Волинський національний університет імені Лесі Українки
Факультет біології та лісового господарства
Кафедра ботаніки і методики викладання природничих наук

Iryna Kuzmishyna

MEDICINAL PLANTS AND MEDICINAL RAW MATERIALS: THEORY AND PRACTICE

Навчально-методичний посібник

Луцьк – 2024

УДК 633.88(072)
К 89

Рекомендовано до друку науково-методичною радою Волинського національного університету імені Лесі Українки (протокол № 6 від 21 лютого 2024 р.)

Рецензенти:

Сухомлін К. Б. – доктор біологічних наук, професор, завідувач кафедри зоології Волинського національного університету імені Лесі Українки

Троцюк А. М. – кандидат філологічних наук, доцент кафедри іноземних мов природничо-математичних спеціальностей Волинського національного університету імені Лесі Українки

Зінчук М. І. – кандидат сільсько-господарських наук, доцент, завідувач кафедри агрономії Луцького національного технічного університету

К 89 Kuzmishyna I. Medicinal Plants and Medicinal Raw Materials: Theory and Practice = Кузьмішина І. Лікарські рослини та лікарська сировина: теорія і практика: навч.-метод. посібник. Луцьк: Вежа-Друк, 2024. 248 с.

У навчально-методичному посібнику «Medicinal Plants and Medicinal Raw Materials: Theory and Practice» згідно з вимогами навчальної програми вибіркового освітнього компоненту «Лікарські рослини та лікарська сировина» подано англійською мовою матеріал до 5 лекцій, 9 тем для самостійного опрацювання, методичних рекомендацій до виконання 7 лабораторних робіт.

Рекомендовано для здобувачів-іноземців освітнього рівня «магістр» спеціальності 091 «Біологія та біохімія» освітньо-професійних програм «Біологія», «Лабораторна діагностика» різних форм навчання факультету біології та лісового господарства ВНУ імені Лесі Українки.

УДК 633.88(072)

CONTENTS

CONTENTS

ПЕРЕДМОВА

Навчально-методичний посібник «Medicinal Plants and Medicinal Plant Raw Materials: Theory and Practice» призначений для магістрів-іноземців факультету біології та лісового господарства I (V) року навчання спеціальності 091 «Біологія» та укладений згідно з силабусом вибіркового освітнього компоненту «Лікарські рослини та лікарська рослинна сировина».

Предметом вивчення вибіркового освітнього компоненту «Лікарські рослини та лікарська рослинна сировина» є рослини як джерела лікарської сировини, **метою** навчання є сформування у студентів системи знань про лікарські рослини: видовий склад, систематичне положення, біологічно активні речовини, їх фізіологічну дію на організм людини, основні форми лікарських засобів та особливості заготівлі лікарської сировини.

На вивчення навчальної дисципліни на денній формі навчання відводиться 120 годин / 4 кредити ECTS, зокрема, лекції – 10 год., лабораторні роботи – 14 год, самостійна робота – 88 год.

Навчально-методичний посібник складається з двох змістових модулів:

1. Система знань про лікарські рослини (System of knowledge about medicinal plants).

2. Діючі речовини лікарських рослин (Active substances of medicinal plants).

Кожен змістовий модуль містить лекції, теми для самостійного опрацювання, лабораторні роботи та методичні рекомендації до їх виконання, тести для самоперевірки, додатки. В лекціях знаком * познаний матеріал для самостійного опрацювання.

У прикінцевій частині навчально-методичного посібника подано питання для підсумкового контролю, список рекомендованої літератури, основні поняття і терміни, додатки.

Structure of the Educational Component

Names of content modules and themes (topics units)	Number of hours					
	Altogether	including				
		Lec.	Pw	Ind. w.	Cons.	
Content module 1 System of Knowledge about Medicinal Plants						
1. Subject and main tasks of the course "Medicinal plants and medicinal plant raw materials". The place of medicinal plants in biology.	8	2	–	6	–	6
2. Peculiarities of harvesting medicinal plant raw materials.	9	–	2	6	1	7
3. Chemical composition of medicinal plants.	11	2	2	6	1	7
4. Biotechnology of medicinal plants.	9	2	–	6	1	7
Together according to content module 1	37	6	4	24	3	27
Content module 2 Active Substances of Medicinal Plants						
5. Medicinal plants and their raw materials containing carbohydrates.	8	–	1	6	1	7
6. Medicinal plants and their raw materials containing proteins and lipids.	7	–	1	6	–	7
7. Medicinal plants and their raw materials containing phenols.	7	–	–	6	1	7
8. Medicinal plants and their raw materials containing flavonoids	7	–	–	6	1	7
9. Medicinal plants and their raw materials containing tannins.	8	–	–	6	–	7
10. Medicinal plants and their raw materials containing essential oils.	9	–	2	6	1	7
11. Medicinal plants and their raw materials containing steroids and cardiac glycosides.	8	–	2	6	–	7
12. Medicinal plants and their raw materials containing alkaloids.	10	2	2	6	–	7
13. Medicinal plants and their raw materials containing vitamins.	8	2	–	6	–	7
14 Practical use of medicinal plants.	11	–	–	10	1	10
Together according to content module 2	83	4	10	64	5	73
Altogether	**120**	**10**	**14**	**88**	**8**	**100**

*independent work

Content module 1

SYSTEM OF KNOWLEDGE ABOUT MEDICINAL PLANTS

LECTURES

Lecture 1 INTRODUCTION. BASIC CONCEPTS, DEFINITIONS AND TASKS OF THE MEDICIONAL PLANT SCIENCE

1 Subject, goal, and objectives of the academic discipline "Medicinal Plants"

2* Brief historical overview of the use of medicinal raw materials

2.1* Ancient pharmacognosy

2.2* Herbal medicine in the history of the Ukrainian state

2.3* Pharmacy gardens, their contribution to the dissemination and use of plant medicinal raw materials

3 Modern development of pharmacognosy. The role of the Ukrainian pharmacognostic school

Literature and Internet resources:

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.8–20. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія-з-основами-біохімії-рослин.pdf (in Ukrainian)

Ukraine State Pharmacopoeia. URL: https://docplayer.net/ 77551242 -Derzhavna-farmakopeya-ukrayini.html

Research Station of Medicinal Plants at the Institute of Agroecology and Nature Management of the National Academy of Agrarian Sciences of Ukraine. History of Creation. URL: http://dslr-naan.com.ua/index.php?option=com_content&view=article&id=33&Itemid=197

Falimirz, Stefan; About Herbs and Their Power, 1534. URL: https://www.dbc.wroc.pl/dlibra/doccontent?id=2228&from=PIONIER%20DLF

1 The subject, goal, and objectives of the academic discipline "Medicinal Plants"

Pharmacognosy is the science that studies medicinal plants, medicinal raw materials of plant and animal origin, as well as products derived from them. In Greek, pharmacognosy translates to the study

of medicine or knowledge about medicine (*pharmakon* – medicine, poison, and *gnosis* – knowledge, study).

Modern pharmacognosy is a highly specialized applied science that examines the biological, biochemical, and medicinal properties of plants, natural raw materials, and products derived from them. The subject of pharmacognosy is medicinal plants, and less frequently, objects of animal origin as sources of medicinal raw materials.

Medicinal plants (in Latin *Plantae medicinales*) are plants that contain biologically active substances and are used for the collection of medicinal plant raw materials. **Medicinal plant** – a plant that serves as a source of medicinal plant material and meets the requirements of the Ukraine State Pharmacopoeia.

They are typically categorized as follows:

- **Official Medicinal Plants** are the plants whose raw materials are allowed for the production of medicinal products in the country. These types of medicinal plant raw materials are listed in the State Register of Medicines of Ukraine.
- **Pharmacopoeial Medicinal Plants** are official plants, the quality requirements of the medicinal plant raw materials of which are outlined in the corresponding article of the State Pharmacopoeia or international pharmacopoeias. The study of medicinal plants and medicinal plant raw materials is one of the directions of pharmaceutical science called Pharmacognosy.
- **Medicinal Plants of Folk Medicine** constitute the broadest category, with most plants in this group being relatively poorly described, and information about the effectiveness of their use has not undergone the necessary verification with modern pharmacology tools. Nevertheless, many plants in this group are actively used in countries where medical care is inaccessible or too expensive.

Medicinal Plant Raw Material – refers to whole medicinal plants or their parts used in dried (sometimes fresh) form to obtain medicinal substances, medicinal products of plant origin (phytopreparations), and medicinal forms, and are permitted for use (berries, herb, shoots, buds, leaves, flowers and inflorescences, fruits and seeds, roots, rhizomes, bulbs, tuber bulb, bark, etc.).

Each medicinal raw material has a Latin name under which it is described in the national pharmacopoeia, standards, and technical conditions. These names typically consist of two words. The first word is the name of the plant organ or product obtained from natural

materials (for example, leaves – *Folia*, herb – *Herba*, flowers – *Flores*, oils – *Olea*, etc.). The second word is the name of the plant genus that supplies this raw material (for example, valerian rhizome with valerian root – *Rhizomata cum radicibus Valerianae*, sunflower oil – *Oleum Helianthi*).

In some cases, the name of the raw material includes the species of the plant (for example, *Folia Belladonnae* – leaves of the plant *Atropa belladonna* (common belladonna), *Herba Absinthii* – herb of the plant *Artemisia absinthium* (wormwood), and less frequently, the names of the genus and species (for example, *Herba Adonidis vernalis* – herb of the plant *Adonis vernalis* (spring pheasant's eye)). The name of the plant is capitalized.

Biologically Active Substances – substances that influence biological processes in the organisms of animals and humans.

Active Ingredients – biologically active substances that can alter the state and functions of the organism or exhibit preventive, diagnostic, or therapeutic effects and are used in the production of finished medicinal products.

Adjunct Substances – a conditional term for products of metabolism found in medicinal plants alongside biologically active substances. They can positively or negatively affect the organism, influencing the absorption of basic biologically active substances, enhancing their effectiveness, and prolonging their effects.

