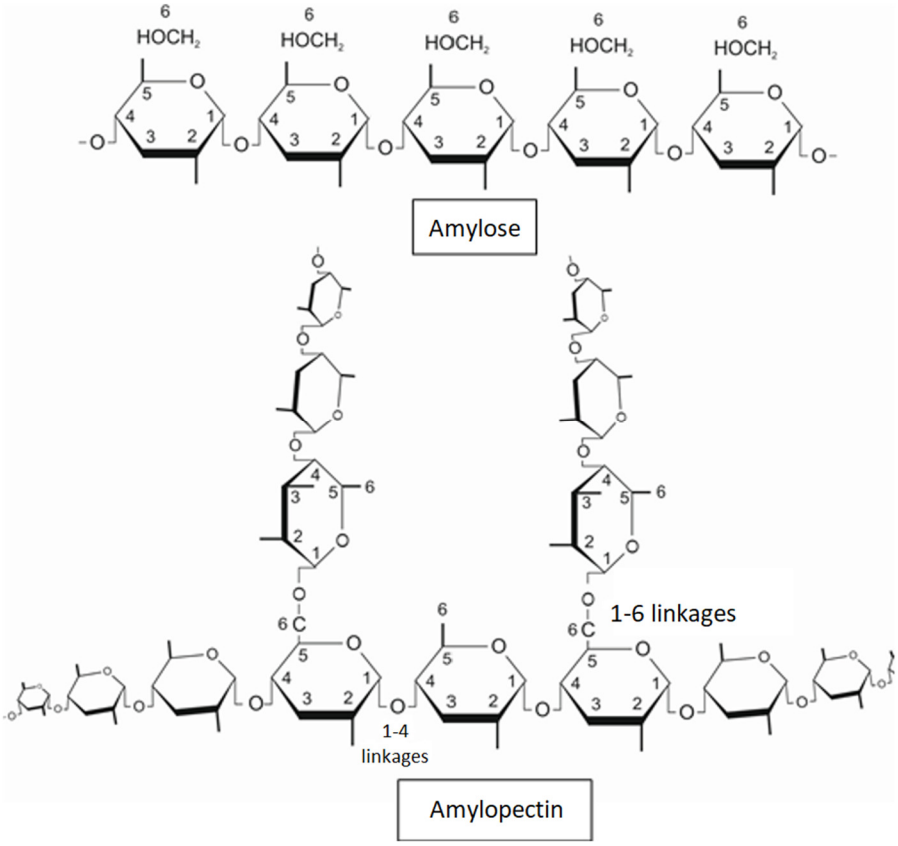


Figure 9. Starch components.

Types of starches:

- *Amylum tritici* – starch isolated from the caryopsis of the species *Triticum vulgare* Mill., *Poaceae;*
- *Amylum maydis* (Ph.Eur.) – starch isolated from the caryopsis of the species *Zea mays* L., *Poaceae;*
- *Amylum solani* – starch isolated from the caryopsis of the species *Solanum tuberosum* L., *Solanaceae;*
- *Amylum oryzae* – starch isolated from the caryopsis of the species *Oryza sa*tiva L., *Poaceae.*

Structure:

Starch results from the combination of the 2 homogeneous polyholosides: amylose and amylopectin.

• amylose = linear molecule, consisting of D-glucopyranose units associated by 1→4 bonds, having a molecular weight of 90.000–200.000 Da, represents 20–30% of the whole molecule; degree of polymerization is n = 600–1200 α.

• amylopectin = highly branched molecule, consisting of D-glucopyranose units associated by bonds 1→4, and 1→6 (lateral branches), having the molecular weight of 1–6 million Da, represents 70–80% from the whole molecule; degree of polymerization n = 6000–36000 α.

Amylopectin is less soluble in water than amylose; because of the ramifications, it retains water better.

Effects and uses:

- Emollient and protective action on the skin.
- In dermatology, in powder form (absolves dermal secretions).
- In pharmaceutical technology for the preparation of tablets and dragees.
- Indicator in iodometric titration.
- In the industry for obtaining glucose, dextrins, and cyclodextrins.

3. DEXTRANUM 40. DEXTRANUM 70

Dextrans are polymers of D-glucopyranose having about 95% 1-6 α-glycosidic bonds in the main chain and lateral branches. There are also 1-3 α-glycosidic bonds at the lateral connections.

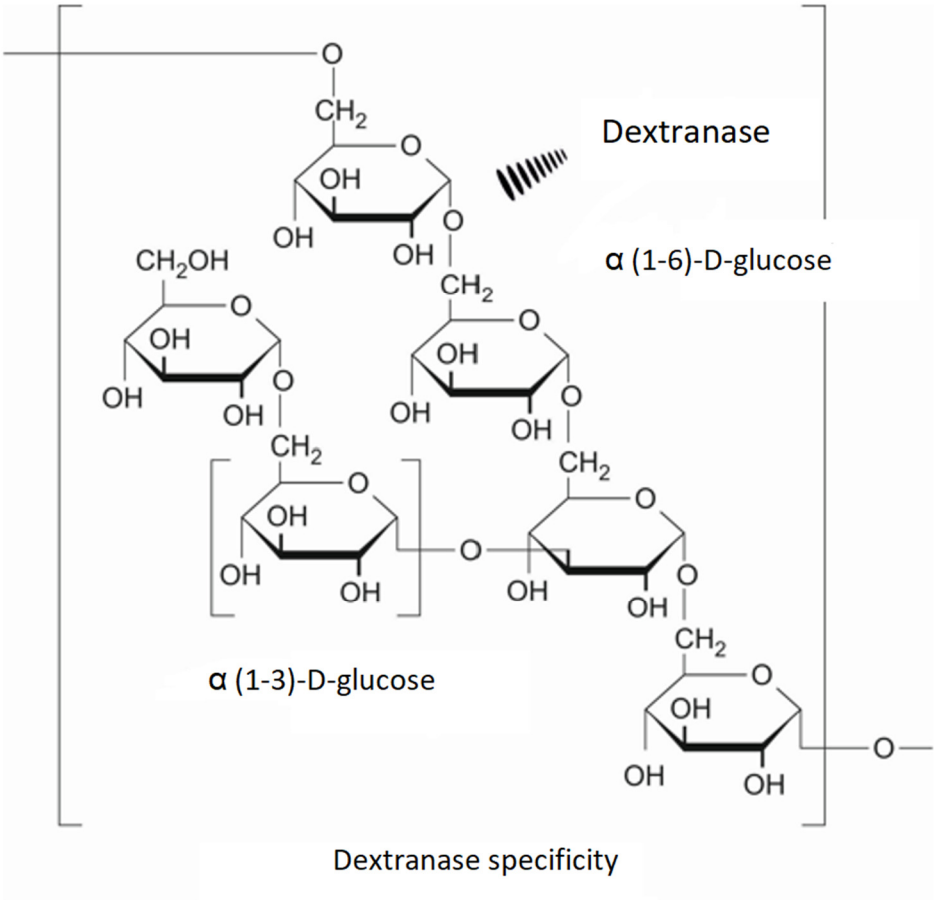


Figure 10. Dextran structure.

Methods of obtaining. Effects and uses:

- The raw dextran (200.000–400.000 daltons) is obtained by the fermentation of sucrose in the presence of microorganisms *Leuconostoc mesenteroides* branch B 512 (*Micrococaceae*).
- By hydrolysis dextrans with lower molecular weight (40.000 or 70.000 daltons) are separated.
- It is presented as a white, crystalline, hygroscopic, water-soluble powder.
- Action: anti-thrombotic and slightly anticoagulant.

- Rols: plasma replacement in hypovolemic shocks (hemorrhagic, traumatic), massive dehydration caused by burns or toxi-infections; They can replace 1–1.5 L of blood or plasma.
- Upon administration, to prevent an anaphylactic reaction, it is better to inject beforehand 10–20 mL of 15% solution of dextran 1.000, which blocks the antigen-antibody sites, and after 2–5 minutes dextran 40 or 70. In massive hemorrhages, it is associated in blood transfusions.
- Medicinal products: Dextran 40 – Rheomacrodex®, Dextran 70 – Macrodex®.

4. LENTINAN

Lentinan is a glucan, a homogeneous polymer isolated from the fungus *Lentinus edodes* (Berk.) Sing., with a branched structure, where the main chain consists of glucose bound 1-3 β-glycosidic and substituted 1-6 β-glycosidic by glucose.

Many other fungi of the *Basidiomycete* family, produce polysaccharide derivatives with properties similar to those of lentinan.

Lentinan has the following properties:

- Immunostimulatory
- Antitumor – associated with cytostatic, especially for stomach cancer.

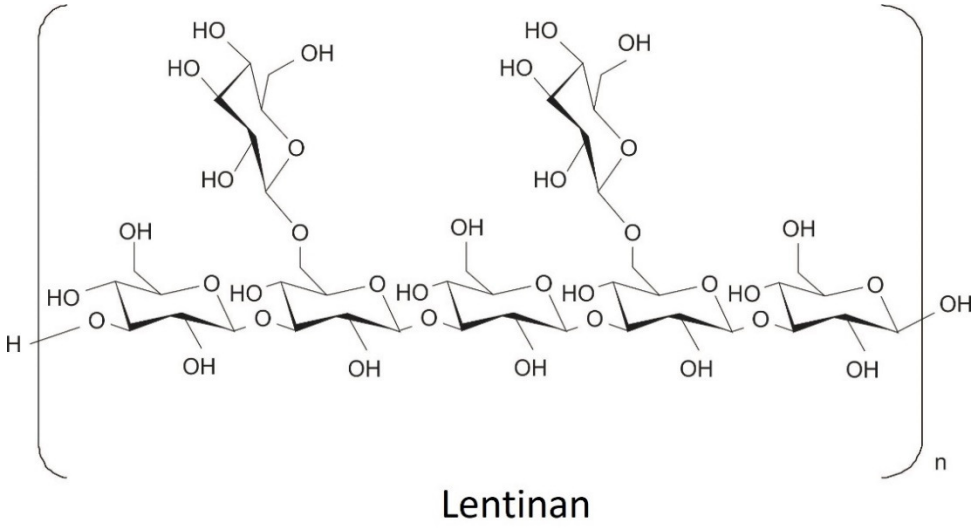


Figure 11. Lentinan structure.

5. Agropyri/Tritici rhizoma, couch grass rhizome (Ph.Eur.)

Agropyron repens (L.) P. Beauv./*Triticum repens* L./*Elymus repens (L.) Gould*, couch grass, Fam. *Poaceae*

Chemical composition: 3–18% triticin (soluble fructan), inulin, fructose, mannitol, mucilage, volatile oil.

Action: diuretic, diaphoretic, laxative, antimicrobial, antifungal.

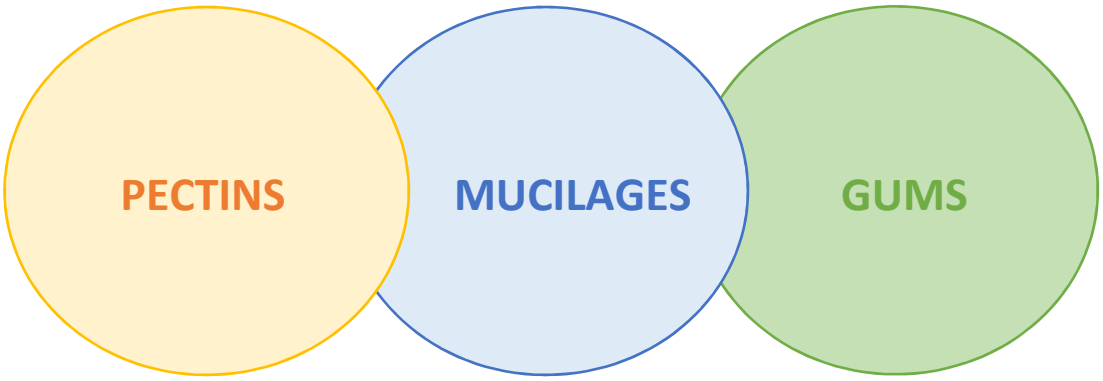
Therapeutic use: treatment of cystitis, urethritis, renal lithiasis, hypertension, alone or in combination with other products.

Figure 12. *Agropyron repens* (L.) P. Beauv.

II. HERBAL PRODUCTS CONTAINING CARBOHYDRATES

PART II – MIXED POLYHOLOSIDES. POLYURONIDES. HETEROGLYCANS

Mixed polyholosides are natural, macromolecular compounds consisting of saccharides (pentoses or hexoses) and uronic acids. They are also called plant hydrocolloids because in contact with water, they form colloidal solutions or gels. Depending on the type of formation, the place of formation, and their physical and chemical properties, they can be classified into:



A. PECTINS

They are polymers of galacturonic acid. The bonds are type 1-4 α-glycosidic and about 50% of the carboxylic groups are esterified with methanol.

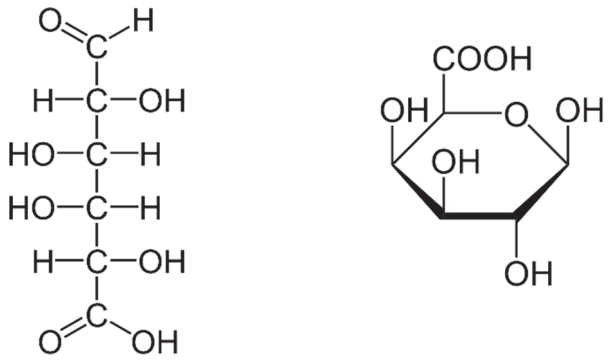


Figure 13. Galacturonic acid – linear form (left) and β-D-galacturonic acid – cyclic form (right).

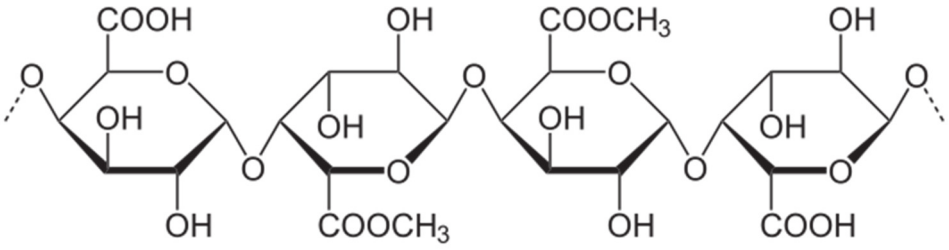


Figure 14. Fragment of a pectin structure.

Pectins exist in almost all living tissues in 3 forms:

- constituent of the primary cell wall in the form of proto-pectins (insoluble in water);
- as a middle lamella cementation substance in the form of pectinates (insoluble in water);
- in the cell juice in the form of water-soluble pectins.

There is a large amount of pectins in apples, citrus fruits, strawberries, figs, carrots, apricots, cherries, quinces, currants, blackberries, etc.

Physical properties:

- They are amorphous substances, yellowish-white, with mucilaginous taste, odorless.

- In water, in a ratio of about 1:20, when hot they form colloidal, viscous solutions, which gelify by cooling.

Extraction: with hot water, in an acidic medium; purification is done by removing starch and proteins.

Effects and uses:

a) Bacteriostatic – creates a pH unfavorable to the development of pathogenic microbial flora involved in the disruption of intestinal transit. When applied to disintegrated tissues and teguments, pectins act as bacteriostatic → they inhibit hyaluronidase and prevent the spread of bacteria into the tissues.

b) Cholesterol-lowering – prevent the absorption of fats and carbohydrates; consumption of 6–30 g per day lowers cholesterol concentration by 16%.

c) Hemostatic – activate thrombocytes, accelerating the rate of blood clotting.

→ symptomatic treatment of gastroenteritis, ulcers, and non-specific diarrhea, especially for infants (in the form of grated apples, purees, etc.), local hemostatic.

In pharmaceutical technology, they are used as gelling agents, for increasing viscosity, and emulsion. In addition, they are used as an adjuvant for delayed-acting drugs.

B. MUCILAGES

They represent hetero-polyholosides neutral or acidic, with a high molecular weight (between 50.000 – 5.000000 daltons). Their structures may or may not contain uronic acids.

Physical properties:

- The neutral or acidic character is determined by free or esterified carboxyl groups.

- They have a great affinity for water.
- In the cold they swell; they form colloidal solutions or viscous gels.
- They are not slimy, like gums.

Extraction: with water-depending on the type of plant product/method chosen, hot or cold water is used. They are purified by precipitation with alcohol or acetone.

Effects and uses:

a) Emollient – thanks to the protection of the mucous membranes and teguments by the colloidal layer they form with water.

b) Laxative – by swelling, they increase the volume of the fecal bolus, thin it, and activate intestinal peristalsis by stimulating baroreceptors. In addition, they favorably develop normal intestinal flora.

c) Slightly **anti-inflammatory.**

d) Slightly **immunostimulatory.**

→ treatment of constipation, inflammations of the respiratory tract, cough, allergic conditions.

C. GUMS

Gums are macromolecular components, mixed polyholosides, with different degrees of polymerization. They have branched chain, which leads to variations in water solubility. Gums are formed by the process called gummosis which involves gelling the membrane, sometimes the cellular contents, too. Indeed, gum comes from the destruction of the cell membrane of connective tissue under the action of an enzyme.

Exudation of gum can be carried out by:

- cracks caused by secretion pressure,
- insect bites, or
- by those produced by man.

Physical properties:

- They are amorphous substances, vitreous or translucent in appearance, their solubility in water is variable, are insoluble in alcohol and acetone.
- In contact with water, they increase their volume and the resulting solution is slimy.

Extraction: by solubilizing gum in water.

Effects and uses:

a) Laxative.

b) Emollient.

c) In pharmaceutical technology they are used as excipients, ointment bases, emulsifiers – stabilizers for suspensions, and tablet disaggregating agents.

II.1. REPRESENTATIVE NATURAL PRODUCTS WITH MUCILAGES

A. Mucilages from algal products

A.1. *AGAR* (Ph.Eur.)

Agar is the gelled and desiccated mucilage, obtained by boiling with acidulated water of the thallus of various red algae (*phylum Rhodophyta*) belonging to the genera: *Gelidium, Gracilaria, Eucheuma, Pterocladia, Phylophora.*

From the point of view of appearance, agar-agar is in the form of narrow, translucent ribbons, with longitudinal streaks, membranous, odorless, tasteless, yellowish-white or yellow-gray color.

Chemical composition: 90% polysaccharides represented by a complex galactan, a mixture of agarose and pyruvyl-agarose, and a sulfated form poor in internal ethers.

Actions: laxative – increases and thins intestinal contents by swelling and water retention; it stimulates intestinal peristalsis. In addition, it promotes the development of normal intestinal flora.

Therapeutic uses:

- Constipation
- Microbiology - culture environment
- Pharmaceutical technology – stabilizer for suspensions and emulsions, disintegrating agent for tablets.
- Cosmetics

A2. *CARRAGEEN, CHONDRUS, IRISH MOSS*

Carrageen is obtained from the thallus of the two red algae (*Rhodophyta*) – *Chondrus crispus* Lingby and *Gigartina mamillosa* Agardh, Fam. *Gigartinaceae.*

Chemical composition: 50-60% carrageenan, polysaccharides, vitamins, amino acids, sterols.

Actions: laxative, mucoprotective, cholesterol-lowering potential; it is non-absorbable, non-digestible, non-toxic.

Therapeutic uses:

- Constipation (increase the volume of the fecal bolus and decrease its consistency), gastritis, duodenitis, ulcers, colitis, dyspepsia.
- Adjuvant in restrictive diets („feeling full" sensation).
- In pharmaceutical technology as suspension stabilizing agents, gelling agents, emulsifiers.

A.3 *LAMINARIAE STIPITES*

It is the product consisting of sterilized and maintained in alcohol, stems obtained from the various brown algae of the genus *Laminaria*: *L. cloustoni* Le Jolis., *L. hyperborea* Fosli., *L. digitata* Lamouroux (*Phaeophyta*).

Chemical composition: 40% alginic acid and sodium alginate (algin), fucoidin, laminarin, mannitol, iodine, amino acids, vitamins (B and C), mineral salts.

Actions: alginic acid and its salts are used for their effects

- Thickening and stabilizing emulsions
- Laxative
- Protector of the gastric mucosa
- Mineralizing

- Energizing
- Anti-coagulant
- Decreases the concentration of circulating lipids

Therapeutic uses:

- Surgical interventions, for the dilation of certain cavities (ear canal, cervix; by hydration their diameter increases 10 times without losing rigidity).
- Constipation.
- Raw material for the extraction of mannitol, alginic acid – food with appreciable energy level – laminarin flour.
- Calcium alginate is an external hemostatic.
- Soluble alginates are used in pharmaceutical technologies as thickening, emulsion, and disintegration agents.

B. Mucilages from herbal products

1. Linum usitatissimum L., flaxseed, Fam. *Linaceae*

Herbal product: *Lini semen* (Ph.Eur.)

Chemical composition: 3–10% mucilage localized in epidermal cells, 30–45% fatty oil, 20–25% proteins, cyanogenic glycosides, minerals 3–4%, omega-3 polyunsaturated fatty acids.

Action: emollient, laxative, regulator of intestinal peristalsis, mucosal protector.

Therapeutic uses: *seeds consumed whole, with water, are used in case of* constipation; whole seeds are hydrated with 10 times more water and used in case of gastritis, enteritis, irritable bowel syndrome.

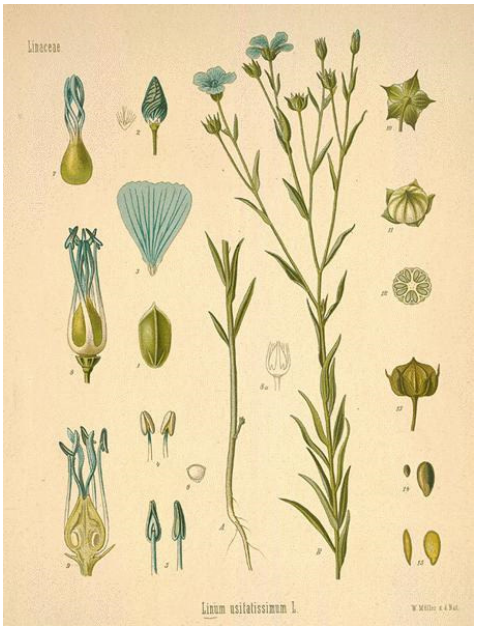


Figure 15. *Linum usitatissimum* L.

2. *Althaea officinalis* L., marshmallow, Fam. *Malvaceae*

Herbal product: *Althaeae folium/radix* (Ph.Eur.)

Chemical composition:
Folium: mucilages, volatile oil, flavonoids
Radix: mucilages, starch, pectins, sugars.

Action: emollient, slightly immunostimulatory properties. It is used in the composition of pectoral herbal teas (*Pectoral Species*). External: maceration of the root or infusion of the leaves in the form of gargling or washing of the oral cavity (pharyngitis, laryngitis, stomatitis, gingivitis).

Therapeutic indications: *irritative disorders* of the mucous membranes: oral → stomatitis, gingivitis, respiratory tract → pharyngitis, laryngitis, cough of various etiologies; irritative disorders of the gastrointestinal mucosa.

Figure 16. *Althaea officinalis* L.

3. *Malva sylvestris* L., Malva *glabra Desv., Malva neglecta Wall.*, wild mallow, wood mallow, common mallow, Fam. *Malvaceae*

Herbal product: *Malvae flos et folium* (Ph.Eur.)

Chemical composition:
Flos*:* 10% mucilages, tannins, anthocyanins.
Folium*:* 8% mucilages, flavonoids, tannins.

Action: emollient, slightly anesthetic, and immunostimulatory properties. It is used in the composition of pectoral herbal teas. External: maceration of the root or infusion of the leaves in the form of gargling or washing of the oral cavity (pharyngitis, laryngitis, stomatitis, gingivitis).

Therapeutic indications: *irritative disorders* of the mucous membranes: oral → stomatitis, gingivitis, respiratory tract → pharyngitis, laryngitis, cough of various etiologies; irritative disorders of the gastrointestinal mucosa.

Figure 17. *Malva sylvestris* L.

4. Tilia cordata Mill., small-leaved linden (in the picture), *Tilia platyphyllos* Scop., linden, *Tilia tomentosa* Moench., silver linden, Fam. *Malvaceae*

Herbal product: *Tiliae flos* (Ph.Eur.)

Chemical composition: 10% mucilages (present in a greater concentration in flowers than in bracts - *Tilia tomentosa* is the richest species), volatile oil, phenolic compounds, flavonoids.

Action: emollient, expectorant, sudorific, slightly sedative and anti-spastic.

Therapeutic uses: respiratory diseases, influenza, mild insomnia, nervousness.

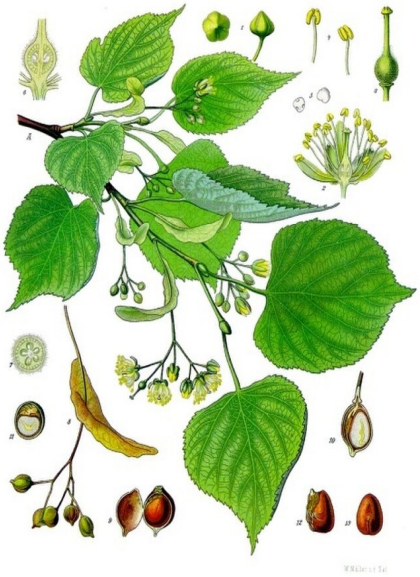


Figure 18. *Tilia cordata* Mill.

5. Tussilago farfara L., coltsfoot, Fam. *Asteraceae*

Herbal product: *Farfarae folium*

Chemical composition: 6–10% mucilages, inulin, tannins, flavonoids, reduced amounts of pyrrolizidine alkaloids (senkirkine, tussilagone).

Action: antitussive, stimulant on the respirator center (tussilagone), emollient, inhibitor of PAF (platelet-activating factor) – has a mediating role in inflammation.

Therapeutic uses: cough of various etiologies, tracheitis, bronchopneumonia, is part of the composition of *anti-asthmatic* and anti-bronchitis herbal teas. Due to pyrrolizidine alkaloids (carcinogenic potential), it is recommended to consume coltsfoot most 4–6 months a year.

Figure 19. *Tussilago farfara* L.

6. Plantago lanceolata L. - lanceolate plantain/ribwort plantain, *P. media* L. - hoary plantain, *P. major* L. - plantain, Fam. *Plantaginaceae*

Herbal product: *Plantaginis folium* (Ph.Eur.)

Chemical composition: 6.5% mucilages, tannins, phenol-carboxylic acids, saponins, flavonoids.

Action: emollient, wound-healing, anti-inflammatory, astringent, antibacterial, slightly immunostimulatory.

Therapeutic uses: cough of various etiologies, respiratory diseases, inflammatory dermal diseases. The leaves are frequently used in folk medicine as hemostatic, wound healing, anti-infectious – freshly applied on wounds.

Figure 20. *Plantago lanceolata* L.

7. Verbascum phlomoides L.*, Verbascum thapsiforme* Schrad.*, Verbascum thapsus* L. - in the picture, *Verbascum speciosum* Schrad., mullein, Fam. *Scrophulariaceae*

Herbal product: *Verbasci flos* (Ph.Eur.)

Chemical composition: 3% polysaccharides consisting of uronic acids, galactose, and arabinose; iridoids, flavonoids, lignans, saponins.

Action: emollient, anti-inflammatory, expectorant, slightly analgesic, sudorific.

Therapeutic indications: cough of various etiologies, stomatitis, gingivitis, pharyngitis, laryngitis (infusion, gargle).

Figure 21. *Verbascum thapsus* L.

II.2. REPRESENTATIVE NATURAL PRODUCTS WITH GUMS

1. *GUMMI ARABICUM. GUMMI ACACIAE* (Ph.Eur.). ACCACIA GUM

It represents the natural or induced exudate, hardened in air by incision of the trunk and branches of *Acacia senegal* (L.) Willd. and other species of *Acacia (Fabaceae).*

Commercial products:

- Kordofan gum arabic – Sudanese origin
- Senegalese gum arabic – Senegalese origin

Chemical composition: arabic acid (gummic acid) - water-soluble polysaccharides, water-insoluble polysaccharides but gel-forming - varied structure (the basic structure is differently substituted linear galactan), enzyme-oxidases and peroxidases, tannin.

Comments!

The presence of enzymes and the absence of starch differentiate it from other gums (*Gummi tragacanthae*).

Actions:

- Emollient, protective – it forms a dense mucilage with water.
- *Gummi arabicum* is compatible with most plant hydrocolloids and alkaloids; it is incompatible with phenolic compounds (thymol, eugenol, morphine), gelatin, Fe salts, etc. due to oxidases and peroxidases.
- therefore, to avoid interaction with other medicinal substances, *Gummi Arabicum desenzyatum* is used in the pharmacy; inactivation is carried out by heating in an oven to 60 °C.

Therapeutic uses:

- in pharmaceutical technology → preparation of tablets;
- formulation of certain hair product excipients;
- in food technology → preparation of instant tea and formulas with volatile oils (it forms a protective film around the oil drops, protecting them from contact with air and against evaporation).

2. *GUMMI TRAGACANTHAE* (Ph.Eur.). TRAGACANTH GUM

It represents the solidified exudate obtained from the branches and trunk of some species of *Astragalus: Astragalus gummifer* Labill., *A.microcephalus* Willd., *A. kurdicus* Boiss., *A. verus* Olivier (*Fabaceae*).

Chemical composition: polysaccharides – mixture consisting of 30–40% tragacanthin (neutral fraction) and 60–70% bassorin (acid fraction), 3% starch, 10–15% water, and 3–4% mineral substances.

Action: slightly laxative (due to swelling) and emollient.

Therapeutic uses:

- at present it is used very rarely in the treatment of chronic constipation;
- in pharmaceutical technology, it is used as an adjuvant in the preparation of gels and hair excipients, emulsion, and stabilizing agent for suspensions.

III. GLYCOSIDES – OVERVIEW

- Also named heterosides, glycosides are natural compounds of plant origin, born from the condensation of one or more monosaccharides having a non-carbohydrate part (genin or aglycone or genol) and a carbohydrate part.
- They are characteristic for the plant kingdom. In the animal organism, there are glycosidic bonds only in DNA and RNA nucleosides.
- The chemical structure of glycosides is very different, which affects the different roles they have in the organism of plants, but also the pharmacological action.
- Glycosides do not form a group of active ingredients with a certain pharmacological action.
- The common feature of glycosides is the presence in the molecule of both partners:

- **a non-carbohydrate (aglycone)**
- **a carbohydrate**

} **Glycosidic bond**

Therapeutic role:

- The pharmacodynamic action is given by the aglycone.
- The carbohydrate part (glycone) is responsible for absorption, bioavailability, elimination.

The carbohydrate partner:

- This can be a single monosaccharide or a simple or branched chain consisting of several saccharides.
- The most frequently encountered monosaccharide in the structure of glycosides is represented by glucose.

- Other lesser-known monosaccharides are: arabinose, xylose, rhamnose, mannose, fructose, galactose.
- If the only carbohydrate partner is glucose, the substance may be called „glucoside"; by analogy we say „rhamnoside", „galactoside".
- If the carbohydrate partner is mixed or if we do not want to accentuate the nature of the carbohydrate partner, we use the name „glycoside".
- Saccharides are bound to the aglycone by an oxydryl α- or β- glycosidic.
- But there are also glycosides whose binding atom can be sulfur (in the case of thioglycoside) or nitrogen (in the case of nucleosides). Glycosides whose carbohydrate chain is bonded by C-C bonds are called C-glycosides.

Aglycone:

- Aglycone is also called genin or genol and belongs to the most diverse chemical classes.
- The only common characteristic of aglycones to typical glycosides is the presence of the hydroxyl group – alcoholic or phenolic – whose saccharide/s is/are bound through the glycosidic bond.

Examples of aglycones: hydroquinone, methyl salicylate, gallic acid, triterpene acids (e.g. betulinic acid).

Classification criteria

- Because of the great structural diversity of glycosides, in order to carry out a systematic study, a classification was required.
- The classification is based on:

-the bond atom between aglycone and monosaccharide/ or oligosaccharide

-the chemical structure of aglycone

Depending on the bond atom, glycosides are classified into:

- O-heterosides or oxygen-heterosides (majority compounds)
- S-heterosides glucosinolates
- C-carbon heterosides
- N-azote heterosides

Depending on the chemical structure of the aglycone there are:

- Phenolic heterosides →
  - Type C6 derived from hydroquinone
  - Type C6-C1 derived from saligenol, salicylic acid, aldehyde, gallic acid
  - Type C6-C3 derived from caffeic acid, cumarines, furanochromones, lignans
  - Type C6-C3-C6 or flavonoides: flavones and derivatives, anthocyanosides, proanthocyanosides, catecholes (catecholes tannins)
- Naphtoquinones
- Anthracenosides
- Sterol heterosides →
  - Phytosterolins
  - Digitalis heterosides
  - Cardiotonic heterosides
  - Withanolides
- Saponosides →
  - Triterpenoid
  - Steroidal
- Cyanogenetic or cyanogenic heterosides
- Glucosinolate heterosides or thioheterosides

Physical properties:

- They are solid, crystallized or amorphous substances, depending on the length of the carbohydrate chain, colorless or yellow (flavonoids, chalcones, aurones), oranges (carotenoids, anthracenosides, flavonoids), red, purple, or blue (anthocyanosides). They are soluble in water, methanol, ethanol, acetone (polar solvents), insoluble in nonpolar solvents (ether, chloroform, benzene, light petroleum, etc.). Aglycones are solid, crystallized, colorless, or colored substances that are insoluble in water (e.g. certain phenolic aglycones-hydroquinone, etc.), soluble in certain polar organic solvents (methanol, ethanol, acetone-phenolic aglycones) and apolar organic solvents (ether, benzene, chloroform, ethyl acetate, etc.).

IV. PHENOLIC GLYCOSIDES TYPE C6. SIMPLE PHENOLIC GLYCOSIDES

- Phenolic glycosides are the simplest glycosides from the point of view of chemical structure.
- Aglycone is an aromatic compound (hydroquinone).
- The most important representatives: arbutoside, methyl-arbutoside, and derivatives.

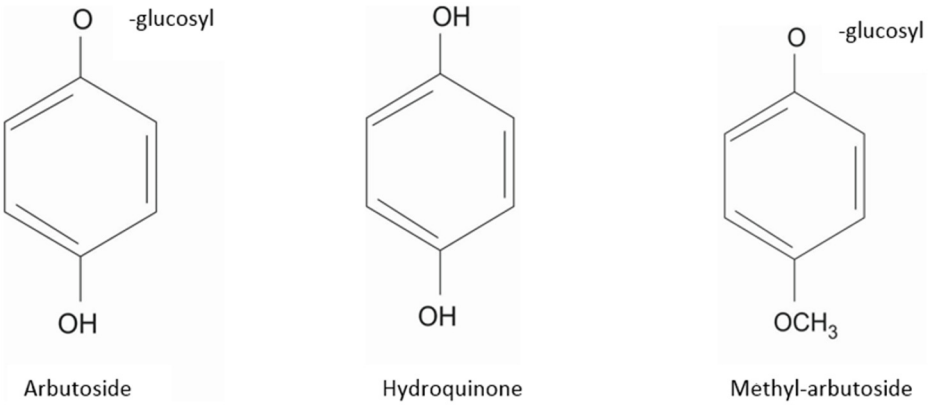


Figure 22. Chemical structure of the representatives of phenolic glycosides type C6.

Pharmacological action:

- Antiseptic: in case of urinary tract infections.
- After administration of extracts (in various pharmaceutical forms), at the intestinal level, under the action of the intestinal flora, hydroquinone is delivered from glycosidic form. After absorption, hydroquinone is metabolized in the intestinal wall and liver into corresponding conjugates (glucurono-conjugates and sulfates), and then they are excreted renally; hydroquinone is released from the conjugated forms (metabolites), activating as a urinary antiseptic**.**

- The antiseptic action is due to hydroquinone, which is eliminated rapidly through the urine and which colors the urine bluish-green.
- Inhibits melanin synthesis → is indicated in local application in the depigmentation of hyper-pigment scars and freckles.
- It may cause leuko-melanoderma with circular depigmentation. This is why we recommend short-term treatment, application by small areas and without sun exposure.

IV.1. REPRESENTATIVE HERBAL PRODUCTS WITH HYDROQUINONE GLYCOSIDES

1. Arctostaphylos uva-ursi (L.) Spreng., red bearberry, Fam. *Ericaceae*

Herbal product: *Uvae ursi folium* (Ph.Eur.)

Chemical composition: arbutoside, methyl-arbutoside, tannins, flavonoids, polyphenolic derivatives, triterpenes.

Action: urinary antiseptic, antibacterial, astringent, diuretic.

Therapeutic uses: infections and inflammations of the urinary tract (cystitis, urethritis, nephritis, pyelitis).

Figure 23. *Arctostaphylos uva-ursi* (L.) Spreng.

2. Vaccinium vitis idaea L., lingonberry, partridgeberry, mountain cranberry, cowberry, Fam. *Ericaceae*

Herbal product: *Vitis idaeae folium*

Chemical composition: arbutoside, methyl-arbutoside, tannins, flavonoids, polyphenolic derivatives, triterpenes.

Action: urinary antiseptic, antibacterial, astringent, diuretic.

Therapeutic indications: infections and inflammations of the urinary tract (cystitis, urethritis, nephritis, pyelitis).

Figure 24. *Vaccinium vitis idaea* L.

3. Vaccinium myrtillus L., European blueberry, bilberry, blue whortleberry, Fam. *Ericaceae*

Herbal product: *Myrtili fructus siccus - dried fruits, Myrtili fructus recens - fresh fruit* (Ph. Eur.), *Myrtili folium*

Chemical composition:
Fructus: anthocyanins (myrtillosides), tannins, vitamins, flavones.
***Folium*:** arbutoside, methyl-arbutoside, flavones, catehic tannins, pro-anthocyanidins.

Action:
Fructus: protective of capillaries, anti-edematous, improves eyesight, antiplatelet agent; dried fruits are anti-diarrheal, fresh fruits are laxative.
Folium: hypoglycemic, antibacterial, diuretic, astringent.

Therapeutic uses:
Fructus: vascular disorders, visual disturbances, diabetic angiopathy.
Folium: adjuvant treatment of diabetes mellitus, urinary tract infections, diarrhea.

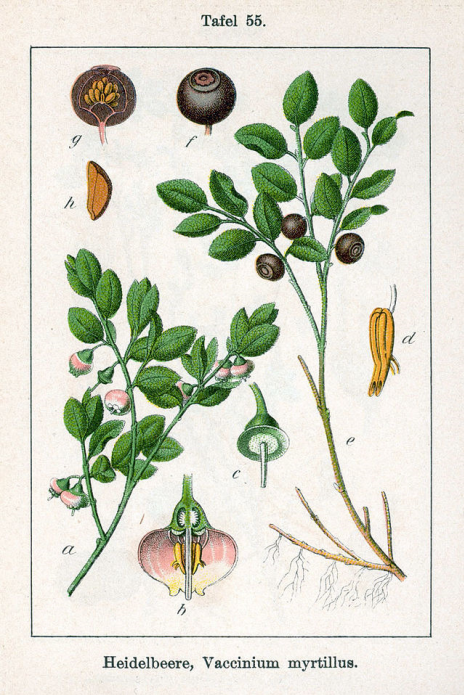


Figure 25. *Vaccinium myrtillus* L.

V. PHENOLIC GLYCOSIDES TYPE C6-C1. SALIGENOL GLYCOSIDES AND THEIR DERIVATIVES

- They are represented by salicoside (salicin) and its benzoylated derivatives (populin), salicyl-populin, salireposide, tremulain, etc.).
- They have an antipyretic, analgesic, anti-inflammatory, anti-platelet action.
- These actions are due to salicylic acid formed at the intestinal level, by the oxidation of saligenol resulting from the hydrolysis of salicoside or by the slow degradation of salicoside (inhibits cyclooxygenase):
    - the extract is considered a product
    - the active compound is delayed (salicylic acid)
    - intestinal hydrolysis of glycosides under the action of the alkaline medium and then the microbial flora takes place (there is no gastric assignment) - saligenol is released
    - absorbed at the intestinal level in proportion of 86%, saligenol is oxidized in the liver (the enzymes of cytochrome p450) to salicylic acid
    - there is no negative influence on the production of gastric mucus (no accumulation of protons in the gastric mucosa; COX1 action is slightly influenced)

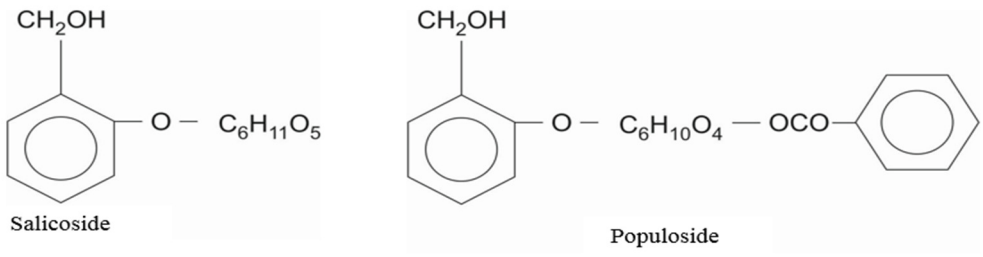


Figure 26. Chemical structure of the representatives of phenolic glycosides type C6-C1.

V.1. REPRESENTATIVE HERBAL PRODUCTS WITH GLYCOSIDES OF SALIGENOL AND THEIR DERIVATIVES

1. *Salix alba* L. – white willow, *S. fragilis* Host, *S. purpurea* L. – purple osier, *S. caprea* L. – goat willow, *S. pentandra* L. – bay willow, Fam. *Salicaceae*

Herbal product: *Salicis cortex* (Ph.Eur.)

Chemical composition: salicoside, populoside, flavones, tannins, polyphenol-carboxylic acids.

Action: anti-inflammatory, analgesic, antipyretic, antiplatelet.

Therapeutic uses: viral infections, mild pain, rheumatic disorders.

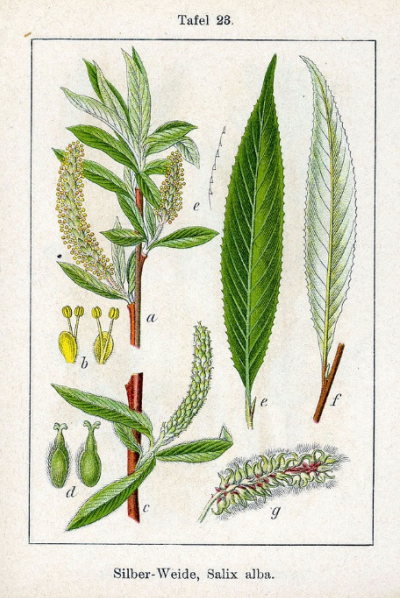


Figure 27. *Salix alba* L.

2. *Populus nigra* L., *P. tremula* L., *P. pyramidalis* L., poplar, Fam. *Salicaceae*

Herbal product: *Populi gemmae*

Chemical composition: salicin, populin, flavonoids, saponins, tannins, waxes.

Action: analgesic, antipyretic, anti-inflammatory, diuretic, antiseptic, expectorant, healing.

Therapeutic uses: dermal lesions, hemorrhoids, rheumatic diseases, acute and chronic diseases of the respiratory system.

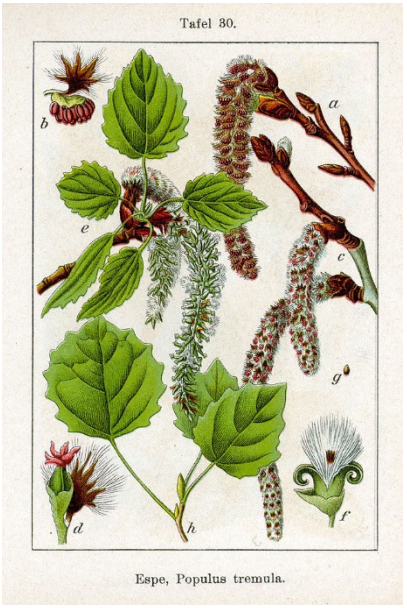


Figure 28. *Populus tremula* L.