Medicinal Products – substances or their mixtures of natural, synthetic, or biotechnological origin used for the prevention, diagnosis, and treatment of human diseases or changes in the state and functions of the organism. Medicinal products from plant and animal raw materials can be classified into the following groups: 1) medicinal raw materials dispensed to the patient from the pharmacy in the form of powder, tea, or collection; 2) galenic and novel galenic preparations – alcohol extracts from plants in the form of tinctures, extracts; novel galenic preparations are extracts purified from accompanying substances; 3) products of primary processing of plants – essential and fatty oils, resins, and camades; 4) individual active ingredients – alkaloids, glycosides, components of essential oils.

Medicinal forms of raw materials of plant and animal origin, intended for external, internal use and for injections are the tablets, powders, decoctions, capsules, liposomes, extracts, drops, ointments, collections, teas, microcapsules, solution for inhalation, solution for

injections, infusions, tinctures, aerosols, pastes, suppositories, suspensions, granules.

Diagnostic Signs (in Greek *diagnostikos* – capable of recognition) – a set of macroscopic and microscopic features characteristic of the object under study, allowing its authenticity to be determined.

Medicinal form – a medicinal product endowed with a convenient form for application and achieving the necessary therapeutic effect.

Modern Pharmacognosy addresses the following tasks:

- **Study of the Chemical Composition of medicinal plants**, pathways of biosynthesis, and dynamics of biologically active substance formation, their accumulation in organs and tissues during plant ontogenesis, and under the influence of environmental factors. Search for optimal conditions for the collection, drying, and storage of medicinal plant raw materials.
- **Standardization of Medicinal Plant Raw Materials**; development of projects for temporary pharmacopoeial articles (TPA) and revision of existing analytical normative documentation (AND); improvement of methods for determining plant identity, purity, and good quality of raw materials.
- **Medicinal Resource Management**: This involves studying the geographic distribution of medicinal plants, identifying natural habitats, inventorying resources, mapping them, and determining possible harvesting volumes. Additionally, it includes developing and implementing measures for the restoration of natural resources for the most valuable species.
- **Medicinal Plant Cultivation**: identification, acclimatization, and introduction of medicinal plants, their cultivation, and the selection of high-yielding varieties.
- **Plant Biotechnology**: growing isolated plant cells and tissues for the extraction of biologically active substances.

Successful study of pharmacognosy requires knowledge in botany, biology, ecology, organic, analytical, physical, colloidal, and biological chemistry, physics, human physiology, and Latin language. Understanding pharmacognosy is essential for studying pharmaceutical and toxicological chemistry, drug technology, pharmacy organization and economics, pharmacology, pharmacotherapy, clinical pharmacy, and more.

2* Historical Overview of Medicinal Plant Usage

2.1* Ancient Pharmacognosy

The healing properties of plants have been known to humanity since time immemorial, as evidenced by conclusions drawn from ethnography and archaeology. The earliest written records of plant applications belong to the **Sumerians**, dating back to around 6,000 BCE.

Assyrians documented their knowledge of plants on clay tablets, and in the capital of Assyria, Nineveh, a garden was established for cultivating medicinal plants.

In the 11th century BCE, **Babylonians** described several hundred plants along with their uses. Special expeditions by **Egyptians** to neighboring countries were conducted to acquire medicinal and aromatic herbs. The experiences of Egyptian medicine were studied by Greek physicians. **Hippocrates**, the founder of scientific medicine, described 236 medicinal plants in his work "Corpus Hippocraticum."

The Greek philosopher and founder of botany, **Theophrastus** (372-287 BCE), systematized accumulated knowledge about medicinal flora in his work "Enquiry into Plants."

Dioscorides (1st century CE), known as the "Father of European Pharmacognosy," a Greek military physician by origin, documented all the plants used in ancient medicine in his work "Materia Medica." Illustrated with plant drawings, it was repeatedly reissued in Latin and served as a practical guide for physicians and pharmacists worldwide for centuries.

Roman physicians were also acquainted with and utilized medicinal plants. **Pliny the Elder** (1st century BCE) compiled the encyclopedia "Naturalis Historia," dedicating 12 volumes to medicine and pharmacy, including descriptions of 304 plants.

Roman physician **Claudius Galen** (c. 130 – c. 200 CE) implemented methods of processing medicinal plants and introduced new pharmaceutical forms, such as alcoholic tinctures, now known as galenic preparations.

Arab scholars played the significant contribution to the development of medicine by adopting and furthering the traditions of Greek science. In several Eastern cities, medical schools were established where Greek and Roman books were translated into Arabic. Eastern physicians extensively utilized complex prescriptions containing various types of medicinal plant material in different proportions. In 977 CE, Arab physician **Abu Mansur Muwaffaq**

wrote a book based on his treatment experience, detailing information about 466 plants and 44 substances of animal origin.

One of the most prominent figures in Arab medicine was the philosopher, scholar, and physician **Abu Ali ibn Sina** (**Avicenna**), who lived from 980 to 1037 CE. His multi-volume work, "The Canon of Medicine," provides descriptions of nearly 900 medicinal plants. Within a century, the "Canon" was translated from Arabic into Latin. For five centuries, this work served as a textbook for physicians, and until the mid-18th century, it was studied in universities across Europe, retaining significant scientific importance.

Uzbek scholar **Abu Rayhan Biruni**, hailing from Khorezm (973 – approx. 1050), made a significant contribution to pharmacognosy with his monumental work, "Pharmacognosy in Medicine." This comprehensive work encompasses information about 750 plant species, including their geographical distribution, descriptions, illustrations, and characteristics regarding identity, purity, and the quality of raw materials.

The unique traditions of Chinese, Indian, Tibetan medicine and philosophy are known worldwide. The primary written source of ancient Chinese medicine is the "**Book of Herbs**" ("Ben-tsao"), dated 2600 BC. is. It contains information about 900 plants with a description of their use. In the 16th century lived the outstanding herbalist **Li Shizheng**, who left behind a work containing information on 1,892 plants. The vegetation of India is extremely diverse. In the 1st–2nd st. to n. e. books were written summarizing knowledge about its medicinal plants. The oldest of them is "**Ayurveda**" ("Science of life"). Later, it was supplemented and reworked by doctors **Charaka** (1st century), **Sushruta** (4th century BC), **Vagbat** (7th–8th centuries). It describes about 1,000 medicinal plants of the local flora. Later, "Ayurveda" became the primary source for the book "Jud-shi" ("Essence of Healing"), which was popular among Tibetan doctors. Indian medicine influenced the formation of the Roman medical school, as well as Tibetan medicine, which is characterized by the use of a large set of medicinal plants, which is of great interest today.

Western European medicine, the level of which was not high in the Middle Ages, felt the special influence of ancient and eastern civilizations. In the 9th and 10th centuries the works of Dioscorides, Halsna, and Apuleius were translated into European languages. The original European herbalists date back to the 15th–16th centuries.

Pharmacies in Europe, organized according to the Arab model, had in their assortment Iranian-Arabic, Indian, American, and African raw materials.

In the 16th century the European physician **Paracelsus** (1493-1541) suggested that the medicinal effect does not belong to the plant as a whole, but to its "quintessence" - the active substance. He summarized the ancient experience of choosing medicines based on their appearance, called their specific features signatures. The doctrine of signatures is an expression of the ancient law of similarity, meaning the treatment of similar with similar.

In the 17th century, chemists **L. Voklen, A. Fourcroy, J. Seguin**, and **A. Baumé** conducted the first studies on the active substances in plants. The Swedish chemist and pharmacist **C. Scheele** (1741–1786) isolated oxalic, malic, citric, and tartaric acids from medicinal plant materials for the first time and also discovered glycerin. In 1806, pharmacist **F. Sertürner** obtained pure morphine from opium and demonstrated its sedative properties.

In the mid-19th century, glycosides, tannins, saponins, resins, and others were isolated from plants. At the end of the 19th to the early 20th century, vitamins were discovered, followed by the identification of the biological activity of flavonoids and coumarin derivatives, phytoncides, and trace elements.

Swiss pharmacognosist **A. Chirch** made a significant contribution to the development of microscopic analysis of medicinal raw materials. His three-volume handbook on pharmacognosy, "Anatomisches Atlas der Pharmakognosie und Nahrungsmittelkunde" (Leipzig, 1900), gained international recognition.

2.2* Herbal Healing in the History of the Ukrainian State

The roots of herbal healing can be traced back to the prehistory of the Ukrainian state. These traditions originate in the culture of the Scythians, who inhabited the North Black Sea region from the Danube to the Don (7th century BCE – 1st century CE). This mysterious people left many enigmas, one of which is the pectoral from the Tovsta Mohyla. On one of its fragments is a scene depicting a visit to a tooth doctor, indicating a high level of medicine in those times. Other archaeological finds also support this notion.

Among the Slavic peoples, traditions of harvesting and drying medicinal raw materials and preparing medicines developed over centuries. During the pagan era, individuals known as "volkhvs,"

"veduny," "znakhari," or folk healers treated people, utilizing plants, minerals, and animal products such as fir *Picea abies*, birch bark *Ulmus minor*, linden *Tilia cordata*, willow *Salix* sp., maple *Acer pseudoplatanus*, birch *Betula pendula*, wild rose *Rosa canina*, hawthorn *Crataegus oxyacantha*, St. John's wort *Hypericum perforatum*, horseradish *Armoracia rusticana*, clay, ash, honey, and more. They were knowledgeable about various poisons, intoxicating plants (narcotics), emetics (such as ivy *Hedera helix*), and used poppy *Papaver somniferum* and hemp *Cannabis sativa* as sedatives. During wars, chemerica *Veratrum lobelianum* extract was applied to arrowheads.

In the 10th century, the Slavic peoples acquired literacy, and Kyivan Rus embraced Christianity, expanding the state's political connections. At the invitation of Volodymyr Monomakh, the Greek physician **Ioann Smir** (1053–1125) came to Kyiv. It was during this time that the first written mentions of healing with plants, referred to as "zeliye," appeared. This term denoted herbs, herbal infusions, poisons, giving rise to "zeliyeknyky" – individuals engaged in healing. Manuscript collections, herbalists, and healers were also called "zeliyeknyky." The "Izbornyk of Grand Prince Sviatoslav Yaroslavovych" (1073) describes several medicinal plants used at that time. The "Shestodnev" by Ioann Bolgarsky (1263) contains brief information on the use of aconite *Aconitum* sp, hemlock *Conium maculatum,* henbane *Hyoscyamus niger*, and obtaining opium from poppy *Papaver somniferum*.

The name of Antipas (982–1073), a native of the ancient town of Lyubech in Chernihiv region, is known from chronicles. He embraced monastic life on Mount Athos, taking the name Antony, and together with Feodosiy, founded the Kyiv-Pechersk Lavra monastery in the 11th century. Antony, referred to as the "wondrous physician" in the monastery chronicle, personally cared for the sick, providing them with healing herbs to ingest.

The most prominent among the monks was considered **Agapit**. A Kyivan by birth, he joined the monastery during Antony's time. "The Kyiv-Pechersk Paterik" recounts that Agapit followed Antony's example both in asceticism and medical practice. His sincere care for the sick and selflessness earned him the people's fame and respect. "It was heard about him in the city that someone in the monastery is a healer, and many sick were healed." The chronicle further states,

"He [Agapit] began to heal all the sick with his prayers, giving medicine from his own table." Agapit treated using fasting, selected dietary products, and utilized remedies brought from other countries, alongside locally available plants. The "Paterik" describes successful cases of Agapit's treatment of common people, boyars, princes, and their relatives, including Prince Volodymyr Monomakh.

The chronicle also mentions a renowned physician of Chernihiv Prince Mykola Davidovych – **Peter Syryianin**, who joined the Pechersk Monastery in 1106, calling him a "very clever healer." When "the blessed prince became ill from his labors, he prepared him healing potions."

Hospitals were established near monasteries. For instance, the Nikon Chronicle attests that Metropolitan **Yefrem of Pereyaslav** built a "bathhouse" in Pereyaslav (1091) and organized a hospital where all parishioners were treated free of charge.

There were also female healers. **Evpraksiya Mstislavna** (first half of the 12th century), the granddaughter of Volodymyr Monomakh, who took the name Zoya (meaning "life") at her coronation, gained fame for her treatise "Mazi." **Euphrosyne**, the daughter of Chernihiv Prince, was "well-versed in Asclepius' writings," a term used for medical books at that time. In one of the old prints, there is mention of a peasant girl, the daughter of a beekeeper, **Fevroniya** (13th century), who treated with herbal infusions and honey.

Regarding the methods used by "lichky" (healers), they were highly individualized because the healers themselves crafted remedies based on the secrets passed down by their predecessors. The accumulated experience of folk medicine spread to countries in Europe and Asia Minor. Avicenna, following the example of ancient Rus healers, recommended honey, linden flowers, and birch sap for various ailments, referring to these remedies as "Rus medicines."

During the period of feudal fragmentation and the subsequent Mongol-Tatar invasions, which culminated in the sacking of Kyiv in December 1240, difficult times prevailed for the development of science and culture. The western lands – Volyn and Galicia – suffered the least from the invaders, allowing them to continue and develop the healing traditions of Kyivan Rus.

The history of medical provision in the Galician region dates back to the 13th century when **Konstancia**, the wife of Prince Lev, allocated land and funds in 1270 to build a monastery with a shelter

and a pharmacy for the sick near the Cathedral of St. John the Baptist. Shelters for the sick were also established in other monasteries, such as the well-known "Asclepion" at the St. George's Monastery in Lviv. Similar institutions existed in other spiritual centers, including the Maniavsky Skete, the women's monastery at the Pochaiv Lavra, and others, offering assistance to people through prayer, advice, and folk medicine remedies.

Medical handbooks for the population were created, such as the "Herbarius maguntiae impressum" published in 1484 in German. It contained descriptions and illustrations of many local flora. However, the foreign language hindered its dissemination among the population of Galicia. Later, S. Falimirz compiled the herbalist "O ziołach i o mocy ich" ("About Herbs and Their Power") in Polish, the state language at that time, in 1534. The first part of the book provided an illustrated description of over 500 medicinal substances, while the second part covered the diagnosis of diseases, their prevention, and treatment methods. The herbalist mainly described herbs, their infusions, and plant oils.

The study of medicine and pharmacy at a professional level in Galicia began with the establishment of the medical school "Collegium medicum" in Lviv in 1661. Subsequently, until 1918, education in these fields was provided at the philosophical faculty of Lviv University in the "Studium farmaceutyche." Pharmacognosy as a separate discipline was introduced in 1855 at the medical and surgical department of the university. In 1897, after the creation of the pharmacology department, a separate course on pharmacognosy was taught at the medical faculty.

From 1920 to 1923, **Tadeusz Feliksowicz Wilczyński** taught a course on plant morphology and taxonomy for pharmacists. Starting in 1929, he led the course on pharmacognosy and botany at the pharmacology department. During this time, T. F. Wilczyński was involved in organizing the educational process, acquiring a building and land for growing medicinal plants. Only in 1940, after granting the medical faculty the status of an institute, was an independent department of pharmacognosy with a botany course established. T. F. Wilczyński became its head. During his leadership from 1929 to 1964, he assembled a unique collection of medicinal plants from various climatic zones, covering an area of 5.5 hectares and comprising around 1500 species.

From 1964 to 1970, the educational and research activities of the department were headed by **I. P. Karpus**, a disciple of T. F. Wilczyński. The department initiated chemical analysis of medicinal plant raw materials in the educational process and continually expanded the plant collection in the nursery, which became one of the best bases for educational practice in pharmacognosy. The traditions are continued by the Department of Pharmacognosy at Danylo Halytsky Lviv National Medical University. Under the leadership of Professor **L. Ya. Ladna-Rogovska**, who led the department from 1971 to 1996, systematic studies of the flora of western regions of Ukraine were initiated with the aim of creating medicinal products. Presently, scientific research is conducted in two main directions: resource studies and phytochemistry.

Zaporizhzhia Sich, serving as a democratic center amidst the dominance of the Russian Empire on Ukrainian territory, distinguished itself with a well-organized system of medical assistance for the sick and wounded. Hospitals operated there under the guidance of experienced bone rights (military administrators), and there were also folk surgeons, known as tsirulnyky, who practiced popular surgery. Beekeepers among the Cossacks, known as pasichnyky, contributed their experience in phytotherapy. These individuals, often long-lived, possessed knowledge of the secrets of medicinal plant usage, the timing of their collection, and specific methods of preparation.

Medicinal plants were well-known to Ukrainians, a fact documented in the memoirs of foreign diplomats, missionaries, and travelers who visited Ukraine in the 16th and 17th centuries. In medieval Ukraine, monks were primarily engaged in medical practices. In addition to them, folk healers played a role in healthcare, drawing on life experience and knowledge inherited from ancient traditions.

2.3* Pharmaceutical Gardens: Their Contribution to the Distribution and Utilization of Medicinal Plant Raw Materials

A significant milestone in the field of medical care can be considered the mid-17th century. During the reign of Alexei Mikhailovich, the Royal Pharmacy Directorate was established, later attaining the status of a state organization providing medical assistance to the royal court and the army. Subsequently, medicinal gardens, where medicinal plants were cultivated, were established in Lubny, Poltava region, Ukraine. In 1730, the Lubny pharmacy garden

harvested the first crop of domestic rhubarb, mint, belladonna, and digitalis, which were in demand among physicians at that time. By the late 18th century, the Lubny botanical garden began cultivating sugar beets, from which purified alcohol was first obtained in Eastern Europe.

The creation of the Academy of Sciences in 1724 had a significant impact on the development of pharmacognosy. Botanical expeditions facilitated the study of the country's flora. Academician Y. K. Trapp (1814-1908), recognizing the need to develop methods for determining medicinal plant raw materials, its quality, and the identification of impurities, established pharmacognosy as an independent discipline and authored the first textbook.

The works of Professor V. O. Tikhomirov, such as "Course of Pharmacognosy" (1885), "Manual for the Study of Pharmacognosy" (1888-1890), and "Textbook of Pharmacognosy" (1900), are well-known. Professor G. Dragendorff (1836–1898) of the University of Tartu (formerly Yuryev, Estonia) authored the handbook "Medicinal Plants of Various Peoples and Times, Their Applications, Major Chemical Substances, and History" (1890), containing information on 12,000 species of medicinal plants. The disciples of Y. K. Trapp, such as Professor O. D. Chirikov of Kharkiv University, and professors M. F. Mentin and D. O. Davidov of the University of Warsaw, made a significant contribution to the development of pharmacognosy. Their textbooks are well-known to many generations of pharmacists.

In 1919, efforts began to establish the pharmaceutical industry using domestic raw materials, studying the raw material base, introducing valuable plant species into cultivation, and training qualified pharmacists. In 1921, the Council of People's Commissars of the RSFSR issued a decree on the collection and cultivation of medicinal plants. In 1930, specialized research stations for medicinal plants were established in various geographical zones of the country (Bitiya, Lubny, Mogilev, Olgin, Sukhumi), which in 1931 were subordinated to the All-Union Scientific Research Institute of Medicinal and Aromatic Plants (VILAR).

The initiation of industrial harvesting and cultivation of medicinal plants in Ukraine dates back to the early 18th century. During this period, "reserve pharmacies" were established (in 1706 in Hlukhiv and 1709 in Lubny) to supply medicines to the imperial army. Over time, these establishments evolved into pharmaceutical gardens.

Consequently, the Lubensky district became a center for industrial harvesting and cultivation of medicinal plants. Historical records indicate that, unlike anywhere else in Ukraine, the Lubny region had numerous wholesale storage facilities where villagers stored dried herbs. According to historical data, 83% of the population in the Lubny region engaged in herb harvesting.

From these "pharmaceutical gardens," certain medicinal plants were introduced into cultivation, retaining their medical significance to this day. Notable examples include medicinal marigolds *Calendula officinalis*, peppermint *Mentha piperita*, and purple foxglove *Digitalis purpurea*. In the pre-revolutionary period, the Lubensky Agricultural Society worked on organizing the marketing and improving the cultivation of medicinal plants. Literary sources indicate that in 1901 alone, 25,000 poods (approximately 410 tons) of medicinal herbs were shipped abroad from the Lubny station. The total value of the harvested and exported raw materials to Germany, England, France, and other countries amounted to around 200,000 karbovanets. Thus, the establishment of the first center for the study and cultivation of medicinal plants in the Lubensky land was not coincidental.