3. Filipendula ulmaria (L.) Maxim./*Spiraea ulmaria* L., meadowsweet, Fam. *Rosaceae*

Herbal product: *Ulmariae flores (herba)* (Ph.Eur.)

Chemical composition: volatile oil (monotropitoside → methyl salicylate), gaultherin, flavones, tannins.

Action: antipyretic, analgesic, anti-inflammatory, diuretic, diaphoretic, astringent.

Therapeutic uses: rheumatic diseases, stomatitis, gingivitis, viral infections.

Figure 29. *Spiraea ulmaria* L.

4. Vanilla planifolia Andrews, vanilla, Fam. *Orchidaceae*

Herbal product: *Vanilla fructus*

Chemical composition: *coniferoside* (fresh), odourless, vanilla and related compounds (vanillic alcohol, vanillic acid), other aldehydes, alcohols, acids and esters (resulting from the enzymatic decomposition of coniferoside), after fermentation → specific odour.

Action: flavouring.

Therapeutic uses: flavouring.

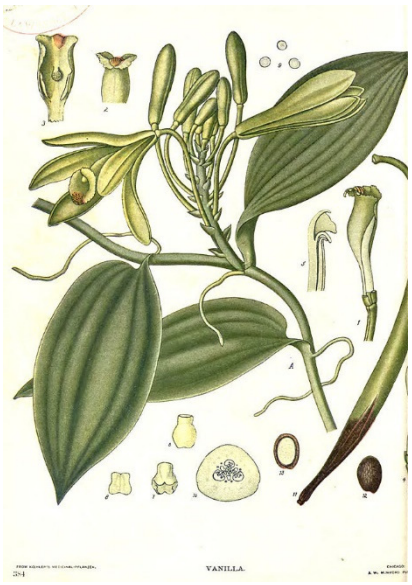


Figure 30. *Vanilla planifolia* Andrews

VI. PHENOLIC GLYCOSIDES TYPE C6-C3. POLYPHENOL-CARBOXYLIC ACID DERIVATIVES

Most of these acids are esters of caffeic, p-coumaric, ferulic, sinapic acids. They are also called ODPs because of the two phenolic groups, ortho-dihydroxy of caffeic acid.

Polyphenol-carboxylic acid derivatives have complex therapeutic properties:

- choleretic-cholagogue
- hepatoprotective
- antioxidant
- immunostimulatory
- hypoglycemic, lipid-lowering effect

The figure below details some representative structures:

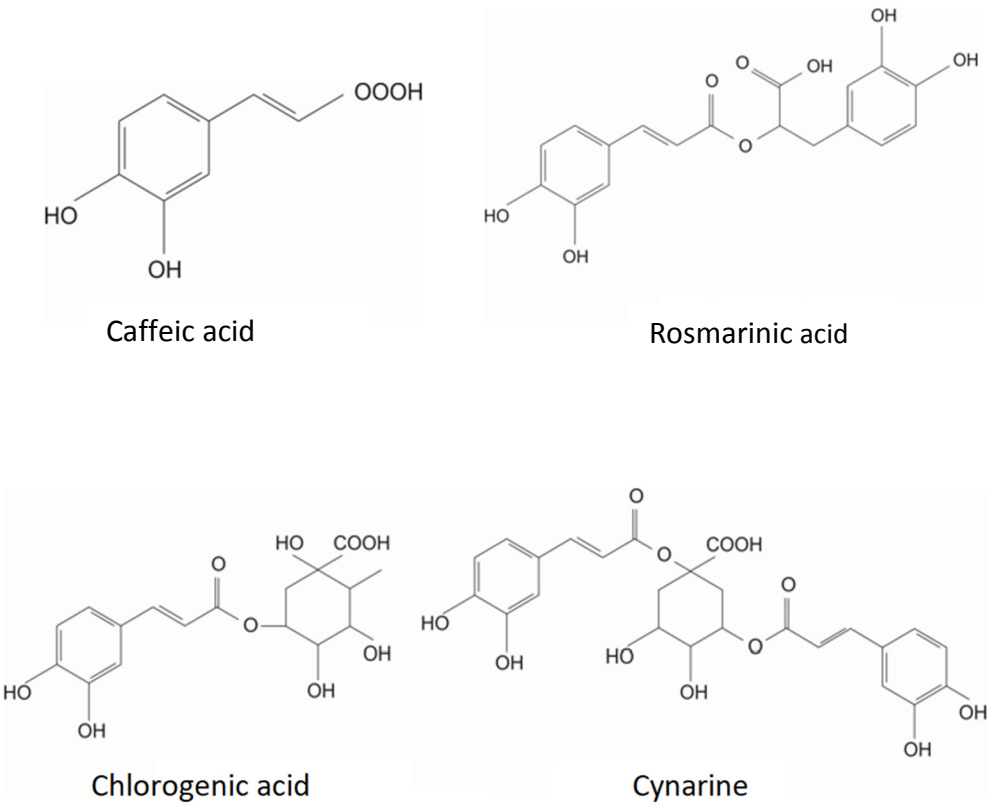


Figure 31. Chemical structure of the representatives of phenolic glycosides type C6-C3.

VI.1. REPRESENTATIVE HERBAL PRODUCTS WITH PHENOLIC GLYCOSIDES TYPE C6-C3

1. Cynara scolymus L., artichoke, Fam. *Asteraceae*

Herbal product: *Cynarae folium* (Ph.Eur.)

Chemical composition: polyphenols (expressed as cynarin), flavone, bitter principles, triterpene compounds, tannin.

Action: cholagogue–choleretic, hepatoprotective, regeneration of liver tissue, bitter tonic, stomachic, cholesterol-lowering, spasmolytic, slightly diuretic, antioxidant.

Therapeutic uses: slow digestion, biliary colic, hepatic and renal failure, hypercholesterolemia, obesity, atherosclerosis.

Figure 32. *Cynara scolymus* L.

2. Echinacea angustifolia DC., *Echinacea pallida* Nutt., *Echinacea purpurea* (L.) Moench, echinacea, Fam. *Asteraceae*

Herbal product: *Echinaceae radix et herba* (Ph.Eur.)

Chemical composition: caffeic acid derivatives - echinacoside, cynarin, cichoric acid, polyuronides, volatile oil.

Action: immunostimulatory, antibacterial, antiviral, anti-inflammatory.

Therapeutic uses: prophylaxis and treatment of infections of the respiratory, urinary, and dermal tract.

Figure 33. *Echinacea angustifolia* DC.

3. Rosmarinus officinalis L., rosemary, Fam. *Lamiaceae*

Herbal product: *Rosmarini folium*, *Rosmarini aetheroleum* (Ph.Eur.)

Chemical composition: rosmarinic acid, caffeic acid, chlorogenic acid, volatile oil, flavonoids, bitter principles.

Action: stimulation of gastric secretions, antispastic, choleretic-cholagogue, antioxidant, hepatoprotective, anti-inflammatory, antibacterial, improves blood circulation at the central and peripheral level, revulsive.

Therapeutic indications: appetite loss, digestive disorders, vertigo, asthenia, migraines, cramps, rheumatism, infections.

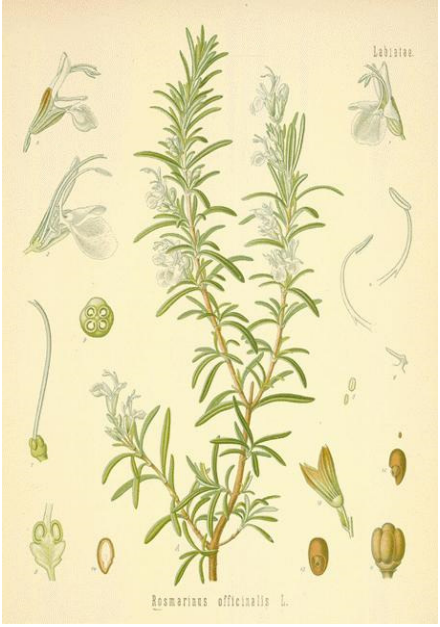


Figure 34. *Rosmarinus officinalis* L.

VII. COUMARINS

Coumarins are natural lactones, with a structure of α-benzo-pyronic type, resulting following the dehydration of o-hydroxy-cinnamic acids. They can be in the form of aglycone or heteroside. Their name derives from the plant *Coumarouna odorata* Aublet., Fam. *Fabaceae,* from which *coumarin* was first isolated in 1820**.** Today there are more than 250 coumarin derivatives.

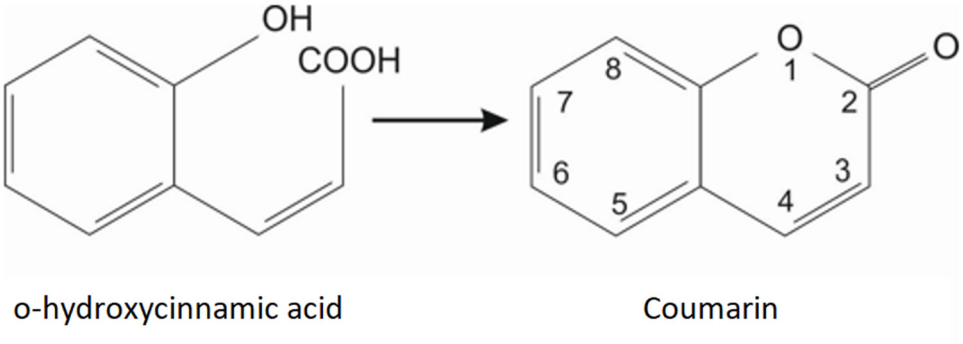


Figure 35. Coumarin synthesis.

Coumarins can have a simple structure, sometimes dimerized, or a more complex structure, resulting from the binding to the benzene ring of a heterocycle, most often of the furan or pyran type.

Depending on the chemical structure, coumarins can be classified into:

- Simple and dimer coumarins
- Furanocoumarins
- Pyranocoumarins
- Isocoumarins
- Coumestans

Physical properties:

- solid, sublimable, crystallized substances.
- have a characteristic, flavored smell.

- a specific property is that of emitting characteristic radiation in ultraviolet light. Therefore, they may exhibit blue, green, violet fluorescence, more intense after alkalization.
- glycosides are soluble in polar solvents: water, alcohol, acetone.
- aglycones are soluble in nonpolar solvents: ether, chloroform, dichloroethane, etc., but also in alcohol.

Action:

- decrease capillary permeability and increase lymphatic and venous flow
- venotonic and vasoprotective
- anti-inflammatory
- anticoagulant, thrombolytic
- choleretic
- diuretic, by promoting the elimination of uric acid
- antispastic
- anticoagulant, thrombolytic
- antibiotic, bacteriostatic
- estrogenic
- photosensitizing
- protection against solar radiation

Observation!

Some plant products of the coumarin class can determine the occurrence of phototoxicity phenomena. They appear after skin contact with these plants and subsequent exposure to the sun. Sweating (damp skin) promotes the appearance of these phenomena.

Therapeutic uses:

- coumarins and their derivatives are used in the treatment of venous thrombosis and pulmonary embolism

- for the prevention of embolisms in patients with atrial fibrillation
- in cardiac surgery
- for the manufacture of anti-UV screens
- in photochemotherapy (PUVA therapy) of psoriasis and leukoderma (vitiligo)
- the procedure carries the risk of induction skin cancer, it can determine digestive ailments, accelerated aging of the lens, photosensitization
- antibacterial coumarins (novobiocin) are used in the treatment of various infections

VII.1. REPRESENTATIVE HERBAL PRODUCTS WITH COUMARINS

1. Melilotus officinalis (L.) Lam., sweet yellow clover, yellow melilot, ribbed melilot, Fam. *Fabaceae*

Herbal product: *Meliloti herba* (Ph.Eur.)

Chemical composition: melilotoside – odorless (β glucoside of coumarinic acid) - by hydrolysis and lactonization turns into coumarin (pleasant odor), coumarin derivatives: coumaric acid, melilotic acid, scopoletin, umbelliferone, saponosites, flavonoids, pentacyclic triterpenes.

Action: anti-edematous, anti-inflammatory, promotes healing, diuretic, flowers – flavoring in various phyto-preparations.

Therapeutic uses: venous insufficiency, adjuvant in case of thrombophlebitis, varicose veins, hemorrhoids, bruises, sprains.

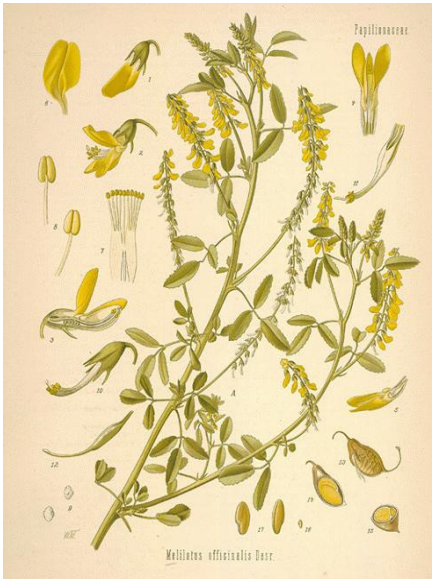


Figure 36. *Melilotus officinalis* (L.)

2. Fraxinus excelsior L., ash, Fam. *Oleaceae*

Herbal product: *Fraxini folium* (Ph.Eur.)

Chemical composition: coumarins, fraxetol, fraxoside, mannitol, tannins, volatile oil, flavonosides (rutoside).

Action: diuretic (increased elimination of uric acid), diaphoretic, laxative, bitter tonic, anti-inflammatory, analgesic.

Therapeutic uses: gout, arthritis, rheumatism, urinary system disorders, slow intestinal transit.

Figure 37. *Fraxinus excelsior* L.

3. Angelica archangelica L., garden angelica, wild celery, Fam. *Apiaceae*

Herbal product: *Angelicae radix* (Ph.Eur.)

Chemical composition: simple coumarins (umbelliferone), furanocoumarins (bergapten, xanthotoxin, angelicin, archangelicin), volatile oil.

Action: carminative, stomachic, choleretic, cholecystokinetic, antirheumatic, antispastic, diuretic, antibacterial, anti-inflammatory, slightly sedative.

Therapeutic uses: inappetence, dyspepsia, colic, bloating, respiratory diseases.

Figure 38. *Angelica archangelica* L.

4. Ammi majus L., Fam. *Apiaceae*

Herbal product: *Ammi majoris fructus*

Chemical composition: furanocoumarins: bergapten, xanthotoxin, isopimpinelin, imperatorin, marmesin, amajinine.

Action: photosensitizing.

Therapeutic uses: epithelial depigmentation, leukoderma, vitiligo, psoriasis (psoriasis - UVA therapy - PUVA therapy).

Figure 39. *Ammi majus* L.

5. Ammi visnaga (L.) Lam., khella, Fam. *Apiaceae*

Herbal product: *Ammi visnagae fructus*

Chemical composition: pyranocoumarins: visnadine, samidine, dihydrosamidine, furanochromones: khelline, visnagine, flavones, volatile oil, lipids, proteins.

Action: spasmolytic, slightly coronarodilatator.

Therapeutic uses: biliary colic, urinary tract infections.

Figure 40. *Ammi visnaga* L. Lam.

6. Aesculus hippocastanum L., horse chestnut, Fam. *Sapindaceae*

Herbal product: *Hippocastani cortex* (Ph.Eur.)

Chemical composition: coumarins: esculoside, esculetol, fraxoside, fraxetol, saponosides, tannin.

Action: vasoprotective.

Therapeutic uses: hemorrhoids, cutaneous capillary fragility, capillary hemorrhages, veno-lymphatic insufficiency.

Figure 41. *Aesculus hippocastanum* L.

7. Asperula odorata L., sweet woodruff, Fam. *Rubiaceae*

Herbal product: *Asperulae herba*

Chemical composition: coumarins, iridoids, flavonoids.

Action: spasmolytic, anti-inflammatory, anti-edematous, vasoprotective, slightly sedative.

Therapeutic uses: venous diseases, sleep disorders.

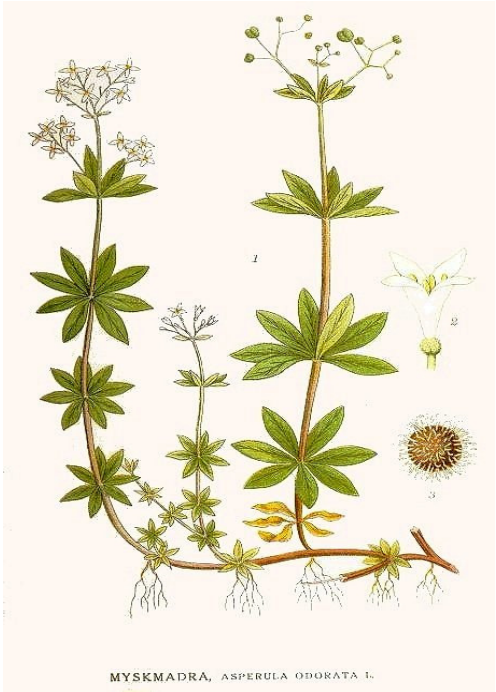


Figure 42. *Asperula odorata* L.

VIII. LIGNANS

Lignans are phenylpropanic condensation compounds (usually 2 - 5 molecules), which exist in macromolecular, acyclic, or cyclic form, linked by side chains, lactonized, β-glucosided, or non-glucosid. They are contained in the intimate structure of cell membranes, next to cellulose and pectins. They can also be constituents of cell juice, in the form of simpler molecules (phenylpropanic dimers).

Classification:

Depending on the number of phenylpropanic units and the type of chemical bonds established between the carbon atoms of the side chain, we know:

(a) **Simple lignans** – dimers formed by condensation 8-8';

(b) **Neolignans** – compounds formed by condensation of types 8-3', 8-1', 8-O-4';

(c) **Hybrid lignans** – combinations of lignans with flavanonols (flavanolignans), coumarin derivatives (coumarinolignans), xanthones (xantholignoids).

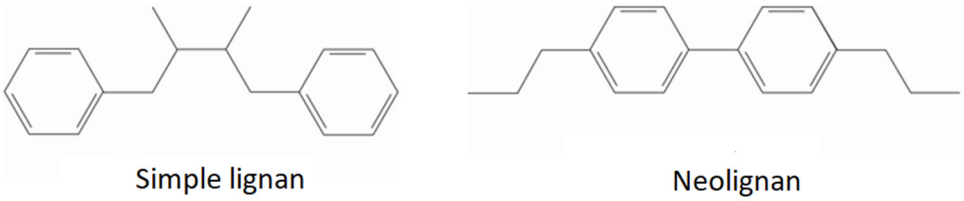


Figure 43. Representation of lignans chemical structure.

Physical properties:

- are solid, crystallized, optically active, colorless substances
- glycoside forms are soluble in water, dilute alcohol, dilute acetone
- non-glycosed forms are soluble in dilute alcohol, acetone, benzene, ether, chloroform, and poorly soluble in light petroleum.

The structures with hydroxylphenolic groups form with alkaline hydroxides phenoxides soluble in water, and poorly soluble in alcohol. Lactonic lignans generate hydroxylated acids. In acidic or basic medium, they isolate easily.

Therapeutic uses:

Therapeutic properties depend on the chemical structure. The main role is that of defense against mycotic infections, but other effects can also be specified: immunostimulating, hepatoprotective, antihypertensive, antiplatelet, antiviral, antiallergic, antirheumatic action.

VIII.1. REPRESENTATIVE HERBAL PRODUCTS WITH LIGNANS

Podophyllum peltatum* L., podophyllum, Fam. *Berberidaceae

Herbal product: *Podophylli rhizoma, Podophylli rezina (Podophyllinum*)

Chemical composition: podophyllotoxin resin, traces of berberine, starch.

Action: cytotoxic, anti-tumor, antimycotic, antimicrobial, laxative, cholagogue.

Therapeutic uses: carcinomas, cholecystitis, raw material for obtaining podophyllotoxin and semi-synthetic derivatives.

Figure 44. *Podophyllum peltatum* L.

IX. FLAVONOIDS

Flavonoids are naturally occurring phenolic compounds of plant origin, derived from C6-C3-C6 to the 2-phenyl-benzopyran (flavan) or 3-phenyl-benzopyran (isoflavan) nucleus. Some structures represent the yellow pigments (flavonols, flavones, chalcones), reds, purples, blues (anthocyanins), brown-brown (tannins) of flowers, fruits, and other plant organs; others (flavanones and colorless flavanonols) are co-pigments.

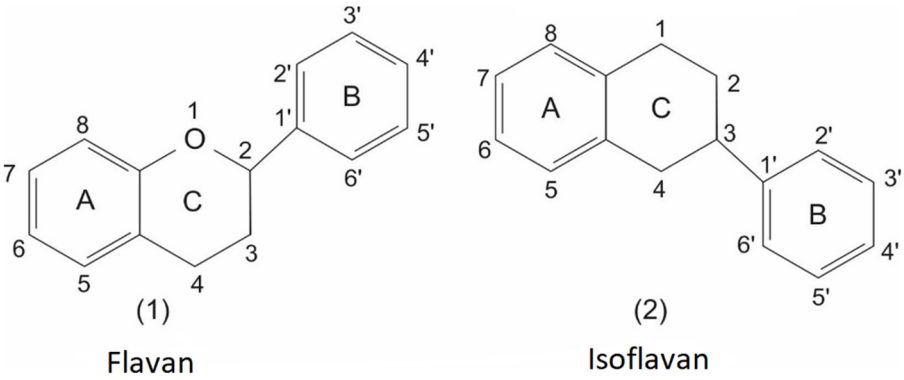


Figure 45. Chemical structure of flavonoids nucleus.

Classification

Depending on the degree of saturation of the C3 segment, the nature of the substituents, the place of insertion of the phenyl, and the number of flavan units, this class of derivatives contains:

A. Genins: polyhydroxylated, sometimes methoxylated or methylated derivatives of chromone/benzo-γ pyrone; classified into:

1. Chromone (benzo-γ pyrone)
2. Flavones or flavonoids (flavones, flavonols, flavanones, flavanonols) → natural yellow pigments, compounds derived from 2-phenylbenzo-γ-pyrone, more rarely 3-phenylbenzo-γ-pyrone
3. Biflavonoids → dimers of flavonoids

4. Chalcones → flavonoids lacking the pyronic ring
5. Isoflavones → derivatives of 3-phenyl benzo pyrone
6. Pterocarpanes, Rotenones → isoflavone derivatives

B. Xanthones/dibenzopyrone: e.g. gentisin (1,7-dihydroxy,3-methoxy-xanthone)

C. **Aurones/benzalcoumarones:** e.g. aureusidine (4,6,3'4'-tetraOH-aurone)

D. Anthocyanosides: natural pigments colored red, blue, or purple, derived from 2-phenyl-benzopyrylium (flavylium)

E. Proantocyanins or leukoatocyanins: colourless pigments derived from 3,4-dihydroxy-flavan

F. Catecholes: natural pigments colored brown–brown, derivatives of 3-hydroxy -flavan

From the IUPAC point of view, they are classified as follows:

- Flavonoids: 2-phenyl chromen-4-one derivatives (2-phenyl 1,4-benzopyronic structure);
- Isoflavonoids: 3-phenyl chromen-4-one derivatives (structure 3 phenyl 1, 4-benzopyronic);
- Neoflavonoids: 4-phenyl coumarin derivatives (structure 4 phenyl 1,2-benzopyronic).

In the plant kingdom, these derivatives are also encountered in the form of free aglycones and in the form of glycosides (aglycone + carbohydrate part). They are found in all types of plant products; heterosidic forms are found dissolved in cell juice, and aglycones in lignified tissues.

The estimated average daily intake of flavonoids is 1 g/day, of which 160–175 mg/day are flavones, flavonols, flavanones, flavanonols, 180–215 mg/day are anthocyanins, 220 mg/day are catechins and 460 mg/day are biflavonosides. Natural sources of flavonoids are presented in Table II.

Table II. Natural sources of flavonoids according to Patel *et al.*, 2008.

Subclass of flavonoids	Non-saturation of the C kernel	C kernel functional grouping	Type of flavonoid	Food sources
Flavanol	Not applicable	3-Hydroxy	(+)-Catechin (+)-Galocatechin	Herbal tea, red grapes, red wine, cocoa, chocolate
		3-O-gallate	(-)-Epicatechin-3-gallate	
Flavanones	Not applicable	4-Oxo	Eriodictyol Hesperetin Naringenin	Citrus fruits (oranges, lemons)
Flavones	Double bond in position 2-3	4-Oxo	Apigenin Luteolin	Parsley, Celery
Isoflavones	Double bond in position 2-3	4-Oxo	Genistein Daidzein Glycitein	Soybeans and other legumes
Flavonols	Double bond in position 2-3	3-Hydroxy 4-Oxo	Quercetin Kaempferol Myricetin	Apple, tomatoes, cherries, broccoli, onion
Anthocyanidins	Double bond in position1-2, 3-4	3-Hydroxy	Cyanidin Petunidine Delfmidine	Wood fruits, blueberries, strawberries, plums, blue grapes

FLAVONOIDS

Flavonoids or flavones are natural yellow pigments, represented by the O- or C- glycosides of some aglycones having a 2-phenylbenzo-γ-pyrone structure (derivatives of (2 or 3)-phenyl-benzo-pyran, also called phenyl-chroman). These are the pigments responsible for the yellow coloration of flowers, fruits and sometimes leaves. Most compounds are hydroxylated C5, C7 on the A core. On the B core one can find 1-3 phenolic groups grafted on C4', C3' and C5'.

Classification

Depending on the degree of oxidation of the C2-C3 segment and the C3 substituents, we know:

- **flavones** – double bond between C2 and C3;
- **flavonols** – derivatives that always have a hydroxyl group on C3 and double bond C2-C3;
- **flavanones** – are flavones 2,3-dihydrogenated;
- **flavanonols** – are flavonols 2,3-dihydrogenated;
- **isoflavones** – 3-phenyl benzopyrone derivatives.

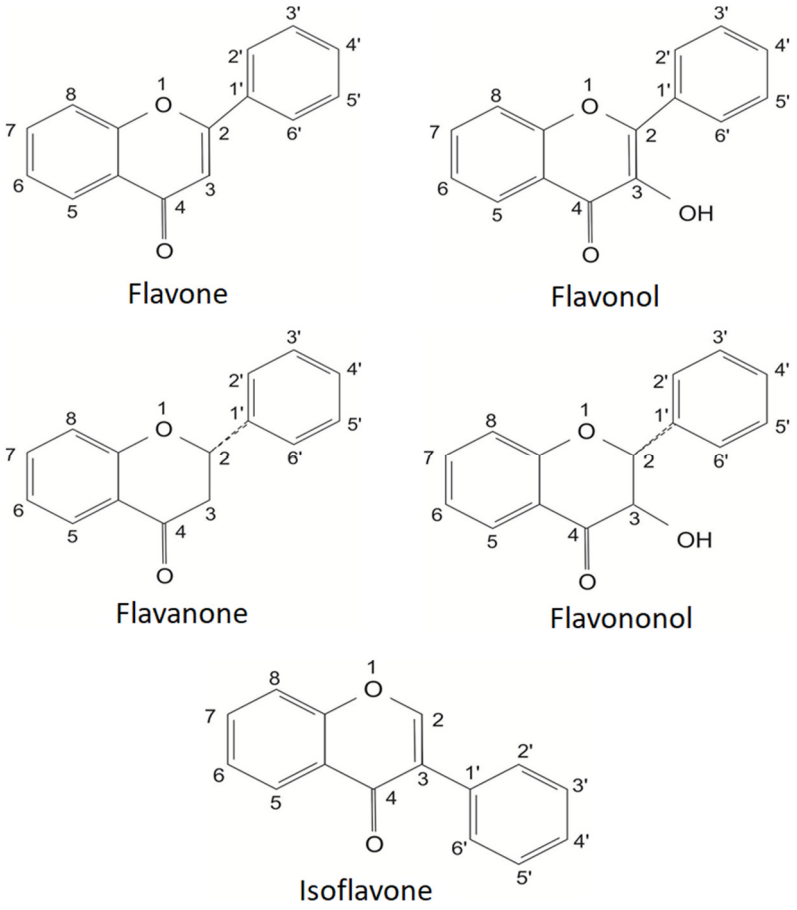


Figure 46. Chemical structure of flavonoid types.

Physical properties:

- solid, crystallized substances, usually in the form of aglycones.
- colored in various shades of yellow, the glycosides having a lighter color. The color of flavonoid derivatives is due to the presence of chromophore

groups. The hydroxyl group of position 3 determines the yellow coloration, and in case there is an OH- group in positions 3 ' and 4 ' the yellow coloration is accentuated.

- flavonones are colorless because the dual bond system is interrupted.
- flavonoids are tasteless and odorless.
- poorly soluble in water, and aglycones are practically insoluble.
- soluble in alcohol, acetone, and acetic acid.
- insoluble in chloroform, benzene, light petroleum.
- in filtered UV light, flavonoids exhibit characteristic fluorescence.

Therapeutic uses:

- The use of flavonoids in therapy began in 1936 after Albert Szent-György discovered their antihemorrhagic effect. In his research, Albert Szent-György observed that mixing flavonoids in citrus fruits (a mixture he called „citrine") can decrease high, pathological capillary permeability and capillary fragility. They bind to intracellular proteins, decreasing the permeability of blood capillaries and strengthening their resistance. This capillary-protective effect was explained by the property of flavonoids to inhibit hyaluronidase and consequently to inhibit the breakdown of hyaluronic acid. Thus, the main action attributed to flavonoids is that of „vitamin" P or P factors (permeability factors).
- The name factor P or vitamin P is also attributed to anthocyanins, pro-anthocyanins, and catechols.
- The notion of factor P is related to observations on the treatment of some forms of scurvy with ascorbic acid alone (vitamin C) or with lemon juice. It was found that after administration of lemon juice, the scurvy symptomatology disappeared, while in the other situation, they were only improved. Thus, the antioxidant role of flavonic derivatives in the protection of vitamin C and in cellular oxidation processes has been discovered.

- Some flavonoids have the property of inhibiting the chemical mediators responsible for the appearance of inflammations, having an antiphlogistic, anti-edematous effect. Other flavonoids have antioxidant properties, they capture free radicals formed in various pathological conditions.
- Flavones are enzyme inhibitors that inhibit on the one hand elastase, collagenase, histidine decarboxylase, and hyaluronidase, which determines the preservation of the integrity of the fundamental substance of the vascular wall, and on the other hand they inhibit COMT (Catechol-O-Methyl-Transferase), which leads to an increase in the amount of catecholamines (adrenaline and noradrenaline) available, determining the strengthening of vascular resistance. Very rarely, flavonoids stimulate enzyme activity, which is observed on proline hydroxylase. It promotes the creation of bridges between collagen fibers, solidifying them.
- Flavonoids also have a diuretic, spasmolytic, antiviral, anti-allergic, antiplatelet, anti-tumor, choleretic, anti-hepatotoxic, bacteriostatic, fungistatic effect. Thanks to their ability to modify certain reactions of the body to allergens, viruses, and carcinogens, they are also called natural modifiers of the biological response. By preventing the oxidative processes of fatty acids in the cell walls, flavonoids have a beneficial effect on the cardiovascular system.
- Isoflavones are a subclass of flavonoids, a family of secondary metabolites that, structurally, share the skeleton of isoflavane with different substitutes. They have a similar structure to estradiol, so they can bind to the estrogen receptor (ER). Thanks to the structural similarity, they bind to ER and they also exhibit slightly estrogen effects and slightly anti-estrogenic effects, being selective moderators of the estrogen receptor modulators, (SERM). They are found in species of the Fabaceae family.

Flavonoids:

- Antioxidant effect
- Improve the function of the vascular endothelium
- Inhibit platelet aggregation
- Modulate a series of enzymes
- Anti-inflammatory effect
- Vasoprotective effect
- Anti-carcinogenic effect
- Antiallergic action
- Improve cardiovascular diseases
- Reduce cardiac ischemia
- Antiviral role
- Reduce cell proliferation
- Decrease the process of angiogenesis
- Anti-thrombotic role
- Cholesterol-lowering role
- Reduce leukocyte migration
- Chelation effect on iron
- Activate the add-in system
- Reduce the level of cyclooxygenase
- Reduce the level of 5-lypooxygenase
- Inhibit NO production

IX.1. REPRESENTATIVE HERBAL PRODUCTS WITH FLAVONOIDS

1. Sophora japonica L., sophora, Fam. *Fabaceae*

Herbal product: *Sophorae japonicae flos, Sophorae japonicae flos immaturus* (flower buds) (Ph.Eur.)

Chemical composition: flavones (rutoside), sophora flavonoids, isoflavones, glycosided pterocarpans.

Action: rutoside has the action of vitamin P, strengthens the resistance of capillaries, reduces their permeability, it has a diuretic, antioxidant, anti-inflammatory action.

Therapeutic uses: raw material for the industrial extraction of rutoside; hemorrhages due to capillary fragility, adjuvant treatment of venous diseases (varicose veins, hemorrhoids), edema, microcirculation disorders, prophylaxis of atherosclerosis.

Figure 47. *Sophora japonica* L.

2. Fagopyrum esculentum Moench, buckwheat, Fam. *Polygonaceae*

Herbal product: *Fagopyri herba* (Ph.Eur.)

Chemical composition: flavones (rutoside), naphthodianthrones (fagopyrins).

Action: reduces permeability and strengthens capillary resistance, anti-edematous, diuretic, antioxidant.

Therapeutic uses: raw material for the industrial extraction of rutoside; hemorrhages due to capillary fragility, adjuvant treatment of venous diseases (varicose veins, hemorrhoids), edema, microcirculation disorders, prophylaxis of atherosclerosis. Grains are used in feed. After prolonged consumption, photosensitization appears, because of fagopyrin (phenomenon known as fagopyrism).

Figure 48. *Fagopyrum esculentum* Moench

3. Citrus x aurantium L., orange tree, Fam. *Rutaceae*

Herbal product: *Aurantii amari epicarpium et mesocarpium. Aurantii amari flos. Aurantii aetheroleum* (Ph.Eur.)

Chemical composition: volatile oil (citral, citronellol), flavonoids (diosmin, hesperidin), bitter principles, coumarins.

Action: capillaro-protective, bitter tonic, stomachic, flavoring, antiseptic.

Therapeutic uses: treatment of venous insufficiency, inappetence, dyspepsia.

Figure 49. *Citrus x aurantium* L.

4. Citrus x limon (L.) Osbeck, lemon, Fam. *Rutaceae*

Herbal product: *Citri pericarpium, Limonis/Citri aetheroleum* (Ph.Eur.)

Chemical composition: volatile oil (citral, citronellol), flavonoids (diosmin, hesperidin), bitter principles, coumarins.

Action: capillaro-protective, bitter tonic, stomachic, flavoring, antiseptic.

Therapeutic uses: treatment of venous insufficiency, inappetence, dyspepsia.

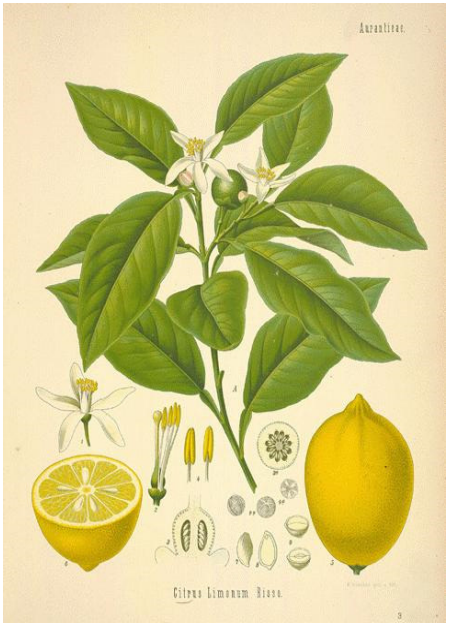


Figure 50. *Citrus x limon* (L.) Osbeck

5. Crataegus monogyna Jacq., white hawthorn, Fam. *Rosaceae*

Figure 51. *Crataegus monogyna* Jacq.

Herbal product: *Crataegi folium cum flore*, *Crataegi fructus* (Ph.Eur.)

Chemical composition:
Folium, flora: flavonoids (hyperoside, rutoside, vitexin), proanthocyanidols, catechol tannins, triterpene acids.
Fructus: flavonoids, triterpene acids, vitamin C, anthocyanosides.

Action: **increases the** force of contraction of the myocardium, improves its irrigation, antispastic, slightly sedative and anti-hypertensive, anti-arrhythmic, increases the oxygenation capacity of the brain.

Therapeutic usess: tachycardia, palpitations, heart failure at the beginning, angina pectoris, myocardial infarction, arrhythmias, neurotonic conditions, minor sleep disorders.

6. Polygonum hydropiper L., knotweed water pepper, Fam. *Polygonaceae*

Figure 52. *Polygonum hydropiper* L.

Herbal product: *Polygoni hydropiper herba*

Chemical composition: flavonoids (rutoside, hyperoside, quercitoside), tannins, volatile oil, bones, phytosterols, vitamin K, organic acids.

Action: hemostatic and antihypertensive.

Therapeutic uses: uterine hemorrhages, hemoptysis, gastric hemorrhages.

7. Ginkgo biloba L., ginkgo bilobe, Fam. *Ginkgoaceae*

Figure 53. *Ginkgo biloba* L.

Herbal product: *Ginkgonis folium* (Ph.Eur.)

Chemical composition: terpene lactones (ginkgolides), flavones, biflavones, catecholic tannins, proanthocyanidins, ginkgolic acids.

Action: central and peripheral vasodilator, vasoprotective, antiplatelet agent, neuroprotective, activation of cellular energy metabolism, especially at the cortical level, increases the ability to learn and memorize, increases tissue resistance in hypoxia conditions.

Therapeutic uses: treatment of attention/memory disorders in the elderly, sequelae after stroke, head trauma, deficient peripheral circulation, vascular fragility. Therapeutic efficacy is higher, and the risk of adverse effects is lower for drugs that contain the standardized extract called Egb 761. It contains 24% ginkoflavonoids and 6% terpenes (ginkgolides A, B, C, and bilobalid). Ginkgolic acids, allergenic substances, are present in a concentration below 5 ppm (parts/million).

8. Polygonum aviculare L., bird knotweed, knotgrass, Fam. *Polygonaceae*

Figure 54. *Polygonum aviculare* L.

Herbal product: *Polygoni avicularis herba* (Ph.Eur.)

Chemical composition: flavonoids (aviculariside), tannins, vitamin C, trace oil, sterols, silicic acid, mucilages

Action: mineralizing, antihemorrhagic, healing, anti-inflammatory, astringent, diuretic, antihypertensive

Therapeutic uses: mild inflammation of the oral-pharyngeal mucosa, peptic ulcer, respiratory diseases, superficial wounds

9. Carduus marianus L. Sin. *Sylibium marianum* (L.) Gaertn., milk thistle, Fam. *Asteraceae*

Herbal product: *Cardui mariae fructus* (Ph.Eur.)

Chemical composition: silymarin, a mixture of flavonolignans, the main components being silybin, silycristin, and silyjianin, flavonoid derivatives (taxifolin, cvercetol, kaempferol, apigenol), lipids, proteins, oses

Action: hepatoprotective, hepato-regenerative, anti-hepatotoxic

Therapeutic uses: prophylaxis and treatment of liver dysfunctions of various etiologies: excessive alcohol consumption, poisoning with organic solvents and chlorinated derivatives, hepatitis, fatty liver, hepatic cirrhosis

Figure 55. *Carduus marianus* L.

10. Betula pendula Roth, white birch, Fam. *Betulaceae*

Herbal product: *Betulae folium* (Ph.Eur.)

Chemical composition: triterpene saponosides (betulinic acid, betulin, betulinol), flavonoids, volatile oils (methyl salicylate), phenolic glycosides

Action: diuretic, antilithiasis, diaphoretic, uricosuric, antirheumatic, anti-cellulite. The latest research indicates that betulinic acid and betulin exhibit anti-melanoma effects

Therapeutic uses: urinary tract infections and inflammations, adjuvant in case of renal lithiasis and rheumatism

Figure 56. *Betula pendula* Roth

11. Cerasus vulgaris Mill., sour cherry, and *Cerasus avium* Moench, cherry, Fam. *Rosaceae*

Herbal product: *Cerasorum stipes*

Chemical composition: flavonoids, saponins, potassium salts, catechol tannins, proanthocyanidols.

Action: diuretic.

Therapeutic uses: urinary tract infections and inflammations, adjuvant in case of renal lithiasis and rheumatism.

Figure 57. *Cerasus vulgaris* Mill.

12. Zea mays L., maize, Fam. *Poaceae*

Herbal product: *Maydis stigma*

Chemical composition: flavonoids, saponins, potassium salts, tannins, volatile oil, vitamins K, C, B_6, E, allantoin.

Action: diuretic, hemostatic, cholagogue, laxative.

Therapeutic uses: urinary tract infections and inflammations, adjuvant in case of renal lithiasis and rheumatism.

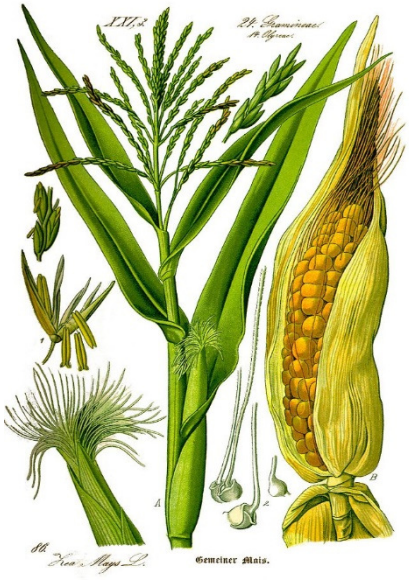


Figure 58. *Zea mays* L.

13. Glycine soja Siebold & Zucc. and *Glycine max* (L.) Merr., soy, Fam. *Fabaceae*

Herbal product: *Sojae seed, Sojae oleum raffinatum, Sojae oleum hydrogenatum* (Ph.Eur.)*, Lecithinum ex soy*

Chemical composition: isoflavonoids (genistein, daidzein), proteins, fatty oil rich in lecithins, carbohydrates

Action: estrogen-mimetic, nutritious, antioxidant, anti-inflammatory, cholesterol-lowering disease. At present, phytoestrogens are used in various phytopreparations for the treatment of symptoms associated with menopause. It is important to clarify that this class of components, more precisely its representative genistein, is already included in clinical studies for patients at risk of suffering from breast, endometrial, prostate, renal, urinary bladder cancer. Recent research indicates that genistein has anti-melanoma effects

Therapeutic Indications: flushing, osteoporosis, cholesterol, liver disease, animal protein substitute

Figure 59. *Glycine max* (L.) Merr.

X. ANTHOCYANOSIDES. LEUCOANTHOCYANINS

Anthocyanosides (anthocyanins) belong to the class of flavonoids. They are natural pigments that print the red, purple, or blue color of flowers, fruits, grains, or leaves (during autumn), depending on the pH of the cell juice and the microelements with which they form phenoxides and chelates. Aglycones are called anthocyanidins or anthocyanidols. The different anthocyanidols are distinguished by the number and position of OH groups and the degree of methylation. The carbohydrate part is formed by one or more bones. The most common is glucose, but we also meet rhamnose and galactose; if it is a biosis, rutinosis is most frequently encountered.