It was only the First World War that, due to the acute need for medicines in hospitals, the dependence of pharmaceutical production on foreign sources, and the shortage of domestic drugs, drew attention to medicinal plants. In 1915, when the demand for medicines increased and their scarcity was keenly felt, Interdepartmental Meetings, with the participation of the Department of Agriculture on March 14-16 and May 20-22, identified a series of major reasons hindering the development of the industry in collecting and cultivating medicinal plants. Measures to overcome these obstacles were developed. To address these issues, at the initiative of the Provincial Zemstvo Administration, the Council of the Lubensky Agricultural Society, considering the history of Lubny (the creation of the first domestic field pharmacy and "pharmaceutical gardens" in the early 18th century), held a meeting on April 18, 1915. The meeting was attended by representatives of the Poltava Provincial Zemstvo, the inspector of Agriculture of the Poltava Province, and Professor of Agronomy at the Imperial Kharkiv University, **Anastasiy Yegorovich Zaikevych**.

The initiative to address the organization of experimental research on medicinal plants in Lubny was first raised by agronomist and

Secretary of the Lubensky Agricultural Society, **Petro Ivanovych Havsevych**, in his report titled "On the Organization of Experimental Study of Medicinal Plants in Lubny." The report included a well-founded request with a brief history of the development of the medicinal plant industry and the results achieved by the Society in the previous period. The petition was partially granted on November 26, 1915, when the City Council approved the allocation of 4.5 acres of land for the establishment of the Lubenska Research Station for Medicinal Plants. Petro Ivanovych's dream came true, as he was tasked with organizing the first research institution for the study of medicinal plants and a plant for the production of essential oils. In 1915, he was appointed as the Senior Specialist of the Department of Agriculture for the cultivation of medicinal plants in Lubny.

The Research Station for Medicinal Plants in the village of Berezotocha, Lubensky district, Poltava region, established in 1916, became a leading institution in the field of medicinal plant cultivation, serving as the first scientific research institution for the cultivation of medicinal plants.

Most of the conceived plans materialized. The first research station in Ukraine was situated on the outskirts of Lubny in the Yaroshenko estate and began operations in 1916. Petro Ivanovych Havsevych, the initiator and organizer, was appointed as the station's director. The first field trials were initiated on March 23, 1916. Additionally, plans were made to organize a breeding nursery with 60 species of medicinal plants, establish research laboratories, a processing plant for medicinal raw materials, and a publishing house for literature.

The location of the seed plantation and the plant in Lubny was chosen by Petro Ivanovych Havsevych not by chance. In his justification document titled "On the Organization of Experimental Study of Medicinal Plants in Lubny," he argued that the native flora indicated significant opportunities for cultivating the most essential plants of that time, including valerian *Valeriana officinalis*, marshmallow *Althaea officinalis*, chamomile *Matricaria recutita~ Chamomilla recutita*, and sage *Salvia officinalis*. Another crucial argument, according to Havsevych, was that medicinal plants were not new to local peasants; they were part of the family income through the collection in nature and cultivation in household gardens. Moreover, there were already fields of mint *Mentha piperita* and factories for its processing into essential oil. His profound knowledge

of medicinal plants allowed him to develop a program for studying medicinal plants and the work of the research institution, which remained largely unchanged for almost a century, adapting only to contemporary problem-solving approaches.

The expenditure budget of 12,000 karbovanets for the establishment and organization of the Lubenska Research and Seed Plantation of Medicinal Plants in 1916 was approved by the Lubensky Agricultural Society on December 27, 1915. The revenue plan was anticipated to come from subsidies of 9,300 karbovanets from the Department of Agriculture, allocations from the Poltava Provincial Zemstvo – 1,700 karbovanets, and own income – 1,000 karbovanets. The budget allocated 6,134.30 karbovanets for the maintenance of the Research Plantation, 3,000 karbovanets for the salary of a medicinal plant specialist, 1,200 karbovanets for a seed specialist for six months, and 420 karbovanets for a clerk. Additionally, funds were allocated for renting premises for the office and museum, office expenses, replenishing the library, and purchasing analytical instruments for the future pharmaceutical laboratory or paying for analyses by other laboratories.

In 1916, the planned nursery transformed into a research and seed plantation, as outlined in the approved program by the Zemstvo and the Department of Agriculture. Due to generous subsidies from the Organization associated with the Supreme Sanitary and Evacuation Unit, this plantation evolved into the Medicinal Plant Research Station. The first head of the station, senior specialist of the Department of Agriculture P.I. Havsevych (1916-1918), noted that this transformation was facilitated by substantial funding from the Organization.

The annual report, compiled and published after a year of operation, served as an official testimony to the establishment of the scientific institution. The report indicated that research was conducted in chemistry, agronomy, and on the collection site. The work was carried out on six plots, covering an area of 4.12 acres, including a botanical plot with 16 species of medicinal plants and observational and experimental plots with two species – chamomile *Matricaria recutita~ Chamomilla recutita*, and mint *Mentha piperita*. The report detailed the allocation of funds for the chemical-pharmaceutical laboratory at the station, with a financial subsidy of 5,000 karbovanets. Notably, Prince A.P. Oldenburg's additional grant of

4,500 karbovanets played a crucial role in the establishment and equipment of the laboratory.

The station's work program outlined scientific research directions for medicinal plants, including agronomy, seed cultivation, collection of local and foreign medicinal plants, acclimatization, and chemical research on medicinal plant raw materials and "pharmaceutical products."

In 1917, due to a shortage of labor and general upheaval, the collection of medicinal plants in Ukraine was almost entirely halted. The study of medicinal plants was mainly continued at the Lubenska Station and the Kyiv Acclimatization Garden.

Despite the challenges during the Civil War, the Lubenska Station did not cease its operations. Initially subordinate to the Poltava Provincial Land Department, it later fell under the authority of the People's Commissariat of Land Management of Ukraine as the Agricultural Research Station for the Cultivation of Medicinal Plants. In 1929, it was reorganized into the Ukrainian Station for Medicinal and Essential Oil Plants (USTALAR) of the All-Ukrainian Academy of Agricultural Sciences.

In its initial nine years, Lubenska Station faced challenges operating under conditions of land and financial scarcity. Seeking to enhance its scientific work in 1925, the station relocated to the village of Berezotocha, 12 km north of Lubny, in the former estate of landowner I.N. Leontovych. This move marked the beginning of a new era for the station.

The director, M.O. Lvov, considered the year 1925 as the start of the second phase in the station's life. The shift from urban conditions, characteristic of its early existence on suburban land, brought the station in close proximity to the rural population, integrating it into village life. The relocation facilitated the establishment of exemplary plots and the initiation of widespread experiments by a team of planters.

Following the move, the station's activities underwent significant changes. The number of scientific collaborators increased, reaching 11 by 1928. Research efforts intensified in agronomy, breeding, and plant protection. In 1934, the institution became part of the newly formed All-Union Scientific Research Institute of Medicinal and Aromatic Plants (VILAR) as the Ukrainian Zonal Research Station. Between 1929 and the beginning of the Great Patriotic War, the

station experienced changes in leadership, with 12 directors during this period. Despite this, the fruitful work of scientists led to an expansion of medicinal plant cultivation areas. By the early 1940s, the areas dedicated to peppermint reached 12,000 hectares, valerian 8,000 hectares, and costmary 10,000 hectares. These efforts positioned the station as a hub for medicinal plant research.

Station scientists actively contributed to the training of specialists at the Lubny All-Union College of Medicinal and Aromatic Plants. The station served as a crucial resource for both educational institutions and assistance to farms in cultivating medicinal crops and studying them across Ukraine.

During World War II, from September 13, 1941, to September 18, 1943, the station was occupied, and official scientific activities were halted. However, a group of enthusiastic scientists, including T.A. Chubarova, O.G. Nikolaev, M.P. Perepichko, M.P. Vetchinina, A.A. Hermanov, T.A. Tovstoles, and others, continued their scientific work against all odds. They preserved a significant portion of seed and planting material and compiled essential data.

After the liberation of Poltava from fascist occupation, the institution resumed scientific activities. Departments for breeding and seed production, agronomy, chemistry, botany, and an experimental base resumed full operation, ensuring the continuity and development of the station's research mission.

In the early 1950s, the Ukrainian Zonal Research Station not only recovered from wartime setbacks but also expanded the cultivation areas for medicinal plants. Playing a crucial role in the restoration and development of medicinal plant cultivation, the station took the lead in providing farms with seeds and planting material. Additionally, it played a key role in organizing theoretical and practical training for specialized personnel.

With Ukraine gaining independence, the Station transformed into the Institute of Medicinal Plants in 1992. By the end of 1998, it underwent further reorganization, becoming the Research Station of Medicinal Plants under the Ukrainian Academy of Agrarian Sciences.

2.4 Modern Development of Pharmacognosy

The advancement of modern pharmacognosy is the result of extensive work by teams of scientific researchers from educational and research institutions. The **Ukrainian pharmacognostic school** is represented by the State Scientific Center of Medicinal Products and

medical products, the National Pharmaceutical Academy of Ukraine (NPhAU), with department of pharmacognosy at Zaporizhia Medical Institute (V. M. Sheludko, K. Ye. Koreshtchuk) and department of pharmacognosy and botany at Lviv Medical Institute (T. D. Vilchynskyi, L. Ya. Ladna-Rohovska), as well as the Department of Pharmaceutical Chemistry and Pharmacognosy at Kyiv Medical Academy of Postgraduate Education named after P. L. Shupyk (T. V. Zinchenko, N. P. Maksyutina, O. M. Grytsenko).

Under the guidance of Professor D. G. Kolesnikov (**State Scientific Center of Medicinal Products and medical products**), comprehensive research on the flora of Ukraine has been conducted to identify sources of plant raw materials for the production of phytopreparations. Technologies for the isolation of biologically active substances have been developed, and their properties have been studied. Approximately 90 phytopreparations have been created, and methods for the semi-synthesis of cardiac glycosides have been developed (V. T. Chornobai, I. X. Makarevich, M. F. Komisarenko). The dependence of biological activity on the structure of α- and γ-pyrones, cardenolides, phenolic acids, and other compounds has been investigated (O. P. Prokopenko, Ya. I. Khadzhai, G. V. Obolentseva, V. I. Lytvynenko, M. F. Komisarenko, P. I. Bezruk). Chemical semiotics methods have been used for the first time with both theoretical and practical purposes. The technology of extracting medicinal plant raw materials with liquefied gases (O. P. Prokopenko, P. P. Vetrov, V. M. Mishev) and the technology of obtaining phytoenzyme preparations (V. T. Chornobai, P. I. Kabachny, S. I. Dikhtyarov) have been developed and implemented in production. Adsorption methods for obtaining morphine and other alkaloids from plant raw materials have also been developed.