Anthocyanosides have as aglycone 2 pheyl-β-chromen-3-ol (unstable component that tends to stabilize in flavored form, transforming into red flavylium cation):

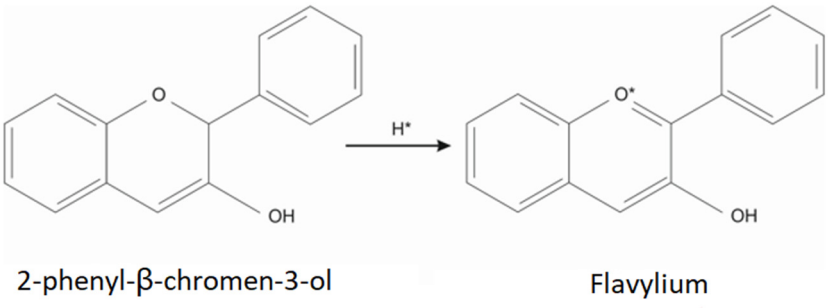


Figure 60. Transformation of the anthocyanosides aglycone (unstable) into flavylium cation (stable).

What distinguishes anthocyanins from other derivatives of the flavonoid group (flavones – coloration in yellow, proanthocyanins – colorless, and catechols – brown) is the darker color (bathochrome effect), given by their structure. The wide variety of the color of plant products that contain this class of components is due to the fact that anthocyanins, depending on the pH of the medium, can have several ions: one oxonium ion (red) in acidic medium; two carbonium cations (pseudobases colorless), in neutral medium; and three phenoxonium ions (purple color), in weak

alkaline medium. In strong alkaline environments, they form blue or green phenoxides. Most anthocyanosides are found as oxonium salts, because of the pH of the cell juice.

Physical properties:

- crystallized, tasteless, and odorless substances.
- soluble in water and alcohol.
- insoluble in ether, benzene, chloroform, and other non-polar solvents.
- in UV light have a red-brown fluorescence, more intense at low temperatures.

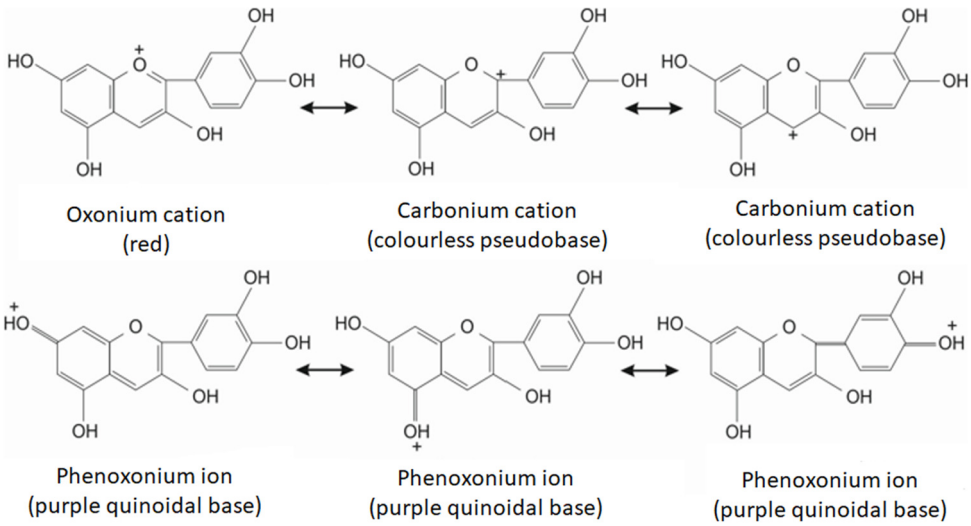


Figure 61. Chemical structure of the oxonium salts.

Therapeutic properties:

- The main action of anthocyanosides is the capillaro-protective action (role of vitamin P or factor P, increase capillary resistance and decrease their permeability), the mechanism of action being identical to that of flavones (inhibit elastase, collagenase, hyaluronidase, and histidine decarboxylase, while maintaining the integrity of the fundamental substance and inhibiting catechol-O-methyl-transferase (COMT), which leads to an increase in the amount of catecholamines available, determining the strengthening of vascular resistance).

- Some anthocyanoside structures have a high tropism for the ocular capillaries and those of the brain. Their positive activity has been demonstrated in diabetic microangiopathy when they reduce the biosynthesis of polymerized collagen and structural glycoproteins responsible for the enlargement of capillary vessels in diabetics. This is why anthocyanoside-based preparations (Difrarel®, Difebiom®) are indicated as adjuvants in treating vascular diseases in diabetics.
- Stimulate the synthesis of rhodopsin (chemoreceptor for retinal), increase visual acuity.
- Decrease the permeability of the blood-brain barrier to toxic substances.
- Have an antiplatelet effect, promoting clot retraction.
- Are diuretic substances, promoting the elimination of uric acid.
- Have an anti-inflammatory, antioxidant effect, ensuring a protective effect on reactive oxygen species (by free phenolic hydroxyl groups).

X.1. REPRESENTATIVE HERBAL PRODUCTS WITH ANTHOCYANOSIDES

1. Vaccinium myrtillus L., bilberry, Fam. *Ericaceae*

Herbal product: *Myrtili fructus siccus* - dried fruits*, Myrtili fructus recens* - fresh fruits (Ph.Eur.), *Myrtili folium*

Chemical composition:
Fructus: anthocyanins (myrtillins), tannins, vitamins, flavones.
***Folium*:** arbutoside, methyl-arbutoside, flavones, catechol tannins, pro-anthocyanidins.

Action:
Fructus: protective of capillaries, anti-edematous, improves eyesight, antiplatelet agent; dried fruits are anti-diarrheal, fresh fruits are laxative.
Folium: hypoglycemic, antibacterial, diuretic, astringent.

Therapeutic uses:
Fructus: vascular disorders, visual disorders, diabetic angiopathy.
Folium: adjuvant treatment of diabetes mellitus, urinary tract infections, diarrhea.

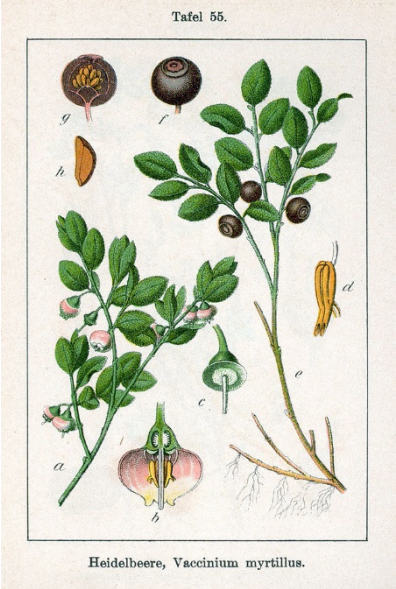


Figure 62. *Vaccinium myrtillus* L.

2. Ribes nigrum L., coarse black, blackcurrant, Fam. *Grossulariaceae*

Herbal product: *Ribes nigri folium* (Ph.Eur.)*, Ribes nigri fructus*

Chemical composition:
Fructus: anthocyanosides, vitamin C, sugars, flavonoids, organic acids.
Folium: flavonoids, tannin, volatile oil, diterpenes.

Action:
Fructus: protective of capillaries, anti-edematous, anti-inflammatory, slightly anti-hypertensive, antiplatelet agent, antioxidant.
Folium: diuretic, antihypertensive.

***Therapeutic uses*:**
Fructus: vascular disorders, joint pain.
Folium: urinary tract infections, kidney stones, adjuvant in the treatment of rheumatism.

Figure 63. *Ribes nigrum* L.

3. Althaea rosea (L.) Cav. Sin. *Alcea rosea* (L.), hollyhocks, Fam. *Malvaceae*

Herbal product: *Malvae arboreae flos sine calicibus*

Chemical composition: altein (anthocyanin complex), mucilages, tannin, phytosterols.

Action: emollient, anti-inflammatory, vasoprotective.

Therapeutic uses: respiratory tract disorders.

Figure 64. *Althaea rosea* (L.) Cav. Sin. *Alcea rosea* L.

4. Viola tricolor L., wild pansy, Fam. *Violaceae*

Herbal product: *Violae herba cum flore* (Ph.Eur.)

Chemical composition: flavonoids, anthocyanins, mucilages, carotenoids, saponosides, volatile oil, methyl salicylate glycosides.

Action: emollient, anti-inflammatory, diuretic, depurative.

Therapeutic uses: respiratory tract disorders accompanied by cough, dermatoses, edema, energy.

Figure 65. *Viola tricolor* L.

5. Centaurea cyanus L., cornflower, Fam. *Asteraceae*

Herbal product: *Cyani flos*

Chemical composition: anthocyanins (centaurocyanin), pectins, iron, flavonoids, bitter substances.

Action: anti-inflammatory, diuretic, antimicrobial, hypoglycemic.

Therapeutic uses: conjunctivitis, blepharitis, renal disorders.

Figure 66. *Centaurea cyanus* L.

6. Papaver rhoeas L., poppy, Fam. *Papaveraceae*

Herbal product: *Papaveris rhoeados flos* (Ph.Eur.)

Chemical composition: anthocyanins, mucilages, alkaloids in traces.

Action: emollient, slightly sedative.

Therapeutic uses: cough, slightly sedative in pediatrics.

Figure 67. *Papaver rhoeas* L.

7. Hibiscus sabdariffa L., roselle, karkadé, Fam. *Malvaceae*

Figure 68. *Hibiscus sabdariffa* L.

Herbal product: *Hibisci sabdariffae flos* (Ph.Eur.)

Chemical composition: anthocyanidols, anthocyanosides, organic acids (citric acid, hibiscus acid).

Action: invigorating, comforting – dried flowers are used to obtain refreshments known as *„Karkadeh*", antispastic, antihypertensive, laxative, spasmolytic, antibacterial, anti-inflammatory.

Therapeutic uses: respiratory diseases, urinary disorders, constipation, stress, convalescence.

LEUCOANTHOCYANINS (proanthocyanins) are derivatives of flavan 3,4-diols. This group of substances forms anthocyanins by acid hydrolysis.

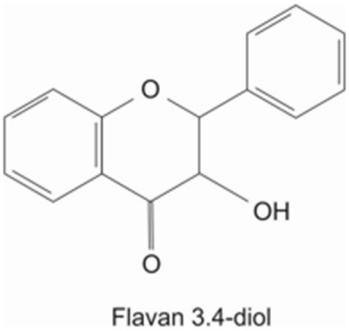


Figure 69. Flavan 3,4-diol chemical structure.

Plant products containing leukoanthocyanins:

- ***Crataegi fructus, folium cum flore*** (Ph.Eur.) – fruits, leaves, and flowers of white hawthorn, *Crataegus monogyna* Jacq., *Crataegus oxyacantha* Linn., Fam. *Rosaceae*;
- ***Vitis viniferae semen*** – vine grains, *Vitis vinifera* L., Fam. *Vitaceae*;
- ***Pini maritimae cortex*** – bark of pine maritime, *Pinus maritima* or *Pinus pinaster* Aiton., Fam. *Pinaceae.*

XI. TANNINS

The specialty literature mentions several definitions for the class of tannins, but none is exhaustive and strictly specific, because of the great heterogeneity of the components that belong to this class of substances. Tannins are polyphenolic organic substances – derivatives of 3-hydroxyflavan, polyesters, or glycosides of gallic acid, soluble in water, having an astringent taste. The characteristic elements are as follows: they exhibit specific reactions to phenols, precipitate with alkaloids, with gelatin, and other proteins, forming impermeable and rot-proof combinations, the leather tanning process being based on these properties.

Classification:

Depending on the chemical structure, tannins are classified into:

A. Catechol tannins – also called non-hydrolyzable or condensed tannins (2-phenylbenzo-pyran derivatives (3-hydroxyflavan) in the form of mono- or polymers = phlobaphenes);

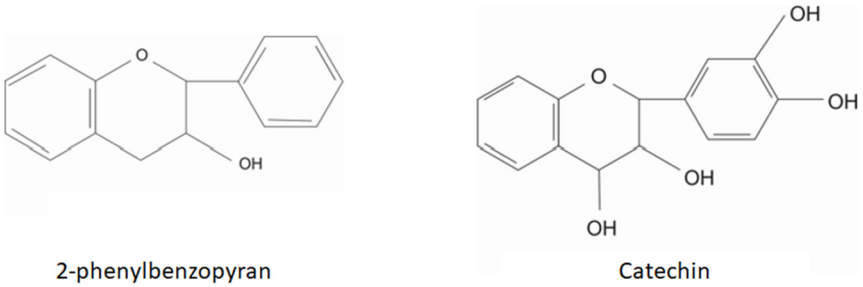


Figure 70. Chemical structure of 2-phenylbenzopyran and catechin.

B. Tannins also called **hydrolyzable tannins**, derivatives of type C6-C1 which may be esters of gallic acid (*gallotannins*), derivatives of hexahydroxydiphenic acid (*ellagitannins*) or esters between two or more molecules of polyphenolic acids*:*

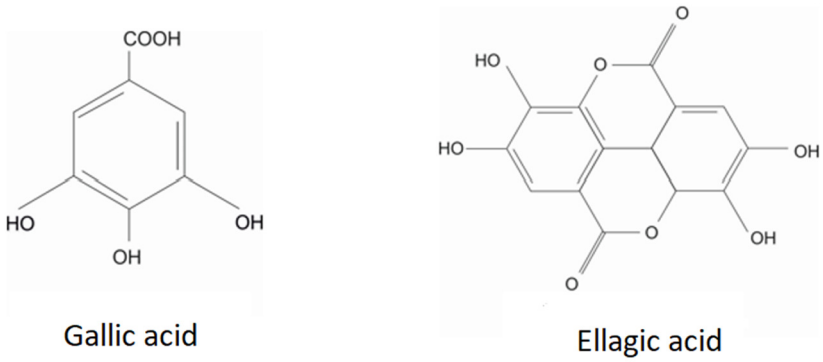


Figure 71. Chemical structure of gallic and ellagic acids.

C. Tannins complex – have esters of gallic acid with catechin, epicatechin, gallocatechin, and epigallocatechin.

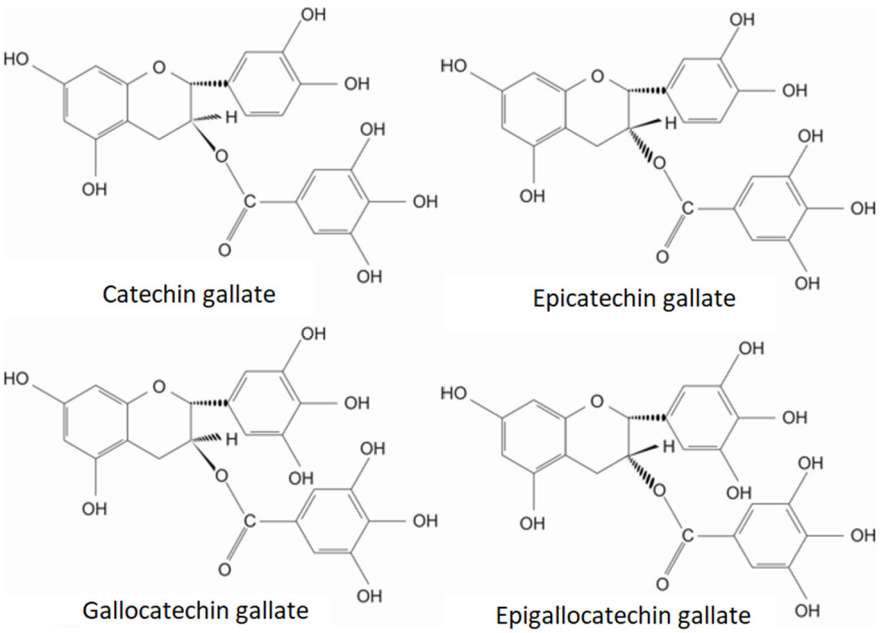


Figure 72. Chemical structure of esters of gallic acid with catechin, epicatechin, gallocatechin, and epigallocatechin.

Physical properties:

- solid, usually amorphous, odorless, white to brown in color (depending on molecular weight).

- have an astringent taste that is attenuated as the degree of polymerization increases.
- soluble in water (they dissolve with difficulty in cold water, may easily in hot water), alcohol, acetone, glycerol.
- insoluble in ether, benzene, and chloroform.
- catechol tannins form colloidal solutions which salify in the presence of electrolytes (saturated solutions of sodium chloride, sodium sulfate, ammonium sulfate).
- with proteins, they form impermeable and rot-proof combinations, an irreversible reaction, similar to that of bachelitization between phenol and formaldehyde. In the case of tannins, phenolic oxhydryls react with the underlying functions of protein structure. Because of the same reaction, the tannins, in solution, precipitate with gelatin. In aqueous solution, tannins precipitate with alkaloids, heavy metals, certain dyes, and saturated solutions of certain salts. The precipitation reaction helps in the identification of tannins.

Therapeutic properties:

- Following the precipitation of bacterial and fungal proteins, they have an antidiarrheic, antifungal, antiviral, and antiseptic action. Through local applications, externally, they waterproof the superficial layers of the skin and mucous membranes, while protecting the underlying layers and accelerating healing. The antiseptic capacity of tannins also contributes to this effect. These actions are common to all types of tannins.
- Catechic tannins increase venous tone, stabilize collagen fiber, increase capillary resistance, and have a vasoconstrictor effect on superficial vessels. In addition, they have antioxidant properties.
- Ellagic tannins stimulate phagocytosis (immunostimulatory effect).
- Degradations have an anti-inflammatory action by decreasing the production of proinflammatory prostaglandins.
- Some tannins, such as those of *Theae folium* and *Myrtilli folium* have a hypoglycemic action, most likely by reducing glucose absorption.

- Administered in large quantities, tannins have hepatotoxic and carcinogenic potential.

XI.1. REPRESENTATIVE HERBAL PRODUCTS WITH TANNINS

1. Krameria triandra Ruiz & Pav., ratanhia, Fam. *Krameriaceae*

Herbal product: *Ratanhiae radix* (Ph.Eur.)

Chemical composition: *catechol tannins,* (ratanhia tannin), ratanhine, minerals, starch, wax, gums, lignins.

Action: hemostatic, anti-diarrheal, antimicrobial.

Therapeutic uses: capillary fragility, venous insufficiency, hemorrhoids, stomatitis, gingivitis.

Figure 73. *Krameria triandra* Ruiz & Pav.

2. Potentilla tormentilla (Crantz) Neck., tormentil, Fam. *Rosaceae*

Herbal product: *Tormentillae rhizoma* (Ph.Eur.)

Chemical composition: catecholic and complex tannins, flavonoids, anthocyanosides, proanthocyanidols, pentacyclic triterpenes.

Action: anti-inflammatory, hemostatic, anti-diarrheal, antimicrobial.

Therapeutic uses: colitis, stomatitis, gingivitis, frostbite, hemorrhoids.

Figure 74. *Potentilla tormentilla* (Crantz) Neck.

3. Lythrum salicaria L., common salicaria, Fam. *Lythraceae*

Herbal product: *Lythri herba*

Chemical composition: gallic tannins, flavonoids, anthocyanosides, mucilages.

Action: astringent, anti-diarrheal, hemostatic, anti-diarrheal, antimicrobial.

Therapeutic uses: diarrhea (internal), bruises, dermatitis, hemorrhoids (external).

Figure 75. *Lythrum salicaria* L.

4. Polygonum bistorta L., bistort, Fam. *Polygonaceae*

Herbal product: *Bistortae rhizoma* (Ph.Eur.)

Chemical composition: complex tannins.

Action: anti-diarrheal, hemostatic.

Therapeutic uses: diarrhea, hemorrhoids, inflammations of the oral-pharyngeal mucosa.

Figure 76. *Polygonum bistorta* L.

5. *Potentilla anserina* L., cinquefoil anserin, Fam. *Rosaceae*

Herbal product: *Potentillae anserinae herba*

Chemical composition: tannins, flavonoids, tormentoside, phytosterols.

Action: astringent, anti-diarrheal, hemostatic, antispastic, antibacterial, strengthens uterine tone.

Therapeutic uses: diarrhea, superficial wounds, hemorrhoids, inflammations of the oral-pharyngeal mucosa, dysmenorrhea.

Figure 77. *Potentilla anserina* L.

6. *Alchemilla vulgaris* L., alchemille, Fam. *Rosaceae*

Herbal product: *Alchemillae herba* (Ph.Eur.)

Chemical composition: gallic tannins, agrimonin, peduunculagin, flavonoids, proanthocyanins.

Action: astringent, anti-diarrheal, hemostatic, antispastic, antibacterial, strengthens uterine tone.

Therapeutic uses: diarrhea, superficial wounds, hemorrhoids, inflammations of the oral-pharyngeal mucosa, dysmenorrhea.

Figure 78. *Alchemilla vulgaris* L.

7. *Agrimonia eupatoria* L., eupatory agrimony, Fam. *Rosaceae*

Herbal product: *Agrimoniae herba* (Ph.Eur.)

Chemical composition: catechol tannins, flavonoids, volatile oil, bitter principles.

Action: astringent, anti-diarrheic, wound healing, diuretic, bacteriostatic, hepatoprotective.

Therapeutic uses: diarrhea, inflammations of the oral-pharyngeal mucosa, superficial lesions of the skin, adjuvant in liver diseases.

Figure 79. *Agrimonia eupatoria* L.

8. *Geum urbanum* L., benoite commune, Fam. *Rosaceae*

Herbal product: *Gei rhizoma*

Chemical composition: gallic and catechic tannins, gallic acid, ellagic acid, a glycoside of eugenol (gein).

Action: astringent, anti-diarrheic, antiseptic, healing, antiperspirant.

Therapeutic uses: diarrhea, inflammations of the oral-pharyngeal mucosa - pharyngitis, laryngitis (gargles), superficial lesions of the skin, hemorrhoids.

Figure 80. *Geum urbanum* L.

9. *Hamamelis virginiana* L., witch hazel, Fam. *Hamamelidaceae*

Herbal product: *Hamamelidis folium, cortex* (Ph.Eur.)

Chemical composition: gallic tannins (hamamelitan), gallic acid, complex tannins (epicatechol gallate), proanthocyanidols.