The pharmacognostic scientific school of the **National Pharmaceutical Academy of Ukraine** (NPhAU) has a rich history and research directions. In 1805, the training of pharmaceutical professionals began at the Department of Medicinal Substances, Pharmacy, and Medical Literature of the Faculty of Medical and Pharmaceutical Sciences at the Kharkiv Imperial University, marking the first such initiative in Ukraine. Five years later, the first graduates received pharmacy master's degrees. In 1812, a pharmaceutical laboratory was established, initiating the training of researchers in organic chemistry and pharmacognosy.

In 1921, the Kharkiv Pharmaceutical Institute was founded in Kharkiv based on the Medical and Pharmaceutical Faculty of the Kharkiv Imperial University. Its first rector in 1921-1922 was M. O. Valiashko, with renowned professors and science figures such as M. P. Krasovsky, A. D. Rosenfeld, M. S. Bokarius, and M. A. Angarska serving as lecturers and founders. The research initiated by Professor M. O. Valiashko was continued from 1939 by Y. G. Borysiuk and his followers.

The initial focus of the pharmacognosy department's research was on essential and fatty oils, as well as morphological-anatomical analysis of medicinal raw materials from Ukrainian flora. Since 1966, under the leadership of Associate Professor M. I. Borisov, research has been conducted on the study of phenolic compounds and the comprehensive processing of medicinal plant raw materials. In 1985, the department was headed by Professor V. M. Kovalov. The team engaged in the search for new biologically active substances in plants used in traditional medicine, agricultural production waste, synthesis of analogs of natural flavonoids, anthraquinones, cardenolides, derivatives of amino sugars, standardization of medicinal plant raw materials and products, and the assessment of medicinal plant resources. A collection nursery of pharmacopoeial plants was established.

At various stages of study and implementation into production, 371 medicinal preparations and substances are being investigated, and 22 scientific schools are operating. There are educational and research laboratories, including the State Research Laboratory for Quality Control of Medicinal Products, Clinical Diagnostic Center with a clinical diagnostics laboratory, Laboratory of Electrical Engineering and Electronics, Scientific Research Laboratory of Microbiological and Immunological Studies, Scientific and Methodological (Research) Laboratory for Pharmaceutical Education, Scientific Research Laboratory for Parenteral and Oral Liquid Medicinal Products, Problem Laboratory for Morphofunctional Studies, Central Research Laboratory (CRL), and the Distance Learning Technology Center at NPhA.

The university takes pride in its clinical diagnostic center of European level, which is listed among the healthcare institutions performing nationwide functions. Internationally recognized scientific schools at NPhA include those in chemistry, technology, pharmacognosy, phytochemistry, pharmacology, organizational and

economic directions, and more. NPhA scientists receive collective grants within the framework of programs such as INTAS, UNTC departments, Drug Information Association, European Directorate for the Quality of Medicines and HealthCare, Abdus Salam International Center for Theoretical Physics (ICTP), and SPRI International.

Employees of the Department of Pharmacognosy in collaboration with the Botany course of the **Pharmaceutical Faculty at Zaporizhzhia State Medical University** have been systematically conducting phytochemical research on biologically active compounds of plants belonging to the genera Artemisia, Thymus, Hypericum, Digitalis, Juniperus, Mentha, and Valeriana for many years. The plant resources of Zaporizhzhia region are studied for the rational use of Ukraine's flora. An express control method for medicinal raw materials regarding nitrate content has been proposed.

Scientists from the pharmaceutical departments of the **Kyiv Medical Academy of Postgraduate Education named after P. L. Shupyk** are actively involved in the creation of new drugs, the development of their technology, and quality control. Under the guidance of Professor N. P. Maksyutina, developments in pharmaceutical medicinal and preventive products based on polyphenols and polysaccharides are underway. Pharmacognostic and phytochemical research is led by Professors O. M. Grytsenko and N. O. Vetyutneva.

Through the collaborative efforts of pharmacognosists, chemists, biologists, pharmacologists, and clinical physicians, pharmacognosy pursues a common goal – the preservation of human health.

Lecture 2 MEDICINAL PLANT BIOTECHNOLOGY

1. Modern directions of medicinal plant biotechnology and their tasks
2. Methods of the medicinal plant biotechnology
2.1 Method of the cell medicinal plant technology
2.2 Method of the DNA medicinal plant technology
2.3 Method of the obtaining transgenic medicinal plants

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.44–47. URL:

https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Kunah, V. A. Plant biotechnology for improving human living conditions. URL: http://dspace.nbuv.gov.ua/bitstream/handle/ 123456789/3927/2008_1_28-39.pdf?sequence=1 (in Ukrainian)

Garnier, F. (1999) Genetic Transformation of *Catharanthus roseus* (Periwinkle). URL: https://link.springer.com/chapter/10.1007/978-3-642-58439-8_6 (in English)

Sergeeva, L.E., Kurchiy, V.M., Bronnikova, L.I. (2020) Combined osmolytes – proline and sucrose – in complex resistant wheat winter (*Triticum aestivum* L.) cell lines. URL: https://www.frg.org.ua/articles/52010064a.pdf (in Ukrainian)

Biotechnology is the industrial use of biological processes to produce highly efficient microorganisms, cell cultures and tissues with programmed properties. Plant biotechnology – growing isolated plant cells and tissues for the release of biologically active substances. The main goal of the medicinal plant biotechnology is the creation of new forms and varieties of plants, the use of cells and biological processes in production for the synthesis on an industrial scale of biologically active substances for the needs of medicine.

1. Modern directions in medicinal plant biotechnology and their tasks

It is an interdisciplinary field of scientific and technological progress that is rapidly developing from the long-known technology of tissue and cell culture in vitro to genetic biotechnology – genetic engineering. Biotechnology is rather heterogeneous, as it solves a complex of problems and is based on elements of various sciences: microbiology, biochemistry, cytology, pharmaceutical botany, organic, inorganic, physical and colloidal chemistry, etc. The accumulation of biologically active substances is controlled by phytochemical methods.

Among the main areas of application of plant biotechnology are medicines, vaccines, high-yielding crops, preservation of the gene pool, diagnostic methods, new forms of plants. An important task of pharmacognosy is the search for new sources of biologically active substances and substances. The global trend in the development of the pharmaceutical industry shows that the use of biotechnology to obtain plant materials with programmed chemical composition is promising and, in some cases, economically viable.

2. Methods of the medicinal plant biotechnology

In modern plant biotechnology, there are three areas:

- cell technologies (technologies based on the use of cell, tissue and organ culture)
- molecular technologies or DNA (=Deoxyribonucleic acid) technologies (molecular methods of analysis, creation of gene constructs and analysis of their regulatory effects on gene expression);
- production of transgenic plants, transgenesis.

These technologies are used to develop alternative energy sources, improve the environment, preserve endangered and new ornamental and agricultural plants, as well as new forms of medicines, dietary food, etc. Let's take a closer look at the main areas of modern plant biotechnology and analyze the state of their development in Ukraine.

2.1 Method of the cell technology of medicinal plants

Plant cell biotechnology is based on the cultivation of cells, tissues or organs *in vitro* on artificial nutrient media.

The unique feature of cultured cells – their **totipotency**, i.e. the ability to regenerate the whole organism (redifferentiation) – is the basis for accelerated microclonal reproduction and plant recovery, as well as the creation of new plant forms by cell selection, genetic engineering, etc. Isolated cells, tissues and organs of plants in in vitro culture retain the ability to biosynthesize substances of specialized metabolism and can be a source of economically important metabolic products.

Cell and tissue culture is advisable for the production of metabolites of medicinal plant raw materials, which has a limited raw material base. The advantage of this method is that the technological process can be carried out in a limited period of time, which saves money on the cultivation of medicinal plants and preserves land resources. A standardized (homogeneous) plant substance is obtained under standard conditions of a controlled process, which limits the impact of environmental and stress factors on the yield of biologically active substances. The resulting biomass is environmentally friendly, as no herbicides or pesticides are used and the composition of the growing medium is regulated.

Plant cell culture is the stimulation of cell division in isolated plant segments. The first information about the possibility of growing pieces of plant tissue dates back to 1893. For the first time, **F. White**

obtained tissue culture of a medicinal plant from the crown branch of periwinkle pink or pink catharanthus *Vinca rosea* in 1945. He and **R. Gautreaux** (1947 - black cohosh *Hyosciamus niger* for the synthesis of alkaloids) are considered the founders of the culture of plant tissues and organs as a new field in biological science. The possibility of growing plant cells and tissues on an industrial scale appeared in the late 50s after the creation of special devices – fermenters, which allow to supply the growing medium, water, air, maintain a stable temperature, regulate pH, and conduct the necessary mixing. The names of R. G. Butenko and O. G. Volosovych are associated with the creation of aymaline strains from the culture of stem tissue of *Rauwolfia serpentina* and reserpine strains from root tissue. Certain successes were achieved in the cultivation of periwinkle pink *Vinca rosea*, smooth stephania *Stephania rotunda*, Indian dope *Datura metel*, common ginseng *Panax ginseng.*

Tissue cultures of medicinal plants

For the first time, **F. White** in 1945 received a culture from the crown gall of pink periwinkle *Vinca rosea*;

1947 **Gautre** – *Hyosciamus niger* for the synthesis of alkaloids;

50s – callus culture of guayula tissues, or parthenium of silver *Partenium argentatum* and medicinal belladonna *Atropa belladonna* for the production of alkaloid atropine;

Since 1958, at the Institute of Plant Physiology named after K. A. Timiryazev – tissue cultures of *Panax ginseng*, *Vinca rosea*, *Rauwolfia serpentina*, *Stephania rotunda;*

1960s – tissue culture of digitalis (*Digitalis lanata, Digitalis purpurea, Digitalis mertonensis*), 1960s – tissue culture of true tobacco *Nicotiana tabacum*, leaves *Agava toumeyana;*

1972 – the first industrial cellular biotechnology of medicinal plants – production of biomass from the callus culture of *Panax ginseng* tissues;

1970s – the technology of obtaining cellular biomass of *Rhodiola rosea* was introduced at two factories in Ukraine;

1983 – the first industrial batch of a pure substance – shikonin dye from the biomass of cultured cells of *Lythospermum erithrorhizon* was obtained in Japan.

Plant tissue culture is based on chaotic cell division that results in callus tissue. **Callus** is an undifferentiated biomass that grows from an explant on an artificial nutrient medium under aseptic conditions.

In nature, callus formation occurs as a response to plant damage, when an outgrowth (callus) forms at the site of injury. They are protected from infection by plant immune mechanisms. When growing tissue culture, all plant cells become callus. Explants (segments of stems, leaves, roots, seedlings, seeds) are mixed into the culture medium. Parenchymal cells dedifferentiate, begin to divide and form undifferentiated biomass (callus). The culture of callus tissue can be maintained for a long time by periodically dividing it into grafts.

Each individual culture of isolated tissues has its own cytological, genetic, morphological and biosynthetic characteristics, so experts comprehensively study each callus culture, which is a producer of biologically active substances.

The prerequisites for the use of cell and tissue culture of higher plants in the biotechnology industry for the search for BAS are:

- their ability to form metabolites that are traditionally used to create drugs;
- the possibility of synthesizing fundamentally new biochemicals that exceed traditional ones in pharmacological activity;
- transformation of cheap precursors into the final valuable product by cells.

The plant tissue culture is mainly grown using two methods – surface and suspension. For the first method, agarized nutrient media, thin layers of gel, and liquid nutrient media are used. In the suspension method, the fecal tissue is continuously grown in a liquid nutrient medium.

An important factor in creating an effective biotechnology system is the choice of a culture medium that meets the needs of the tissue culture in the chemical components required for optimal biosynthesis of the target product. Essential components of culture media are mixtures of mineral salts (macro- and microelements), phytohormones, and carbon sources.

The tissue culture method is gradually spreading in pharmaceutical production. Thus, biologically active substances ginsenosides are obtained from ginseng *Panax ginseng*, berberine from Japanese coptis *Coptis japonica*, shikhonin from red-root sparrowberry *Lithospermum erythrorhizon*, rosmarinic acid from *Coleus blumei*, periwinkle *Catharanthus roseus* – vinblastine, snake's feet *Rauwolfia serpentina* – aymaline, reserpine, lemon-leaved morinda *Morinda citrifolia* –

anthraquinones, purple echinacea *Echinacea purpurea* – polysaccharides, yews *Taxus* spp. – taxol.

It should be noted that the tissue culture method, along with its positive features, has certain disadvantages: it requires complex and expensive equipment of controlled biotechnological reactors, yields low yields of bioactive substances, cellular aging and associated blockage or failure in biosynthesis processes, etc. The decision to introduce a substance into industrial production is made by the company taking into account these factors, the demand for the substance on the global pharmaceutical market, and economic feasibility.

Thus, the possibilities of the biotechnological method of tissue culture of medicinal plants are great, but the production of commercial raw materials must compete with alternative systems for obtaining biologically active substances.It should be noted that today in Ukraine almost all planting material for potatoes, many types of ornamental, flower and berry crops, such as blueberries, rootstocks and varieties of fruit and some industrial crops, such as hops, is obtained mainly by accelerated reproduction and recovery in vitro. Microclonal propagation technology is very common, as it allows to obtain up to 1 million units of improved planting material from one source plant per year.

2.2 Method of DNA technology of medicinal plants

DNA technologies, or molecular biotechnologies, are methods of analyzing and using genetic information that are used to solve a wide range of problems.

DNA technologies allow to:

- detect and evaluate DNA polymorphism, as well as the peculiarities of its occurrence;
- to study the structure of the genome and gene pools; to be an additional tool in taxonomy, systematics and breeding;
- to use DNA polymorphism data in breeding, in particular, to map the main genes of quantitative traits (QTL) and to conduct marker-assisted selection (MAS) with the help of molecular genetic markers;
- to determine the exact physical localization of cloned DNA sequences on a chromosome or on its fragments;
- create physical maps of the genome or individual chromosomes using restriction enzymes;
- create gene banks of individual chromosomes;

- to observe the fate of the whole genome during targeted selection or its elements during their introduction into another genome;

- detect the presence of pathogens, transgenes, etc;

- study the processes of physical recombination and isolate new recombinant forms of DNA;

- create gene constructs and analyze their regulatory effects on the expression of various genes;

- study DNA molecules with different topologies.

Today, polymerase chain reaction (PCR) analysis is considered to be the most effective, as it allows for the study of molecular genetic polymorphism with the least amount of time and materials. A wide variety of PCR analysis types, high technological efficiency, and the availability of computer programs help to solve many problems in genetic and breeding research. Depending on the goal, a dominant or codominant, mono- or polylocus, bi- or polyallelic type of marker is selected to meet the needs of the study.

PCR technology can significantly modernize and improve the efficiency of plant breeding. For example, DNA technologies for identifying grape plants with bacterial cancer were first used at the Tairov Institute of Viticulture and Winemaking and the Magarach Institute of Grapes and Wine (In the West, similar techniques appeared later, but are still used today). In Ukraine, the problem of bacterial cancer is much more acute than in Western Europe, where the mild climate and sparing methods of soil cultivation do not lead to the formation of a wound surface. However, the proven achievements of domestic biotechnology have not been in demand today. Important results were also obtained at the National Agrarian University under the leadership of M. Melnychuk, where they developed ways to detect transgenes, pathogens, etc. in plants and food.

2.3 Methods of the obtaining transgenic medicinal plants

Transgenic plants are organisms that contain a recombinant gene(s) in their genome.

Genetic engineering makes it possible to isolate DNA sequences containing the desired genes and introduce them into the plant genome. In this way, plants resistant to pests and herbicides, viruses, fungal pathogens, bacteriosis, abiotic stress factors, with increased overall productivity, improved quality of plant products, and improved storage are obtained. Genes encoding animal and human proteins,

including genes whose products are medicinal substances of animal origin and other important components, are introduced into plants.

In particular, molecular cloning of many genes encoding biosynthetic pathways of alkaloids important for medicine was carried out, and a population of transgenic tobacco *Nicotiana tabacum* was created, whose plants contain cDNA encoding enzymes for the synthesis of periwinkle *Vinca rosea* alkaloids.

The production of traditional products such as carbohydrates (sugar, starch), lipids (various oils) and proteins in conventional and transgenic plants used for food and industry is also economically viable, as evidenced by the annual harvest of millions of tons of crops from agricultural land.

Biolistic method. The most common method that allows the introduction of a foreign DNA construct into the plant genome is the biolistic method of using Ti-plasmid from *Agrobacterium tumefaciens.*

During the biolistic method, gold or tungsten particles (carriers) with a diameter of 0.4-1.2 μm are used with a specific DNA structure attached to them. Such particles are "fired" under high pressure on plant tissue or individual cells. Carriers penetrate into the cell in order to transfer foreign genetic information to the plant genome in order to obtain plants with desired beneficial traits

This method has been used successfully for many crops. In particular, the method of biolistics is effectively used in the modification of monocots, such as wheat, corn, etc.

Agrobacterial transformation for dicotyledonous plants. To transform dicotyledonous plants, agrobacterial transformation, developed on the basis of a natural process, is most often used.

The soil bacterium *Agrobacterium tumefaciens* is capable of infecting dicotyledonous plants, causing the formation of tumors – "crown galls".

During infection, a specific segment of bacterial plasmid DNA – T-DNA (from English transferred DNA) — is inserted into the genome of a plant cell. T-DNA is a part of the plasmid that induces tumor development; it is carried by most strains of *A. tumefaciens*.

During the infection of a plant cell with an agrobacterium, the transport of T-DNA occurs according to the same principle as in the case of the transfer of plasmid DNA from the donor cell to the recipient cell during the conjugation process

The **main advantages** of transgenic plants are:

- the possibility of large-scale production, low cost, ease of purification, absence of impurities that have allergenic, immunosuppressive, carcinogenic, teratogenic and other side effects on the human body

- plants can synthesize, glycosylate and compose mammalian proteins from subunits

- consumption of raw vegetables and fruits containing genes that encode the synthesis of vaccine proteins results in immunization of the body.

Problems of safe use of transgenic plants (biosafety). Among these problems the main ones are:

- assessment of the potential risk of vertical and horizontal gene transfer during the release of transgenic (genetically modified) plants into the environment;

- careful study of the safety of transgenic plants with viral sequences and management of such plants, especially those containing genes of *Bacillus thuringiensis* bacilli that encode insecticidal proteins (Bt genes);

- search for new marker genes;

- development of rules for the release of transgenic plants into the environment;

- approval of consensus documents on biosafety of certain forms of transgenic plants of cultivated species;

- development of a methodology for post-commercial monitoring of transgenic plants.

Lecture 3 CHEMICAL COMPOSITION of MEDICAL PLANTS

1 The dry substances of plants

1.1 The organic substances of plants (primary and secondary метаболіти)

1.2 The mineral substances of plants. Concept about есенціальні mineral elements, biogenic, or macronutrients, мікро- and ultramicroelements of plants

3 The toxic elements and substances of plants

4 The ash-contents of plant

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 26-31. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

1 The Dry substances of plants

Every plant consists of water and dry substances. Water is the most widespread on Earth connection. It is a natural environment for the vital functions of all living organisms. Plant jrgans and tissues are able to retain the different amount of water (on the average from 50 to 90%). Basic part of water is in the free state, other – bound in cellular colloids. The residual ("marketable") humidity to which plant raw materials are dried should not exceed 15%.

1.1 The organic substances of plants (primary and secondary metabolites)

The dry substances of plants can be divided into two groups: organic and mineral. Organic substances that appear in a plant or distinguished by her as a result of metabolism name metabolites, they are divided into the substances of primary synthesis, or biosynthesis, and substance of secondary synthesis.

Substances of **primary synthesis**, or primary metabolites, are c arbohydrates, squirrel and lipids. Some of them act specifically.