Action: astringent, hemostatic, bacteriostatic, vasoconstrictive, vasoprotective.

Therapeutic uses: venous disorders (varicose veins, hemorrhoids, phlebitis), irritative dermatitis, in cosmetology for skin care cellulitis.

Figure 81. *Hamamelis virginiana* L.

10. Quercus robur L., pedunculate oak – in image, *Quercus sessiliflora* Salisb., gorun, Fam. *Fagaceae*

Herbal product: *Quercus cortex* (Ph.Eur.)

Chemical composition: catechol tannins, complex tannins, proanthocyanidols, flavonoids (quercetin derivatives).

Action: astringent, hemostatic, anti-diarrheic, antiseptic.

Therapeutic uses: diarrhea, inflammatory dermatitis, mucosal inflammation.

Figure 82. *Quercus robur* L.

11. *Gallae*

Gallae turcicae *(G. halepensis), Aleppo gall*, oak galls: are pathological formations that develop after the bite produced by the insect *Cynips gallae tinctoriae* (*Himenopterae*) in the leafy buds of the tree *Quercus lusitanica var. infectoria* (Fam. *Fagaceae*)

Gallae sinensis, Chinese gall: these are pathological formations obtained after the bites of the leafy buds of the species *Rhus semialata,* by the insect *Aphis chinensis*

Figure 83. *Gallae*

Chemical composition: gallic tannins, gallic acid, sterols, triterpenes, starch.

Action: antiseptic, hemostatic.

Therapeutic uses: gingivitis, mouth ulcers, dermatoses; galls are raw material for the extraction of officinal tannin (tannic acid).

XII. ANTHRACENOSIDES

Anthracenosides are phenolic glycosides having as binding atom C- or O- and hydroxyl anthraquinone aglycones, of varying degrees (anthrones, oxanthrones, anthranols, anthrahydroquinones). Depending on the structure, they have a laxative-purgative, anti-lithiatic or dyeing properties.

In fresh produce, anthracenosides are found in reduced form (anthranols, anthrones, oxanthrones). Anthranol, stabilized only in solution, is soluble in cytoplasm, while anthrahydroquinone (the most oxidized form) is less soluble and is deposited on cell walls. The reduced forms, under the action of oxidases or certain external oxidizing agents, are oxidized gradually. The phenomenon takes place during the drying and preservation of plant products. In the anthronic form, they can be dimerized by forming dianthrones and naphto-dianthrones.

Classification

Depending on the position of the hydroxyl groups on the nucleus, there are two groups of anthraquinone derivatives:

1. Hydroxylated derivatives on nuclei A and C (at C1 and C), having laxative-purgative properties.
2. Hydroxylated derivatives usually on the A nucleus (at C1 and in any other position) or on the A and C nuclei (but not at C8).

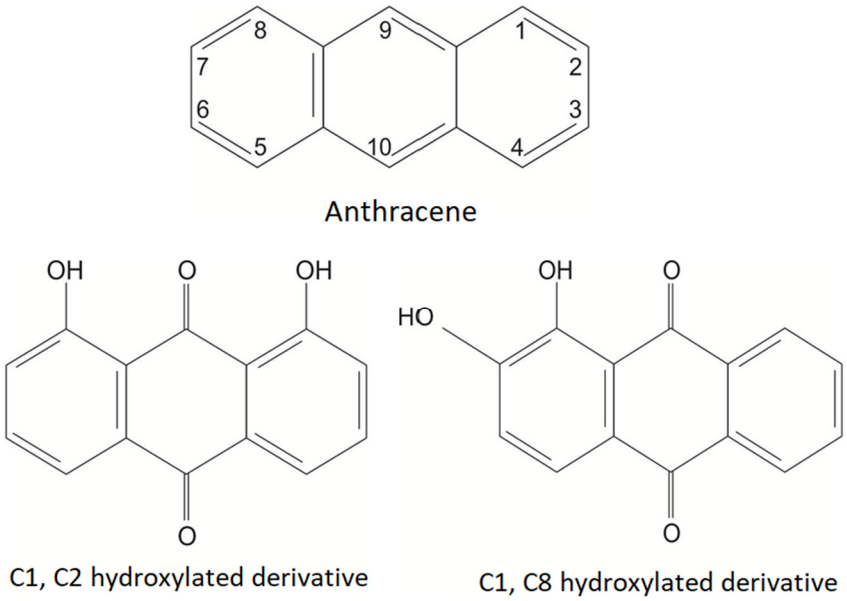


Figure 84. Chemical structure of anthracenosides basis nucleus.

C1 and C8 hydroxylated derivatives of particular therapeutic interest, thanks to their laxative-purgative action. Dianthrones (condensed forms) can be formed of molecules of the same type (homodianthrones) or different anthrones (heterodianthrones). Hydroxylated derivatives on the A core (at C1 and other positions), or on the A and C nuclei (but not at C8) are represented by the dyeing components of *Rubia tinctorum* L. (alizarin = the aglycone of ruberitric acid and its derivatives) and those of *Cocus cacti* L. (carminic acid).

Physical properties:

- solid, amorphous, crystallizing substances, bitter, odorless, yellow-orange to red-brown, sublimable.
- reddish-yellow fluorescence in UV light.
- soluble in water, alcohol, and hydro-alcoholic solutions, insoluble in non-polar solvents. Solubility in water increases with the number of oses in the molecule.
- aglycones are crystallized substances, depending on the degree of oxidation, nature, position, and number of substitutes they are colored from yellow to red. They are insoluble in water, soluble in alcohol, acetic

acid, benzene, chloroform, toluene (they form solutions colored yellow or orange), or in alkaline hydroxide solutions (form bright red-red color phenoxides).

Therapeutic properties:

- Plant products have a laxative or purgative action, depending on the dose. They activate by stimulating the peristalsis of the large intestine – the reduced forms (anthranols) present in the plant product are strongly active-purgative, but irritating (they give colic, nausea, vomiting) – the oxidized forms (anthraquinones) are less active but bine tolerated by the body.
- This is why only oxidized (anthraquinone) forms are used resulting from the preservation of the plant product for a year, or by heating for 1 h at 105 °C. They are well tolerated by the gastric mucosa.
- Having a congestive action on the pelvic organs, anthraderivatives are not administered to the elderly, small children, pregnant women, or nursing mothers.
- Anthranols, being irritating substances, can cause abdominal congestion and prolonged menstrual bleeding.
- Anthranolic forms, strongly reductive, are used only externally, for their antiseptic properties.
- For cholagogue-choleretic, laxative, and purgative effects are used 1,8-dihydroxyanthraquinones.
- 1,2-dihydroxyanthraquinone derivatives have dyeing and anti-lithiasis properties.

XII.1. REPRESENTATIVE HERBAL PRODUCTS WITH ANTHRACENOSIDES

1. Rhamnus frangula L., bumblebee, Fam. *Rhamnaceae*

Herbal product: *Frangulae cortex* (Ph.Eur.)

Chemical composition: anthracenosides (glucofrangulosides, frangulosides), flavonoids, tannins, mucilages, bitter principles.

Action: laxative or purgative depending on the dose. The plant product will not be used fresh, as it is toxic (strongly purgative). It is allowed to dry at chamber temperature for a year or 1 hour at 105 °C so that anthranols turn into anthraquinones.

Therapeutic uses: constipation.

Figure 85. *Rhamnus frangula* L.

2. Rhamnus purshiana DC., cascara sagrada, Fam. *Rhamnaceae*

Herbal product: *Rhamni purshianae cortex* (Ph.Eur.)

Chemical composition: anthracenosides (cascarosides, dianthrones), flavonoids, tannins, bitter principles.

Action: laxative or purgative depending on the dose. The action is stronger than that of bourdaine bark, as it has a greater concentration of anthracenosides. The plant product will not be used fresh, as it is toxic (strongly purgative). It is allowed to dry at chamber temperature for a year or 1 hour at 105 °C so that anthranols turn into anthraquinones.

Therapeutic uses: constipation.

Figure 86. *Rhamnus purshiana* DC.

3. *Rhamnus cathartica* L., purgative buckthorn, Fam. *Rhamnaceae*

Herbal product: *Rhamni catharticae fructus*

Chemical composition: anthracenosides (glucofrangulosides, frangulosides), flavonoids, tannins, bitter principles

Action: laxative or purgative depending on the dose, diuretic, depurative. It is allowed to dry at chamber temperature for a year or 1 hour at 105 °C so that anthranols turn into anthraquinones.

Therapeutic uses: constipation. The plant also has dyeing properties.

Figure 87. *Rhamnus cathartica* L.

4. Rheum palmatum L., webbed rhubarb, Fam. *Polygonaceae*

Herbal product: *Rhei radix* (Ph.Eur.)

Chemical composition: reoanthracenosides, reotanoglicosides, flavonoids, proanthocyanidols, tannins, volatile oil, resins

Action: thanks to the content of anthraderivatives and tannins, depending on the dose, the vegetable product develops laxative (1–3 g), astringent, stomachic (0.1–0.3 g) effects; it also has anti-inflammatory properties

Therapeutic uses: constipation, diarrhea – depending on the dose, gingivitis

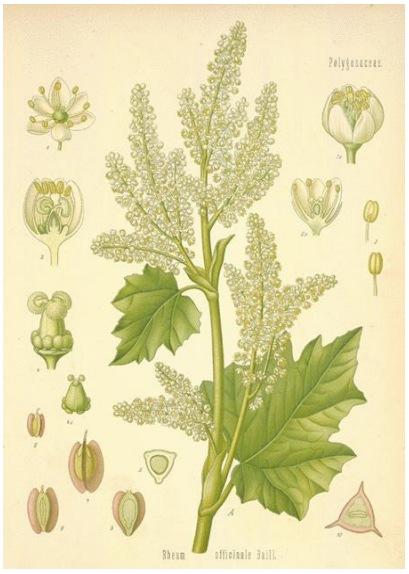


Figure 88. *Rheum palmatum* L.

5. *Rumex sp.*, *Rumex acetosa* L., common sorrel, Fam. *Polygonaceae*

Herbal product: *Rumicis radix*

Chemical composition: anthracenosides, tannins, flavonoids, carbohydrates, mineral salts, Fe, vitamin C, K.

Action: laxative, tonic, antianemic.

Therapeutic uses: constipation.

Figure 89. *Rumex acetosa* L.

6. *Cassia sp.*, *Cassia acutifolia* Delile, senna, Fam. *Fabaceae*

Herbal product: *Sennae folium, Sennae fructus* (Ph.Eur.)

Chemical composition: anthracene derivatives: di-anthraglycosides (sennosides A, A1, B-G), as well as reduced amounts of anthraglycosides (aloe-emodol, reol-8-glucosides), mucilages, flavonoids, phytosterols, carbohydrates, resins.

Action: laxative or purgative depending on the dose.

Therapeutic uses: constipation.

Figure 90. *Cassia acutifolia* Delile

7. *Aloe sp., Aloe vera* (L.) Burm.f., aloe, Fam. *Asphodelaceae*

Herbal product: *Aloe* (Ph.Eur.)

Chemical composition: anthracenosides (aloins A and B, aloinsides A and B, 5-hydroxyaloin A, aloe-emodol, crisofaol), resins, bitter substances, mineral salts.

Action: depending on the dose: 10–20 mg stomachic, cholagogue; 10–25 mg laxative; 25 mg–1 g strongly purgative; High doses are oxytocic; aloe gel represents the mucilaginous exudate of the leaves of the species. It has anti-inflammatory, antibacterial, moisturizing, healing, immunostimulating, detoxifying effects.

Therapeutic uses: constipation.

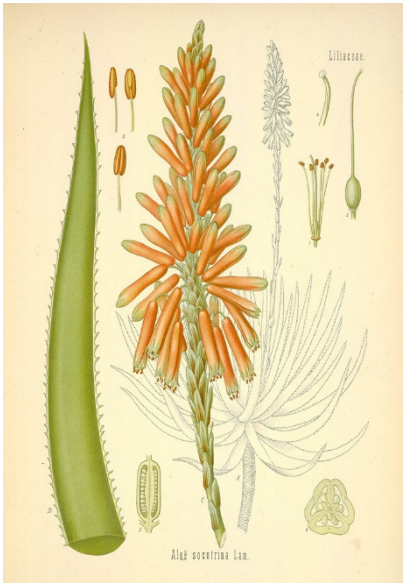


Figure 91. *Aloe vera* (L.) Burm.f.

8. *Rubia tinctorum* L., dyers' madder, Fam. *Rubiaceae*

Herbal product: *Rubiae tinctorium radix*

Chemical composition: anthracenosides (alizarin), tannin, phytosterols.

Action: diuretic, renal antilithiatic, anti-spastic, slightly laxative.

Therapeutic uses: renal lithiasis, dyeing agent.

Figure 92. *Rubia tinctorum* L.

9. *Hypericum perforatum* L., St. John's wort, St. John's grass, Fam. *Hypericaceae*

Herbal product: *Hyperici herba* (Ph.Eur.)

Chemical composition: naphthodianthrones (hypericin), tannin, flavonoids, phenol-carboxylic acids, volatile oil, triterpenes, carotenoids.

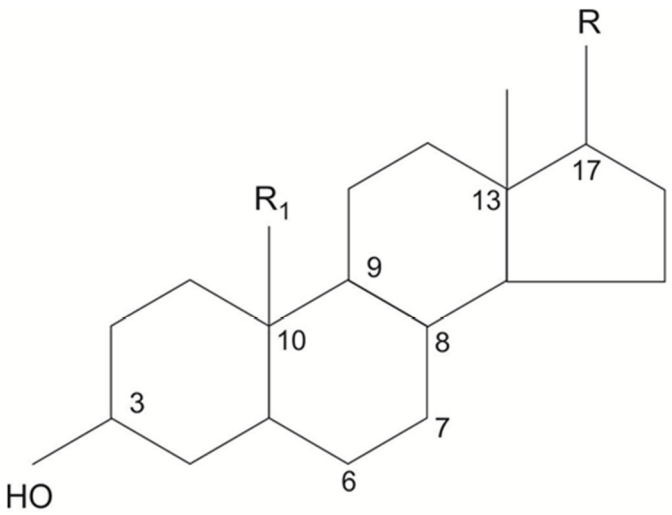
Action: choleretic, cholagogue, antidepressant, slightly sedative, healing, anti-inflammatory, antimicrobial, antiviral, capillaro-protective, diuretic.

Therapeutic uses: hepatobiliary disorders, ulcers (gastric, duodenal, leg), superficial burns, wounds, depression, insomnia.

Figure 93. *Hypericum perforatum* L.

XIII. STEROIDAL GLYCOSIDES. CARDIOTONIC GLYCOSIDES

Glycosides are a class of components of plant origin, more rarely animal, with the basic core of the steranic type (cyclopentanoperhydrophenanthrene). Most often, glycosylation is achieved at C3, through an O atom (O-glycosides), in plant products we can also find free aglycones. This class of components has either therapeutic activity (most often at the cardiac level) or economic importance, representing raw material of plant origin in the semi-synthesis of certain steroid hormones.



Steranic core (cyclopentanoperhydrophenanthrene)

Figure 94. Chemical representation of the steranic core.

Classification

Depending on the structure of the radical in position 17, there are the following classes:

- Phytosterolins (phytosterol glycosides)
- Digital glycosides (pregnan e-glycosides)
- Cardiac glycosides
- Withanolides

- Sterolic saponosides
- Glycosteroidal alkaloids

CARDIAC GLYCOSIDES

Cardiotonic or digitalis glycosides are the glycosides of unsaturated sterol lactone, having a certain steric configuration. They are used in the treatment of heart failure.

Classification:

Depending on the structure of the unsaturated lactone of the C17 position, the cardiac glycosides are classified into:

- *cardenolides* – having the unsaturated lactone formed by five atoms; are the most numerous and important;
- *bufadienolides* – having the unsaturated lactone formed by six atoms; are the least common.

Physical properties:

- solid, amorphous, rarely crystallized, colorless substances with a bitter taste.
- depending on the length of the carbohydrate chain, they are soluble in water, alcohol, ethyl acetate, chloroform.
- aglycones are solid, crystallized, water-insoluble, alcohol-soluble, and non-polar organic solvents. Aglycones, like their glycosides, have optical activity.

Therapeutic properties. Warnings.

- As their name suggests, cardiotonic glycosides have *cardiac tropism*. They operate on the heart affected by heart failure in doses to which the healthy heart does not respond.
- Regarding the *mechanism of action*: they increase the force of myocardial contraction (positive effect), increase tonicity (positive tonotrope effect), increase excitability (positive bathmotropic effect), slow down the atrioventricular conduction velocity (negative dromotrope effect) and heart rate (negative chronotropic effect).

- *Overdose* can lead to digestive disorders (nausea, vomiting, diarrhea), visual (yellow imagery), nervous (confusion, neuralgia), heart rhythm (ventricular extrasystoles, joint tachycardia, bradycardia). High doses can lead to death by stopping the heart in systole.
- Plant products with cardiotonic glycosides have an inconsistent action. For this reason, they are not administered as such or in various pharmaceutical forms. They are used for the industrial extraction of pure glycosides: digitoxin (digitoxoside), digitalin, digoxin (digoxoside), lanatoside C, G-strofantoside.
- Cardiac glycosides are not indicated in ventricular hyperexcitability (extrasystoles), or atrioventricular block.
- It is forbidden to administer at the same time substances that modify digestive absorption (medicinal charcoal, antacids), hypokalemiants (diuretics, corticosteroids, antibiotics - amphotericin B, laxatives, anthranosides) that increase their toxicity by removing potassium, by promoting rhythm disorders.

XIII.1. REPRESENTATIVE HERBAL PRODUCTS WITH CARDIOTONIC GLYCOSIDES

1. Digitalis purpurea L., purple foxglove, Fam. *Plantaginaceae*

Herbal product: *Digitalis purpureae folium* (Ph.Eur.)

Chemical composition: cardiotonic glycosides (purpurea glycosides A, B, E), steroid aponosides, digitalis glycosides, flavonoids, terpenes, phenolic acids.

Action: cardiotonic, anti-arrhythmic. The leaves of the species *Digitalis purpurea* L. represent the raw material for the industrial production of digitoxoside, known as digitoxin (FR X). The obtaining is achieved by removing a glucose molecule from the molecule of purpurea glycoside.

Therapeutic uses: heart failure.

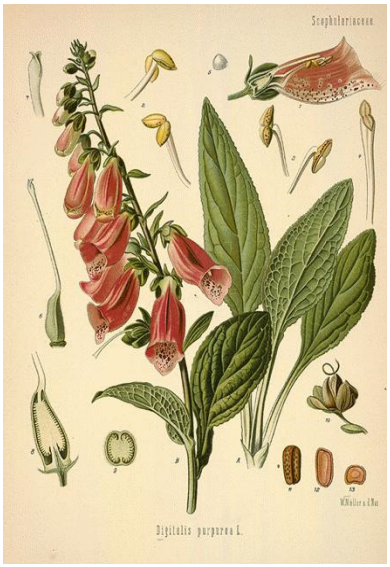


Figure 95. *Digitalis purpurea* L.

2. Digitalis lanata Ehrh., woolly foxglove, Fam. *Plantaginaceae*

Herbal product: *Digitalis lanatae folium*

Chemical composition: cardiotonic glycosides (lanatosides A-E), non-cardioactive glycosides, saponosides, flavonoids, sterols.

Action: cardiotonic, anti-arrhythmic. The leaves of the species *Digitalis lanatate* Ehrh. represent the raw material for the industrial production of digoxoside known as digoxin (FR X), lanatoside C. Digoxin is obtained by partial hydrolysis of lanatoside C. It is eliminated from the body faster than digitoxin.

Therapeutic uses: heart failure.

Figure 96. *Digitalis lanata* Ehrh.

3. Strophanthus kombe Oliv. and *Strophanthus gratus* (Wall. & Hook.) Baill., Fam. *Apocynaceae*

Herbal product: *Strophanthi semen*

Chemical composition: cardiotonic glycosides (strofantosides), fatty substances, mucilages, choline, resins.

Action: cardiotonic, anti-arrhythmic; strofantosides are emergency cardiotonics in acute heart failure and acute pulmonary edema.

Therapeutic uses: heart failure.

Figure 97. *Strophanthus gratus* (Wall. & Hook.) Baill.

4. Adonis vernalis L., large bull's eye, Fam. *Ranunculaceae*

Herbal product: *Adonidis herba*

Chemical composition: cardiotonic glycosides (adonitoxin), flavones, pregnane derivatives.

Action: cardiotonic – faster and short-lived, diuretic, coronary dilator.

Therapeutic uses: heart failure (in digitalis breaks), angina pectoris.

Figure 98. *Adonis vernalis* L.

5. Convallaria majalis L., thrush, Fam. *Asparagaceae*

Herbal product: *Convallariae herba*

Chemical composition: cardiotonic glycosides (convalatoxoside, convalatoxoloside), sterol saponosides, flavonoids, volatile oil in flowers.

Action: cardiotonic, coronary dilator.

Therapeutic uses: heart failure (during digitalis pauses), angina pectoris; the raw material is used for the extraction of convalatoxoside.

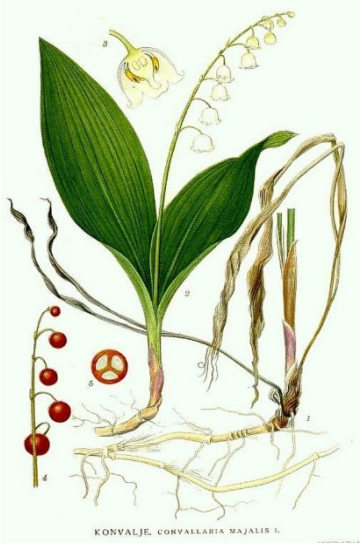


Figure 99. *Convallaria majalis* L.

6. Nerium oleander L., oleander, Fam. *Apocynaceae*

Herbal product: *Nerii folium*

Chemical composition: cardiotonic glycosides (oleandroside), flavonoids.