Substances of **secondary synthesis**, or secondary metabolites, belong to different chemical groups (phenolic compounds, alkaloids, terpenoids, etc.). They participate in exchange processes and perform important functions for plants. Some of them, for example, organic acids, do not accumulate in plants and, as a rule, after formation are used by the plant for biosynthetic needs. Other substances (flavonoids, polysaccharides, terpenoids, etc.), on the contrary, tend to accumulate in significant quantities, which allows us to consider the plant as a source of these substances. Pharmacognosy studies the LRS of primary and secondary metabolites that have pharmacological activity.

1.2 The mineral substances

Living organisms circulate carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, sodium, potassium, calcium, silicon, iron, chlorine, magnesium, the so-called biogenic or macroelements, and micro- and ultramicroelements.

Mineral substances

Macroelements 10^{-1}-10^{-2}%: C, H, O, N, Ca, P, K, Na, Mg, S, Cl	Microelements 10^{-3}-10^{-4}%: Zn, Mn, Co, Cu, F, I	Ultramicroelements 10^{-6}-10^{-12}%: B, Li, Al, Si, Sn, Cd, Se, V, Ti, Cr, Ni, Rb, Au

Macroelements, or **biogenic**, or **macronutrients** (Greek: *makros* – large + Latin: *elementum* – element, primary substance) are chemical elements present in the body in high concentrations. Of the 106 elements of D.I. Mendeleev periodic table, 86 are constantly present in the human body, 25 of which are essential for normal life. If the amount of an element in the body exceeds 2-10%, it is considered a trace element. With an average body weight of 70 kg, a person's body contains (in grams): calcium – 1700, potassium – 250, sodium – 70, magnesium - 42, iron – 5, zinc – 3. The elements H (Hydrogen), C (Carbon), O (Oxygen), N (Nitrogen), which make up 96% of the weight of living matter, and Ca (Calcium), P (Phosphorus), K (Potassium), Na (Sodium), Mg (Magnesium), S (Sulfur), Cl (Chlorine) make up 10-20% or more of the body weight.

Microelements, or **micronutrients** (Greek: *mikros* – small + Latin: *elementum* – element, primary substance) are chemical elements present in the body in low concentrations (from 0.001 to 0.000000000001%): the first group (trace elements, less than 0.01%): Zn (Zinc), Mn (Manganese), Co (Cobalt), Cu (Copper), F (Fluorine), I (Iodine), the second group (ultramicroelements, less than 0.001%): B (Boron), Li (Lithium), Al (Aluminum), Si (Silicon), Sn (Stannum, Tin), Cd (Cadmium), Se (Selenium), V (Vanadium), Ti (Titanium), Cr (Chromium), Ni (Nickel), Rb (Rubidium), Au (Aurum, Gold).

Mineral elements essential for the life of certain living organisms are called **essential**. This term comes from the Latin word *essentia*, which means "*essence*".

The current classification of trace elements is as follows: by vital necessity: 1) essential - Fe, I, Cu, Zn, Co, Cr, Mo, Se, Mn; 2) conditionally essential - As, B, Br, F, Li, Ni, V, Si; 3) toxic - Al, Cd, Pb, Hg, Be, Ba, Vi, Tl; 4) potentially toxic - Ge, Au, In, Rb, Ag, Ti, Th, U, W, Sn, Zr; by immunomodulatory effect: 1) essential for the immune system - Fe, I; 2) Cu, Zn, Co, Cr, Mo, Se, Mn, Li; 3) immunotoxic: Al, As, B, Ni, Cd, Pb, Hg, Be, Vi, Tl, Ge, Au; 4) Sn.

Of the 110 elements found in nature, 71 are found in the human body. The following elements are essential for humans: Fe, Zn, Cu,

Co, Mn, Mo, Se, Cr, F, Ni, Fi, Si, Sn, As, Ag, Hg, Cd, Pb, Rb. They are part of specific organic compounds (enzymes, hormones, vitamins, pigments, etc.) and often determine their chemical and biological (physiological for plants and pharmacological for humans) activity. Through metabolic processes, mineral elements affect the main functions of the body: growth, development, reproduction, hematopoiesis, etc. Inorganic compounds are involved in the formation of various structures (bone and muscle tissue, cell membranes), regulation of physicochemical processes in the body: maintaining a certain level of osmotic pressure of cell sap, blood, lymph, acid-base balance, constant pH, etc.

Thus, mineral elements perform catalytic, structural and regulatory functions. The lack of mineral elements leads to a violation of these functions. When they enter the body in excessive amounts, poisoning is possible, sometimes fatal.

People get minerals with food, water, and some with air. They are absorbed by the body mainly in ionic form. Lack of trace elements can occur due to insufficient intake of essential nutrients (exogenous deficiency) or in case of impaired absorption of substances in the gastrointestinal tract, abnormalities of their absorption at the level of organs, tissues and cells, inadequate biological transport and other factors (endogenous deficiency).

The following dosage forms are used to treat and prevent mineral deficiencies in humans: soluble mineral salts; mineral elements in the form of organometallic compounds (cobamide, ferroascorbinate, ferroplex); and a complex of macro- and microelements from plants. The latter form of mineral intake has a number of advantages. In plants, they are bound to organic compounds, are in an optimal ratio for the body, are more naturally involved in metabolism than synthetic complexes, and are therefore better absorbed.

Plants are the main sources of minerals in the human body. Brief information on the physiological significance of the most important of them and plant sources is given below.

Sodium (Na) is involved in water-salt metabolism, regulates blood pressure, and activates digestive enzymes. Fragrant celery *Apium graveolens*, garden or sowing carrots *Daucus carota* subsp. *sativus*, cucumber *Cucumis sativus*, green beans *Phaseolus vulgaris*, sowing peas *Pisum sativum*, eastern persimmon *Diospyros kaki*, forest and garden berries are rich in sodium.

Potassium (K) is involved in intracellular metabolism, regulation of water and electrolyte balance, metabolism and osmotic pressure. Fruits are rich in potassium, especially common cherry *Prunus cerasus*, common apricot *Prunus armeniaca*, common viburnum *Viburnum opulus*, common mountain ash *Sorbus aucuparia*, blood-red hawthorn *Crataegus sanguinea*, dog rose *Rosa canina*.

Phosphorus (P) is a component of proteins, fats, nucleic acids, and activates mental and physical activity. A significant amount of phosphorus compounds is found in the fruits of the common rowan *Sorbus aucuparia* and blood-red hawthorn *Crataegus sanguinea*, apples of the domestic apple tree *Malus domestica*, seaweed, cereals Poaceae and legumes Fabaceae.

Chlorine (CI) is important for the formation of gastric juice, blood plasma formation, and is an activator of some enzymes. It is involved in all biochemical reactions involving sodium.

Sulfur (S) is a component of some amino acids, SH-enzymes. Its deficiency in the body leads to metabolic disorders. Garden onion *Allium cepa*, sowing garlic *Allium sativum*, white mustard *Sinapis alba* and black mustard *Brassica nigra*, garden cabbage *Brassica oleracea*, garden or sowing carrots *Daucus carota* subsp. *sativus*, common horseradish *Armoracia rusticana*, plants of the celery family Apiaceae are rich in sulfur compounds.

Calcium (Ca) forms the basis of bone tissue, participates in metabolism, processes of transmission of neuromuscular excitation. Consumption of oriental persimmon *Diospyros kaki*, domestic plum *Prunus domestica*, lingonberry *Vaccinium vitis-idaea*, gooseberry *Ribes uva-crispa*, cabbage *Brassica oleracea*, and beetroot *Beta vulgaris* contributes to the intake of calcium in the body.

Magnesium (Mg) is a component of enzymes, is found in bones and teeth, and is a regulator of the nervous system. Fruits are rich in it, where calcium and magnesium ions are combined with acids and ensure a balanced intake of these elements in the body; cashew fruits *Anacardium occidentale*, buckwheat *Fagopyrum esculentum*, pine nuts (Siberian pine *Pinus sibirica*), almonds *Prunus amygdalus*, real pistachio *Pistacia vera*, cultivated peanuts *Arachis hypogaea*, hazelnuts *Corylus maxima*, kelp or seaweed *Laminaria digitata* and *Saccharina latissima*, barley groats from seed barley *Hordeum sativum*, wheat and oat bran from wheat *Triticum* sp. and oat bran *Avena sativa*, millet from common millet *Panicum miliaceum*, walnut

or Greek walnut *Juglans regia*, soybeans from bristlecone soybeans *Glycine max*, peas from *Pisum sativum*, common beans *Phaseolus vulgaris*.

Strontium (Sr) is an element whose metabolism is linked to calcium metabolism. It prevents the development of caries and osteoporosis. Apricot fruit *Prunus armeniaca*, white-leaved aconite *Aconitum leucostomum*, tree aloe *Aloe arborescens*, common anise *Pimpinella anisum*, thick-leaved frankincense *Bergenia crassifolia*, lingonberry *Vaccinium vitis-idaea* are rich in it, snake bitterbrush *Persicaria bistorta*, common oak *Quercus robur*, Indian dope *Datura metel*, laxative *Rhamnus cathartica*, tall aralia *Aralia elata*, medicinal plantain *Sanguisorba officinalis*, creeping anchovy *Tribulus terrestris*.

Silicon (Si) is involved in the formation of connective and epithelial tissues, promotes hair and nail growth, and stimulates phagocytosis. Horsetail *Equisetum arvense*, knotweed *Polygonum aviculare*, fruits and vegetables provide its intake.

Manganese, or manganese (Mn), is necessary for the formation and metabolism of vitamin C, is an integral part of enzyme systems, affects protein metabolism, and, together with nickel and zinc, improves lipid absorption in atherosclerosis. Manganese-rich nuts *Juglans regia*, almonds *Prunus amygdalus*, peppermint *Mentha piperita*, curly parsley *Petroselinum crispum*, three-spurred birdseye *Bidens tripartita*, spring adonis *Adonis vernalis*, May lily of the valley *Convallaria majalis*, purple digitalis *Digitalis purpurea* and woolly digitalis *Digitalis lanata*, mud dried flower *Gnaphalium uliginosum*, celandine *Chelidonium majus*, St. John's wort *Hypericum perforatum*, peppercorn *Persicaria hydropiper*, tree aloe *Aloe arborescens*, sea buckthorn or buckthorn *Hippophae rhamnoides*.