Action: cardiotonic.

Therapeutic uses: heart failure (during digitalis pauses); raw material is used for the extraction of oleandroside.
The whole plant is poisonous. Ten to twenty grams of fresh leaves are considered lethal.

Figure 100. *Nerium oleander* L.

7. Helleborus niger L., purple hellebore, Fam. *Ranunculaceae*

Herbal product: *Hellebori rhizoma*

Chemical composition: Cardiotonic glycosides (helebrosides), sterol saponins.

Action: cardiotonic, antiallergic, anti-inflammatory, immunostimulatory.

Therapeutic uses: heart failure – little used, joint disorders, myalgia, neuralgia – total extracts without cardiotonic glycosides are used.

Figure 101. *Helleborus niger* L.

XIV. SAPONINS

Saponins or saponosides (from the Latin *sapo* = soap) are substances of plant origin, with a sterol or triterpene structure. They can be found in free plant products, in the form of aglycone or conjugated with various bones, in the form of glycosides. The characteristic feature of this class of components is the fact that they have surfactant properties – glycosides together with water form colloidal solutions, which by agitation form a foam. In addition, most saponosides are irritating to the skin and mucous membranes, have hemolytic properties and they are toxic to cold-blooded animals.

Classification

Depending on the structure of the aglycones (sapogenols) we can distinguish two main classes:

- *sterolic saponins (toxic or neutral)*: they are characterized by the fact that they have a sterol core and spirocetal chain. Aglycone contains 27 C atoms; are little used in therapy, used rather in industry for the synthesis of steroid hormones (cortisol, aldosterone, estrogens);
- *triterpenic saponins (non-toxic or acid)*: aglycone contains 30 C atoms, and the basic nucleus can be:
    - pentacyclic – *amyrinic* (glycyrrhizic acid), *lupeolic* (betulinol)
    - tetracyclic – *damaranic* type (ginsenosides);
  - are the most widely distributed saponosides with important therapeutic properties

Physical properties:

- Saponins are usually amorphous, colorless, yellow or brown, hygroscopic substances. They are optically active substances. They form colloidal solutions with water. Some sterol saponins can be encountered in crystalline form, also, triterpenes are amorphous. Some saponins are poorly soluble in cold water, but they can be solubilized in hot water.

They are well soluble in diluted or concentrated alcohol by boiling. In other organic solvents, they are poorly soluble or even insoluble. They are surfactants, reducing surface tension at the water-oil or water-air interface. This ability gives them foaming, emulsifying, and detergent properties. Sterol saponins form combinations with cholesterol, they lower cholesterol physiological acid, so they are toxic.

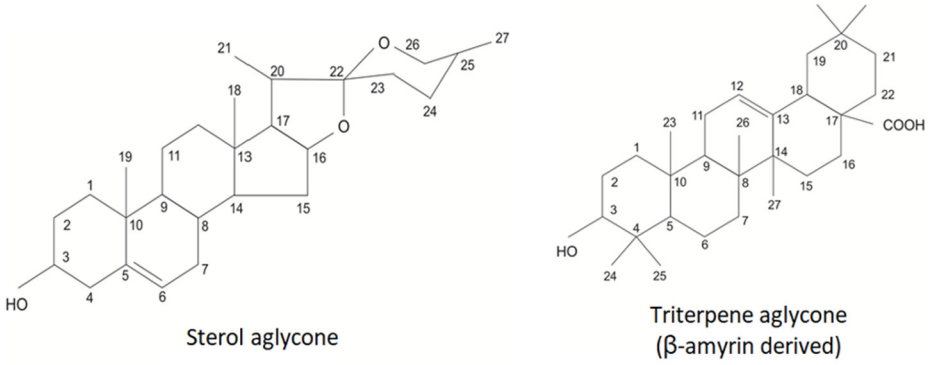


Figure 102. Chemical representation of the two saponin types aglycons.

Therapeutic properties

- Because of their toxicity, sterol saponosides are less used in therapy. They are used more in industry, for the synthesis of steroid hormones (cortisol, aldosterone, estrogens).
- Triterpene saponins have important therapeutic actions.
- Thanks to the surfactant properties, they have an irritating action at the level of the epithelia:
    - respiratory → expectorants (low dose)
    - digestive → emetogenic (higher dose)
    - renal → diuretics
- Thanks to the surfactant properties, they are used as foaming agents, washing, emulsifying agents.
- They have anti-inflammatory, expectorant, diuretic, capillaro-protective properties, anti-exudative, being frequently used in venous or dermatological conditions.

- They have adaptogen effects.
- They have hemolytic action.
- Triterpene saponosides are difficult to absorb orally, but they influence the solubility and absorption of other substances (by increasing these parameters) – by reducing surface tension in the intestinal villi.

XIV.1. REPRESENTATIVE HERBAL PRODUCTS WITH SAPONINS

1. Primula officinalis (veris) L. Hill, primrose, Cuckoo, Fam. *Primulaceae*

Herbal product: *Primulae radix* (Ph.Eur.)

Chemical composition: triterpene saponosides (primulagenol glycosides, privaterogenol), flavonoids.

Action: expectorant; in large quantities the product is emetic.

Therapeutic uses: wet cough.

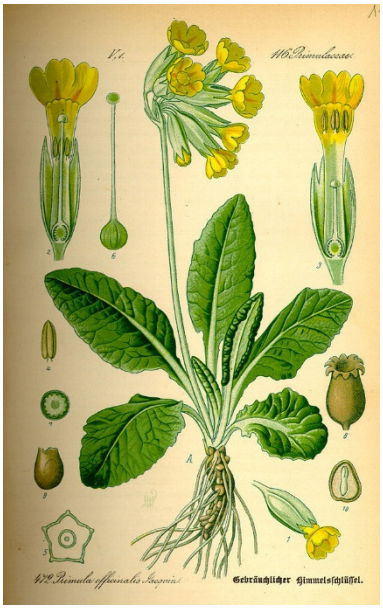


Figure 103. *Primula officinalis* L. Hill

2. Gypsophila paniculata L., oriental saponaria, Fam. *Caryophyllaceae*

Herbal product: *Saponariae albae radix (Gypsophilae radix)*

Chemical composition: triterpene saponosides (gypsogenol glycosides), bones, gums, lipids, volatile oil.

Action: expectorant, diuretic. It is used in the food and textile industry for its surfactant properties.

Therapeutic uses: wet cough.

Figure 104. *Gypsophila paniculata* L.

3. Saponaria officinalis L., saponaria, Fam. *Caryophyllaceae*

Herbal product: *Saponariae rubrae radix*

Chemical composition: triterpene saponosides (gypsogenol glycosides), bone, flavonoids.

Action: expectorant, diuretic; used in the food and textile industry for its surfactant properties.

Therapeutic uses: wet cough.

Figure 105. *Saponaria officinalis* L.

4. Hedera helix L., ivy, Fam. *Araliaceae*

Herbal product: *Hederae folium* (Ph.Eur.)

Chemical composition: triterpene saponosides (heredasaponins A-I, the main ones being hererderasonins B, C, and K10), flavonoids, polyphenols, sterols.

Action: oral – expectorant, anti-spastic, anti-inflammatory, slightly febrifuge, slightly analgesic; topical – healing, anti-inflammatory, anti-edematous, antifungal.

Therapeutic uses: productive cough, respiratory diseases, orange-peel.

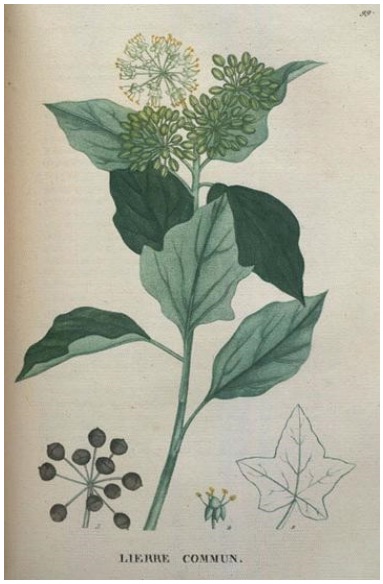


Figure 106. *Hedera helix* L.

5. Aesculus hippocastanum L., horse chestnut, Fam. *Sapindaceae*

Herbal product: *Hippocastani semen* (Ph.Eur.)

Chemical composition: triterpene saponside complex (ESCIN), flavonoids, coumarins.

Action: anti-inflammatory, anti-edematous, anti-cellulite, venotonic, capillaro-protective.

Therapeutic uses: venous insufficiency, varicose veins, hemorrhoids, phlebitis, cellulitis.

Figure 107. *Aesculus hippocastanum* L.

6. Glycyrrhiza glabra L., licorice, Fam. *Fabaceae*

Herbal product: *Liquiritiae radix* (Ph.Eur.)

Chemical composition: triterpene saponosides (main components – glycyrrhizic acid (glycyrrhizin), and glycyrrhetic acid or glycyrrhetinic, in the form of calcium or potassium salt), flavonoids (liquiritoside), chalcones, coumarins, phytosterols, carbohydrates.

Action: expectorant, emollient, diuretic, cortisonic anti-inflammatory, anti-spastic, sweetener, antiulcer. It is used in the food industry as a sweetener and foaming agent.

Therapeutic uses: cough, bronchitis, gastritis, peptic ulcer, joint pain.

Figure 108. *Glycyrrhiza glabra* L.

7. Ononis spinosa L., thorny bugrane, Fam. *Fabaceae*

Herbal product: *Ononidis radix*

Chemical composition: triterpene saponosides, flavonoids, isoflavones, volatile oil.

Action: diuretic, anti-lithiasis, cholagogue.

Therapeutic uses: inflammation of the urinary tract, kidney stones.

Figure 109. *Ononis spinosa* L.

8. Betula pendula Roth, white birch, Fam. *Betulaceae*

Herbal product: *Betulae folium* (Ph.Eur.)

Chemical composition: triterpene saponosides (betulinic acid, betulin, betulinol), flavonoids, volatile oil (methyl salicylate), phenolic glycoside.

Action: diuretic, anti-lithiatic, diaphoretic, uricosuric, antirheumatic, anti-cellulite. Recent research indicates that betulinic acid and betulin have anti-melanoma effects.

Therapeutic uses: urinary tract infections and inflammations; adjuvant in case of kidney stones and rheumatism.

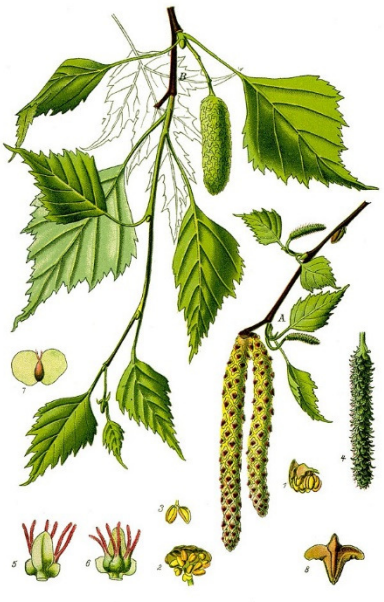


Figure 110. *Betula pendula* Roth

9. Equisetum arvense L., ponytail, horsetail, Fam. *Equisetaceae*

Herbal product: *Equiseti herba* (Ph.Eur.)

Chemical composition: triterpene saponosides, flavonoids, potassium salts, calcium, silicic acid.

Action: diuretic, anti-inflammatory, remineralizing, strengthening of connective tissue and bone.

Therapeutic uses: inflammation and infections of the urinary tract, renal calculosis, osteoporosis, rheumatism, injuries.

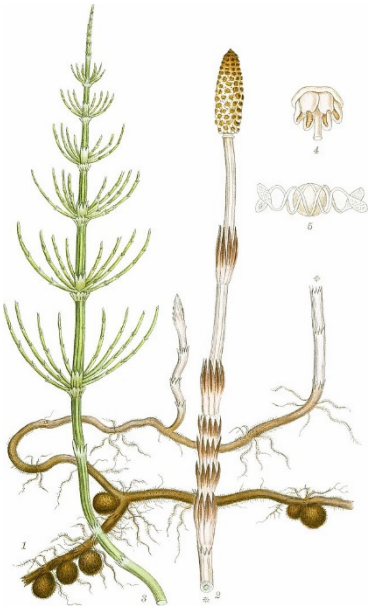


Figure 111. *Equisetum arvense* L.

10. Panax ginseng C.A.Mey., Korean ginseng, Fam. *Araliaceae*

Herbal product: *Ginseng radix* (Ph.Eur.)

Chemical composition: damranic triterpene saponosides – tetracyclic (ginsenosides), polysaccharides, fatty acids, amino acids.

Action: general tonic, adaptogen, slightly immunostimulatory, antiplatelet agent, hypoglycemic.

Therapeutic uses: convalescence, postoperative, geriatrics.

Figure 112. *Panax ginseng* C.A.Mey.

11. Eleutherococcus senticosus (Rupr. & Maxim.) Maxim., Siberian ginseng, Fam. *Araliaceae*

Herbal product: *Eleuterococci radix*

Chemical composition: triterpene oleanolic saponosides (eleutherosides), polyphenol-carboxylic acids, coumarins, polysaccharides.

Action: general tonic, adaptogen, slightly immunostimulatory, antiplatelet agent, hypoglycemic.

Therapeutic uses: convalescence, postoperative, geriatrics.

Figure 113. *Eleutherococcus senticosus* (Rupr. & Maxim.) Maxim.

12. Centella asiatica (L.) Urb., Asian hydrocotyle, Fam. *Apiaceae*

Herbal product: *Centellae herba* (Ph.Eur.)

Chemical composition: triterpenic saponosides (asiaticoside), flavonoids.

Action: adaptogen, general tonic, venotonic, healing, anti-inflammatory, antiulcer, antimicrobial, diuretic.

Therapeutic uses: venous insufficiency, varicose veins, hemorrhoids, convalescence, postoperative, geriatrics.

Figure 114. *Centella asiatica* (L.) Urb.

13. Ruscus aculeatus L., small holly, butchers' broom, Fam. *Asparagaceae*

Herbal product: *Rusci rhizoma* (Ph.Eur.)

Chemical composition: sterol saponosides (ruscoside, ruscine, and their partial hydrolysis derivatives), phytosterols, triterpenes.

Action: venous and venolimphathic insufficiency (improves functional symptomatology).

Therapeutic uses: venous insufficiency, varicose veins, hemorrhoids.

Figure 115. *Ruscus aculeatus* L.

XV. CYANOGENETIC GLYCOSIDES (CYANOGENIC GLYCOSIDES)

Cyanogenetic glycosides are heterosidic structures of type 2 (α) - hydroxy-nitril-O-glycosides, which, either by enzymatic hydrolysis or in a weak acid medium, release a molecule of hydrocyanic acid, a carbonyl component of the aldehyde or ketone type and one or more bones. They are found in the vacuolar juice, while the enzymes responsible for achieving hydrolysis are found in the cytoplasm. The action of enzymes on these components is therefore exerted at the time of tissue disintegration, either by clashes, crushing, or fungal infections.

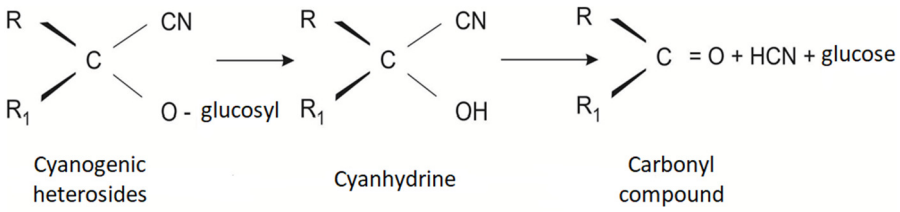


Figure 116. Cyanogenic heterosides hydrolysis.

Classification

There are two elements responsible for the classification of this type of component, more precisely the amino acid which is the biological precursor, and the radicals which enter into the structure of cyanhydrine. The literature therefore describes the following:

- aromatic radical glycosides from phenylalanine or tyrosine (e.g. PrunaSoside, AmyGdalo Side, SambnigroSide, Duroside);
- aliphatic radical glycosides which have as precursor synthetic bios leucine, isoleucine, valine (e.g. lotaustraline, linamaroside);
- glycosides in which radicals are elements of an unsaturated ring (prevalent in *Passifloraceae*, *Flacourtiaceae*);
- glycosides in which radicals are unsaturated (e.g. trigloquinine).

Physical properties:

- solid, crystallized, colorless, odorless, bitter-tasting, optically active substances.
- high solubility in water, alcohol, and ethyl acetate.
- insoluble in nonpolar organic solvents.

Therapeutic properties:

- Plant products that contain these structures are frequently used in the treatment of bronchopulmonary diseases, thanks to the expectorant action that stimulates respiration.
- Following hydrolysis, these structures release hydrocyanic acid, therefore the use of plant products containing these structures must be carried out with caution.

XV.1. REPRESENTATIVE HERBAL PRODUCTS WITH CYANOGENIC GLYCOSIDES

1. Sambucus nigra L., elderberry, Fam. *Viburnaceae*

Herbal product: *Sambuci flores* (Ph.Eur.)

Chemical composition: cyanogenic glycosides (sambunigroside, prunasoside), flavones (rutoside), volatile oil, mucilages, saponosides, tannin, polyuronides, chlorogenic acid.

Action: sudorific, diuretic, expectorant, emollient, slightly immunostimulatory.

Therapeutic uses: viral infections, respiratory diseases.

Figure 117. *Sambucus nigra* L.

2. Prunus amygdalus Batsch var. *dulcis*, sweet almond, Fam. *Rosaceae*

Herbal product: *Amygdalae dulcis semen* from which *Amygdalae oleum virginale* and *Amygdalae oleum raffinatum* are obtained

Chemical composition: cyanogenic glycosides (amygdaloside, prunasoside), fatty oil (with oleic acid and linoleic acid), mucilages, enzymes, proteins.

Action: expectorant, flavoring, gastroprotective, emollient, laxative (oil).

Therapeutic indications: respiratory diseases, the oil is used as an excipient in the preparation of ointments and cosmetic oils, the grains are used in the food industry, also.

Figure 118. *Prunus amygdalus* Batsch var. *dulcis*

3. Prunus laurocerasus L., cherry laurel, Fam. *Rosaceae*

Herbal product: *Laurocerasi folium*

Chemical composition: cyanogenic glycosides (prunasoside), flavonoids, mucilages.

Action: cough suppressant for spastic cough, flavoring.

Therapeutic uses: the leaves are the raw material for obtaining *Aqua laurocerasi*, a preparation used for its anti-spastic effect in the treatment of spastic cough or for the flavoring action, and as a taste corrector. At present, this preparation is less used in this form but has practical applicability in homeopathy.

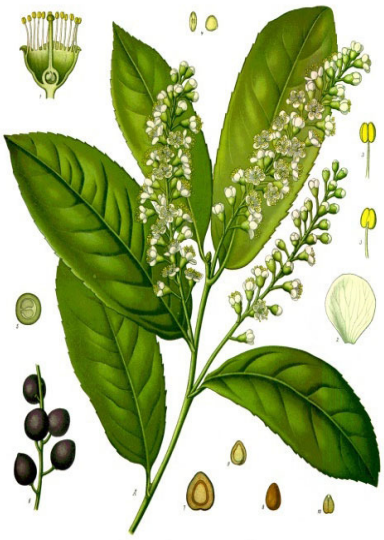


Figure 119. *Prunus laurocerasus* L.

XVI. GLUCOSINOLATE GLYCOSIDES (THIOHETEROSIDES)

It is a group of structures whose carbohydrate part is linked to an aglycone (frequently an anionic structure) through the interlude of a sulfur atom. A characteristic element of this class of components is the fact that in the presence of the enzyme myrosinase, responsible for hydrolysis and at an almost neutral pH, it releases components with a characteristic odor (horseradish, mustard, radish, etc.).

The aglyconic part is represented by the sulfuric ester of methanthio-hydroxamic acid C-substituted. The substitute can be an alkyl radical or unsaturated aryl. For most components, the cation is represented by the potassium ion, but there are also situations when it is represented by a quaternary base (e.g. sinalboside). As for the carbohydrate part, it is always glucose.

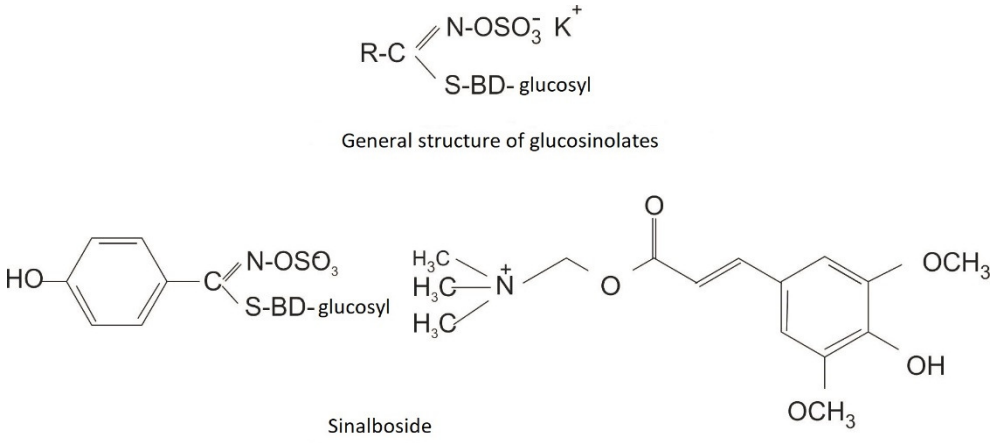


Figure 120. Chemical representations of the main thioheterosides general structures.

Physical properties:

- Glycosides are optically active substances, difficult to crystallize, soluble in water and alcohol. In the presence of myrosinase, an enzyme present in plants containing thioglycosides, at neutral pH they form sennavols (isothiocyanates), potassium hydrogen sulfate, or

sinapine (if the cation is represented by a quaternary base), the case of sinalboside) and glucose.

- Aglycones-senevols are volatile liquids (those with alkyl structure) or non-volatile liquids (those with aryl structure), with an irritant odor, characteristic pungency, and pungent-burning taste. They are optically active substances, immiscible with water, and miscible with nonpolar solvents.

Therapeutic properties:

- Aglycones have antibiotic, antifungal, cholesterol-lowering properties, anti-hypertensive properties and slightly immuno-stimulating properties.
- On the skin and mucous membranes, they have an irritating, hyperemic action.
- The consumption of foods containing thioheterosides benefit from a chemopreventive effect against colon cancer.
- Because of the mechanism of action – they catch iodines and prevent their thyroid fixation – they are administered with caution in people with hypothyroidism.

XVI.1. REPRESENTATIVE HERBAL PRODUCTS WITH GLUCOSINOLATE GLYCOSIDES

1. Sinapis nigra L. Sin. *Mutarda nigra* (L.) Bernh., black mustard, Fam. *Brassicaceae*

Herbal product: *Sinapis nigrae semen*

Chemical composition: thioglycosides (sinigroside), fatty oil, proteins, enzymes.

Action: revulsive, anti-inflammatory, analgesic, bacteriostatic.

Therapeutic uses: joint disorders, respiratory diseases.

Figure 121. *Sinapis nigra* L.

2. Sinapis alba L., white mustard, Fam. *Brassicaceae*

Herbal product: *Sinapis albae semen*

Chemical composition: thioglycosides (sinigroside), fatty oil, volatile oil, enzymes, phytosterols.

Action: revulsive, anti-inflammatory, stomachic, bacteriostatic, cholesterol-lowering.

Therapeutic uses: joint disorders, respiratory diseases, cardiovascular.

Figure 122. *Sinapis alba* L.

3. Raphanus sativus L. var. *niger* (Mill.) Kerner, black radish, Fam. *Brassicaceae*

Herbal product: *Raphani radix*

Chemical composition: thioglycosides (glucobrasicoside), polyholosides, minerals, vitamins, phytosterols, enzymes.

Action: antimicrobial, expectorant, diuretic, carminative, choleretic-cholagogue, anti-spastic.

Therapeutic uses: respiratory diseases, digestive disorders, urinary, erythema, superficial burns.

Figure 123. *Raphanus sativus* L. var. *niger* (Mill.) Kerner

4. Armoracia rusticana G.Gaertn., B.Mey. & Schreb., horseradish, Fam. *Brassicaceae*

Herbal product: *Armoraciae radix and folium*

Chemical composition: thioglycosides (sinigrin, gluconasturtin), polyholosides, minerals, vitamins, phytosterols, enzymes.

Action: antimicrobial, expectorant, diuretic, carminative, choleretic-cholagogue, anti-spastic.

Therapeutic uses: respiratory diseases, digestive disorders, urinary disorders, joint disorders.

Figure 124. *Armoracia rusticana* G.Gaertn., B.Mey. & Schreb.

XVII. BIBLIOGRAPHY

References

1. Council of Europe. *European Pharmacopoeia.* 10th ed. Strasbourg: Council of Europe, **2020.**
2. Alamgir, A. N. M. Therapeutic Use of Medicinal Plants and Their Extracts: Volume 1: Pharmacognosy. Cham: Springer International Publishing, **2017.**
3. Alamgir, A. N. M. Therapeutic Use of Medicinal Plants and their Extracts: Volume 2: Phytochemistry and Bioactive Compounds, **2018.**
4. Anand, U., Jacobo-Herrera, N., Altemimi, A., Lakhssassi, N. (**2019**). A comprehensive review on medicinal plants as antimicrobial therapeutics: potential avenues of biocompatible drug discovery. *Metabolites*, *9*(11), 258.
5. Badal, S., Delgoda, R., Pharmacognosy: Fundamentals, Applications and Strategies, Academic Press, Elsevier, London, **2017.**
6. Bokelmann, J. M. Medicinal Herbs in Primary Care – An Evidence-Guided Reference for Healthcare Providers, Elsevier, **2021.**
7. Bruneton, J. Pharmacognosie Phytochimie Plantes médicinales. Se édition. Lavoisier, Paris **2016.**
8. Cahlíková, L., Šafratová, M., Hošťálková, A., et al. Pharmacognosy and Its Role in the System of Profile Disciplines in Pharmacy. *Natural Product Communications*. **2020**; 15(9). doi: 10.1177/1934578X20945450.
9. Chevallier, A. Herbal Remedies handbook. More than 140 plant profiles. Remedies for more than 50 common conditions, DK Publishing, **2018.**
10. Cox-Georgian, D., Ramadoss, N., Dona, C., Basu, C. (**2019**). Therapeutic and medicinal uses of terpenes. *Medicinal plants: from farm to pharmacy*, 333-359.
11. Danciu, C., Antal, D., Avram, S., Buda, V., Pavel, I.Z., Minda, D., Ardelean, F., Nicolov, M., Dehelean, C. Phytochemicals: Plant sources and Potential Health Benefits, Chapter 1: Essential Mineral Elements: Macronutrients And Micronutrients From Herbs In Human Health. Plant Sources And Potential Health Benefits, Nova Science Publishers, **2019.**
12. Drăgulescu, C. Plantele în medicina populară românească. Editura Univ. Transilvania, Brașov, **2020.**
13. El Aziz, M.M.A., Ashour, A.S., Melad, A.S.G. A review on saponins from medicinal plants: chemistry, isolation, and determination, *J. Nanomed. Res* 8.1 (**2019**): 282-288.
14. Heinrich, M., Barnes, J., Prieto Garcia, J.M., Gibbons, S., Williamson, E.M., Fundamentals of Pharmacognosy and Phytotherapy, Third Edition, Elsevier Health Sciences, **2018.**
15. Hussein, R. A., El-Anssary, A. A. "Plants secondary metabolites: the key drivers of the pharmacological actions of medicinal plants." *Herbal medicine* 1(3), 11-30, **2019.**

16. Kuntal, D. Pharmacognosy and Phytochemistry - I, Nirali Prakashan Publisher, **2019**.
17. Leisegang, K. „Herbal pharmacognosy: An introduction." *Herbal Medicine in Andrology*. Academic Press, **2021.** 17-26.
18. Lesley, B., Marc, C. Herbs and Natural Supplements, 2-Volume set: An Evidence-Based Guide 4th Edition, Churchill Livingstone Australia **2015.**
19. Lu, W., Shi, Y., Wang, R., Su, D., Tang, M., Liu, Y., Li, Z. (**2021**). Antioxidant activity and healthy benefits of natural pigments in fruits: A review. *International journal of molecular sciences*, *22*(9), 4945.
20. Nattow, A.B.. The vitamin and mineral food counter. Gallery Books **2020**, ISBN 9781982160395.
21. Oluwole, O., Fernando, W. B., Lumanlan, J., Ademuyiwa, O., Jayasena, V. (**2022**). Role of phenolic acid, tannins, stilbenes, lignans and flavonoids in human health–a review. *International Journal of Food Science & Technology*, *57*(10), 6326-6335.
22. Pandey, R.K., Shukla, S.S., Vyas, A., Jain, V., Jain, P., & Saraf, S. Fingerprinting Analysis and Quality Control Methods of Herbal Medicines (1st ed.). CRC Press, **2018.**
23. Pattanayak, S. Healthcare system using succulent parts of plants, vol. II, Calcutta Block & Print, **2019.**
24. Pengelly, A. The Constituents of Medicinal Plants: An introduction to the chemistry and therapeutics of herbal medicine, Routledge, **2020.**
25. Rombi, M., Robert, D. Le dictionnaire des plantes médicinales, Alpen, Monaco, **2015.**
26. Shedoeva, A., Leavesley, D., Upton, Z., Fan, C. Wound healing and the use of medicinal plants. *Evidence-Based Complementary and Alternative Medicine*, *2019*(1), 2684108, **2019.**
27. Stanescu, U., Hancianu, M., Cioanca, O., Aprotosoaie, A.C., Miron, A., Plante medicinale de la A la Z , Editura Polirom, Iași, **2014.**
28. Stanescu, U., Hancianu, M., Gîrd, C.E., Farmacognozie. Produse vegetale cu substanțe bioactive, Editura Polirom, Iași, **2020.**
29. Szöke, É., Kéry, Á., Lemberkovics, É. From Herbs to Healing - Pharmacognosy - Phytochemistry - Phytotherapy – Biotechnology, Springer, **2023.**
30. Tran, N., Pham, B., Le, L. (**2020**). Bioactive compounds in anti-diabetic plants: From herbal medicine to modern drug discovery. *Biology*, *9*(9), 252.
31. Tungmunnithum, D., Thongboonyou, A., Pholboon, A., & Yangsabai, A. Flavonoids and other phenolic compounds from medicinal plants for pharmaceutical and medical aspects: An overview. *Medicines*, *5*(3), 93, **2018.**
32. Uritu, C. M., et al. Medicinal plants of the family Lamiaceae in pain therapy: A review. *Pain Research and Management* 2018.1 (**2018**): 7801543.

33. Vaou, N.; Stavropoulou, E.; Voidarou, C.; Tsigalou, C.; Bezirtzoglou, E. Towards Advances in Medicinal Plant Antimicrobial Activity: A Review Study on Challenges and Future Perspectives. *Microorganisms* **2021**, *9*, 2041. https://doi.org/10.3390/microorganisms9102041.
34. Velu, G., Palanichamy, V., Rajan, A. P. (**2018**). Phytochemical and pharmacological importance of plant secondary metabolites in modern medicine. *Bioorganic phase in natural food: an overview*, 135-156.
35. Wang, T. Y., Li, Q., Bi, K. S. (**2018**). Bioactive flavonoids in medicinal plants: Structure, activity and biological fate. *Asian journal of pharmaceutical sciences*, *13*(1), 12-23.

Images

1. https://commons.wikimedia.org/wiki/Category:Ebers_Papyrus
2. https://commons.wikimedia.org/w/index.php?search=hippocrates&title=Special:MediaSearch&go=Go&type=image
3. https://commons.wikimedia.org/w/index.php?search=aristotle&title=Special:MediaSearch&go=Go&type=image
4. https://commons.wikimedia.org/w/index.php?search=theophrastus&title=Special:MediaSearch&go=Go&type=image
5. https://commons.wikimedia.org/w/index.php?search=dioscorides&title=Special:MediaSearch&go=Go&type=image
6. https://commons.wikimedia.org/w/index.php?search=galenus&title=Special:MediaSearch&go=Go&type=image
7. https://www.botanical.com/botanical/mgmh/g/grasse34.html
8. https://www.botanical.com/botanical/mgmh/f/flax--23.html
9. https://botanical.com/botanical/mgmh/m/mallow07.html
10. https://commons.wikimedia.org/w/index.php?search=Malva+sylvestris+botanic+&title=Special:MediaSearch&go=Go&type=image
11. https://commons.wikimedia.org/w/index.php?search=Tilia+cordata&title=Special:MediaSearch&type=image
12. https://www.botanical.com/botanical/mgmh/c/coltsf88.html
13. https://commons.wikimedia.org/w/index.php?search=Plantago+lanceolata+botanic&title=Special:MediaSearch&go=Go&type=image
14. https://www.botanical.com/~botanid5/botanical/mgmh/m/mulgre63.html
15. https://commons.wikimedia.org/w/index.php?search=Arctostaphylos+uva-ursi&title=Special:MediaSearch&type=image
16. https://commons.wikimedia.org/w/index.php?search=Vaccinium+vitis-idaea&title=Special:MediaSearch&type=image
17. https://commons.wikimedia.org/w/index.php?search=Vaccinium+myrtillus+botanic&title=Special:MediaSearch&go=Go&type=image

18. https://commons.wikimedia.org/w/index.php?search=salix+alba+botanic&title=Special:MediaSearch&go=Go&type=image
19. https://commons.wikimedia.org/w/index.php?search=populus+tremula+botanic&title=Special:MediaSearch&go=Go&type=image
20. https://commons.wikimedia.org/w/index.php?search=filipendula+ulmaria+botanic&title=Special:MediaSearch&go=Go&type=image
21. https://commons.wikimedia.org/w/index.php?search=vanilla+planifolia+botanic&title=Special:MediaSearch&go=Go&type=image
22. https://commons.wikimedia.org/w/index.php?search=cynara+scolymus&title=Special:MediaSearch&go=Go&type=image
23. https://commons.wikimedia.org/w/index.php?search=Echinacea+angustifolia&title=Special:MediaSearch&go=Go&type=image
24. https://www.botanical.com/~botanid5/botanical/mgmh/r/rosema17.html
25. https://www.botanical.com/~botanid5/botanical/mgmh/m/melilo29.html
26. https://www.botanical.com/botanical/mgmh/a/ash--073.html
27. https://commons.wikimedia.org/w/index.php?search=Angelica+archangelica&title=Special:MediaSearch&go=Go&type=image
28. https://commons.wikimedia.org/w/index.php?search=Ammi+majus&title=Special:MediaSearch&go=Go&type=image
29. https://commons.wikimedia.org/w/index.php?search=khella&title=Special:MediaSearch&go=Go&type=image
30. https://commons.wikimedia.org/w/index.php?search=Aesculus+hippocastanum+botanical&title=Special:MediaSearch&type=image
31. https://commons.wikimedia.org/w/index.php?search=Asperula+odorata&title=Special:MediaSearch&type=image
32. https://www.botanical.com/~botanid5/botanical/mgmh/m/maname11.html
33. https://commons.wikimedia.org/w/index.php?search=Sophora+japonica&title=Special:MediaSearch&type=image
34. https://botanical.com/botanical/mgmh/b/buckwh81.html
35. https://botanical.com/botanical/mgmh/o/oraswe12.html
36. https://www.botanical.com/~botanid5/botanical/mgmh/l/lemon-16.html
37. https://commons.wikimedia.org/w/index.php?search=Crataegus+monogyna+botanic&title=Special:MediaSearch&type=image
38. https://www.botanical.com/botanical/mgmh/s/smartw54.html
39. https://commons.wikimedia.org/w/index.php?search=ginkgo+biloba+botanical&title=Special:MediaSearch&type=image

40. https://commons.wikimedia.org/w/index.php?search=polygonum+avicularе+botanical&title=Special:MediaSearch&type=image
41. https://www.botanical.com/~botanid5/botanical/mgmh/t/thistl11.html
42. https://commons.wikimedia.org/w/index.php?search=betula+pendula+botanical&title=Special:MediaSearch&type=image
43. https://en.wikipedia.org/wiki/Prunus_cerasus
44. https://commons.wikimedia.org/w/index.php?search=zea+mays&title=Special:MediaSearch&type=image
45. https://commons.wikimedia.org/w/index.php?search=glycine+max&title=Special:MediaSearch&type=image
46. https://commons.wikimedia.org/w/index.php?search=Vaccinium+myrtillus+botanic&title=Special:MediaSearch&go=Go&type=image
47. https://commons.wikimedia.org/w/index.php?search=ribes+nigrum+botanical&title=Special:MediaSearch&type=image
48. https://www.botanical.com/~botanid5/botanical/mgmh/h/holhoc30.html
49. https://www.botanical.com/botanical/mgmh/h/hearts10.html
50. https://commons.wikimedia.org/w/index.php?search=centaurea+cyanus+botanical&title=Special:MediaSearch&type=image
51. https://www.botanical.com/botanical/mgmh/p/popred63.html
52. https://commons.wikimedia.org/w/index.php?search=hibiscus+sabdariffa&title=Special:MediaSearch&type=image
53. https://www.botanical.com/~botanid5/botanical/mgmh/r/rhatan12.html
54. https://www.botanical.com/botanical/mgmh/t/tormen25.html
55. https://commons.wikimedia.org/w/index.php?search=lythrum+salicaria+botanical&title=Special:MediaSearch&go=Go&type=image
56. https://commons.wikimedia.org/w/index.php?search=polygonum+bistorta+botanical&title=Special:MediaSearch&go=Go&type=image
57. https://commons.wikimedia.org/w/index.php?search=potentilla+anserina+botanical&title=Special:MediaSearch&go=Go&type=image
58. https://commons.wikimedia.org/w/index.php?search=alchemilla+vulgaris+botanical&title=Special:MediaSearch&go=Go&type=image
59. https://commons.wikimedia.org/w/index.php?search=agrimonia+eupatoria+botanical&title=Special:MediaSearch&go=Go&type=image
60. https://commons.wikimedia.org/w/index.php?search=geum+urbanum+botanical&title=Special:MediaSearch&go=Go&type=image
61. https://commons.wikimedia.org/w/index.php?search=hamamelis+virginiana+botanical&title=Special:MediaSearch&go=Go&type=image
62. https://commons.wikimedia.org/w/index.php?search=quercus+robur+botanical&title=Special:MediaSearch&go=Go&type=image

63. https://commons.wikimedia.org/w/index.php?search=Oak+Galls&title=Special:MediaSearch&go=Go&type=image
64. https://commons.wikimedia.org/w/index.php?search=rhamnus+frangula+botanical&title=Special:MediaSearch&go=Go&type=image
65. https://commons.wikimedia.org/w/index.php?search=Cascara+sagrada&title=Special:MediaSearch&go=Go&type=image
66. https://www.botanical.com/botanical/mgmh/b/buckth80.html
67. https://www.botanical.com/~botanid5/botanical/mgmh/r/rhubar14.html
68. https://www.botanical.com/botanical/mgmh/s/sorcom64.html
69. https://commons.wikimedia.org/w/index.php?search=cassia+acutifolia+botanical&title=Special:MediaSearch&go=Go&type=image
70. https://botanical.com/botanical/mgmh/a/aloes027.html
71. https://www.botanical.com/~botanid5/botanical/mgmh/m/madder02.html
72. https://commons.wikimedia.org/w/index.php?search=hypericum+perforatum+botanical&title=Special:MediaSearch&go=Go&type=image
73. https://www.botanical.com/botanical/mgmh/f/foxglo30.html
74. https://commons.wikimedia.org/w/index.php?search=digitalis+lanata+botanical&title=Special:MediaSearch&go=Go&type=image
75. https://commons.wikimedia.org/w/index.php?search=strophanthus+gratus+botanical&title=Special:MediaSearch&go=Go&type=image
76. https://commons.wikimedia.org/w/index.php?search=adonis+vernalis+botanical&title=Special:MediaSearch&go=Go&type=image
77. https://commons.wikimedia.org/w/index.php?search=convallaria+majalis+botanical&title=Special:MediaSearch&go=Go&type=image
78. https://commons.wikimedia.org/w/index.php?search=nerium+oleander+botanical&title=Special:MediaSearch&go=Go&type=image
79. https://commons.wikimedia.org/w/index.php?search=helleborus+niger+botanical&title=Special:MediaSearch&go=Go&type=image
80. https://commons.wikimedia.org/w/index.php?search=primula+officinalis+botanical&title=Special:MediaSearch&go=Go&type=image
81. https://commons.wikimedia.org/w/index.php?search=gypsophila+paniculata+botanical&title=Special:MediaSearch&go=Go&type=image
82. https://www.botanical.com/botanical/mgmh/s/soawor61.html
83. https://www.botanical.com/botanical/mgmh/i/ivycom15-l.jpg
84. https://www.botanical.com/~botanid5/botanical/mgmh/c/chehor58.html
85. https://commons.wikimedia.org/w/index.php?search=glycyrrhiza+glabra+botanical&title=Special:MediaSearch&go=Go&type=image

86. https://commons.wikimedia.org/w/index.php?search=ononis+spinosa+botanical&title=Special:MediaSearch&go=Go&type=image
87. https://commons.wikimedia.org/w/index.php?search=betula+pendula+botanical&title=Special:MediaSearch&go=Go&type=image
88. https://commons.wikimedia.org/w/index.php?search=equisetum+arvense+botanical&title=Special:MediaSearch&go=Go&type=image
89. https://commons.wikimedia.org/w/index.php?search=panax+ginseng+botanical&title=Special:MediaSearch&go=Go&type=image
90. https://commons.wikimedia.org/w/index.php?search=eleutherococcus+senticosus+botanical&title=Special:MediaSearch&go=Go&type=image
91. https://commons.wikimedia.org/w/index.php?search=centella+asiatica+&title=Special:MediaSearch&go=Go&type=image
92. https://commons.wikimedia.org/w/index.php?search=ruscus+aculeatus&title=Special:MediaSearch&go=Go&type=image
93. https://www.botanical.com/botanical/mgmh/e/elder-04.html
94. https://commons.wikimedia.org/w/index.php?search=prunus+amygdalus+&title=Special:MediaSearch&go=Go&type=image
95. https://commons.wikimedia.org/w/index.php?search=prunus+laurocerasus+botanical&title=Special:MediaSearch&go=Go&type=image
96. https://www.botanical.com/~botanid5/botanical/mgmh/m/mustar65.html
97. https://commons.wikimedia.org/w/index.php?search=sinapis+alba+botanical&title=Special:MediaSearch&go=Go&type=image
98. https://commons.wikimedia.org/w/index.php?search=raphanus+sativus+botanical&title=Special:MediaSearch&go=Go&type=image
99. https://commons.wikimedia.org/w/index.php?search=armoracia+rusticana+botanical&title=Special:MediaSearch&go=Go&type=image
100. https://commons.wikimedia.org/w/index.php?search=glucose&title=Special:MediaSearch&go=Go&type=image
101. https://commons.wikimedia.org/w/index.php?search=fructose&title=Special:MediaSearch&go=Go&type=image
102. https://commons.wikimedia.org/w/index.php?search=sorbitol&title=Special:MediaSearch&go=Go&type=image
103. https://commons.wikimedia.org/w/index.php?search=mannitol&title=Special:MediaSearch&go=Go&type=image
104. https://commons.wikimedia.org/w/index.php?search=saccharose&title=Special:MediaSearch&go=Go&type=image
105. https://commons.wikimedia.org/w/index.php?search=lactose&title=Special:MediaSearch&go=Go&type=image

106. https://commons.wikimedia.org/w/index.php?search=galacturonic&title=Special:MediaSearch&go=Go&type=image
107. https://commons.wikimedia.org/w/index.php?search=Pectin+Structure&title=Special:MediaSearch&go=Go&type=image