Iron (Fe) is involved in respiration, hematopoiesis, redox reactions, and immune system reactions. Deficiency contributes to the development of iron deficiency and other anemias. Sources: common bean *Phaseolus vulgaris*, common buckwheat *Fagopyrum esculentum*, sand cumin *Helichrysum arenarium*, swollen lobelia *Lobelia inflata*, dyeing daisy *Rubia tinctorum*, sophora *Leuzea carthamoides*, blue cyanosis *Polemonium caeruleum*, mud dried flower *Gnaphalium uliginosum,* all types of rose hips *Rosa* sp.

Zinc (Zn) is involved in the synthesis of proteins, copying of genetic material, hematopoiesis, functioning of the immune and endocrine systems, and acts as a cofactor of many enzymes.

Deficiency causes growth retardation. It is contained in tree aloe *Aloe arborescens*, hanging birch *Betula pendula*, Indian dope *Datura metel*, upright cinquefoil *Potentilla erecta*, mud flower *Gnaphalium uliginosum*, field violet Viola arvensis, three-parted bindweed *Bidens tripartita*, big celandine *Chelidonium majus*, black currant *Ribes nigrum*, legume fruits Fabaceae, *Schizandra chinensis*, vegetables.

Copper (Cu) is involved in tissue respiration, anabolic processes, synthesis of hemoglobin and other iron porphyrins, pigments of the skin, hair, eyes, and affects the functioning of endocrine glands. Cereals Poaceae, tea *Thea sinensis*, fruits, nuts *Juglans regia*, soybeans *Glycine max*, coffee *Coffea*, marshmallow roots *Althaea officinalis*, peppermint *Persicaria hydropiper*, dioecious nettle *Urtica dioica*, coltsfoot *Tussilago farfara*, peppermint *Mentha piperita* are rich in copper, cinquefoil *Potentilla erecta*, dyer's maidenhair *Rubia tinctorum*, mud dried flower *Gnaphalium uliginosum*, plantain *Plantago major*, wild chicory *Cichorium intybus*, blackberry *Rubus*, lingonberry *Vaccinium vitis-idaea*, common sea buckthorn or buckthorn *Hippophae rhamnoides*, rosehip *Rosa* sp.

Fluoride (F) stimulates immune defense and hematopoiesis, increases the resistance of teeth to caries, participates in skeletal growth, and prevents osteoporosis. An excess causes fluorosis. Common lentils *Lens culinaris* and garden onions *Allium cepa* are relatively rich in fluoride.

Bromine (Cr) is involved in the regulation of the central nervous system, thyroid and gonads. Excessive accumulation in the body leads to skin diseases and central nervous system depression. Plants from the legume family Fabaceae, figs *Ficus carica*, knotweed *Polygonum aviculare*, yellow pitcher plants *Nuphar lutea*, spring adonis *Adonis vernalis*, and common shepherd's purse *Capsella bursa-pastoris* accumulate bromine.

Iodine (I) is necessary for thyroid gland functioning. Its deficiency causes endemic goiter, hypothyroidism, atherosclerosis. It is contained in seaweed and other seafood (kelp *Laminaria* sp, *Fucus* sp.), in plants (feijoa *Feijoa sellowiana*, persimmon *Diospyros lotus*, sowing rye *Secale cereale*, sowing buckwheat *Fagopyrum esculentum*, wheat *Triticum aestivum*, sowing oats *Avena sativa*, sowing peas *Pisum sativum*, common beans *Phaseolus vulgaris*, garden spinach *Spinacia oleracea*, sweet celery *Apium graveolens*, sour sorrel *Rumex acetosa*, broccoli *Brassica oleracea* var. *italica*.

Selenium (Se) stimulates the immune system, prevents cardiac disorders and cancer. Selenium-rich plants include big celandine *Chelidonium majus*, cinquefoil *Podophyllum peltatum*, wild strawberries *Fragaria vesca*, woolly foxglove *Digitalis lanata*, chamomile *Matricaria recutita*, pink cataract *Catharanthus roseus*, dog rose *Rosa canina*, naked licorice *Glycyrrhiza glabra*, blood-red hawthorn *Crataegus sanguinea*, aloe vera *Aloe arborescens*, coltsfoot *Tussilago farfara*, *Schizandra chinensis*, black currant *Ribes nigrum*, juniper *Juniperus communis*, globular eucalyptus *Eucalyptus globulus*, common pumpkin *Cucurbita pepo*, garden dill *Anethum graveolens*, parsnip *Pastinaca sativa*, *Rhodiola rosea*.

Cobalt (Co) stimulates hematopoiesis, is a part of B_{12}-dependent enzymes, and activates a number of enzymatic processes. Legumes Fabaceae, cereals Poaceae, wild strawberries *Fragaria vesca*, mud dried flower *Gnaphalium uliginosum*, rose hips *Rosa* sp., belladonna officinalis *Atropa belladonna*, yellow pitcher plants *Nuphar lutea*, bird cherry *Prunus padus*, celandine *Chelidonium majus*, chamomile officinalis *Matricaria recutita* are rich in cobalt.

Molybdenum (Mo) activates some enzymes, is an antagonist of copper in biological systems; it retains fluoride and prevents caries. It is contained in plants of legume Fabaceae and cereal Poaceae families, in rose hips *Rosa* sp., hawthorn *Crataegus sanguinea*, mountain ash *Sorbus aucuparia*, viburnum *Viburnum opulus*, black elderberry *Sambucus nigra*; the trace element is accumulated by common rosemary *Ledum palustre*, periwinkle *Vinca minor*, knotweed *Polygonum aviculare*, barberry *Berberis vulgaris*, laxative *Rhamnus cathartica*, dioecious nettle *Urtica dioica*, peppermint *Mentha piperita*, spring mountaineer *Adonis vernalis*, lily of the valley *Convallaria majalis*, purple foxglove *Digitalis purpurea* and woolly foxglove *Digitalis lanata*.

Chromium (Cr) regulates blood sugar levels. It is contained in the fruits of wild plants, plantain, large plantain *Plantago major*, peppermint *Mentha piperita*, marshmallow *Althaea officinalis*, blueberry leaves *Vaccinium myrtillus*, dioscorea nipponensis *Dioscorea nipponica*, lobelia swollen *Lobelia inflata*, common shepherd's purse *Capsella bursa-pastoris*, spring lily of the valley *Adonis vernalis*, lily of the valley *Convallaria majalis*, foxglove purple *Digitalis purpurea*.

Nickel (Ni) and **vanadium (V)** are involved in redox processes, respiration, and hematopoiesis. Sources of nickel include belladonna

officinalis *Atropa belladonna*, yellow poppy *Glaucium flavum*, flesh-red passionflower *Passiflora incarnata*, lanceolate thermopsis *Thermopsis lanceolata*, five-lobed motherwort *Leonurus quinquelobatus*, peppermint *Mentha piperita*, medicinal marshmallow *Althaea officinalis*, Chinese lemongrass *Schizandra chinensis*, juniper *Juniperus communis*, hawthorn flowers *Crataegus sanguinea*, *Sanguisorba officinalis* roots and wolfberry *Ononis* sp. roots, tea, fruits, vegetables and leaves of wild plants.

Lithium (Li) prevents the development of neuropsychiatric diseases. The trace element is accumulated by cassia narrow-leaved *Cassia acutifolia,* senna of Alexandria *Senna alexandrina*, bearberry *Arctostaphylos uva-ursi*, black cinquefoil *Hyoscyamus niger*, Indian dope *Datura metel*, belladonna *Atropa belladonna*, aloe vera *Aloe arborescens*, etc.

Argentum, silver (Ag) has a bactericidal effect. It is contained in coltsfoot *Tussilago farfara*, celandine *Chelidonium majus*, lily of the valley *Convallaria majalis*, purple foxglove *Digitalis purpurea*, blue cyanosis *Polemonium caeruleum*, lingonberry *Vaccinium vitis-idaea*, garden dill *Anethum graveolens*, lobelia *Lobelia inflata*, ginseng *Panax ginseng*, mountain arnica *Arnica montana*, grayish yellow *Erysimum diffusum*, melon tree *Carica papaya*.

The daily requirement for certain minerals without regard to gender, age and metabolic characteristics of the human body is given below:

Item	Daily allowance	Item	Daily allowance
Sodium	4-6 g	Manganese	2.5-5 mg
Potassium	3-5 g	Copper	2-7 mg
Phosphorus	1.6-2 g	Fluorine	2-4 mg
Chlorine	2-4 g	Bromine	0.5-2 mg
Calcium	0.9-1.2 g	Molybdenum	75-250 μg
Sulfur	850 mg	Chromium	100-200 mcg
Magnesium	280-350 mg	Iodine	100-200 mcg
Silicon	20-40 mg	Selenium	100-200 mcg
Iron	10-15 mg	Cobalt	40-70 mcg
Zinc	5-20 mg	Nickel	35 mcg

There is a link between the accumulation of bioactive substances in plants and the concentration of trace elements in them. For example, plants containing cardiac glycosides selectively absorb manganese, molybdenum, and chromium from the soil; alkaloids – cobalt, manganese, and zinc; saponins are synthesized in plants with a high content of molybdenum and tungsten, terpenoids – manganese.

The therapeutic effect of trace elements sometimes increases the activity of the main active ingredients. For example, adding ash from the herb spring mountaineer to the drug phycomin enhances its effect on the heart muscle.

Medicinal plants and medicinal plant raw materials can be enriched with trace elements during the cultivation process. For example, iodine treatment leads to an increase in pharmacological activity and a decrease in the toxicity of digitalis purpurea leaves.

3. Toxic elements and plant substances

Plants can absorb **toxic elements** and **substances** from contaminated soil, including heavy metals, radionuclides, nitrates, pesticides, etc. Medico-biological requirements and sanitary norms of the quality of food raw materials and food products, which also apply to LRS, require a hygienic assessment for the presence of **toxic elements** within the limits of permissible concentrations, mg/kg: lead – 1.0, cadmium – 0.05, mercury – 0.01, zinc – 3.0, copper – 1.0; of **pesticides**, mg/kg, no more: hexachloran (used as an insecticide, however, the use of hexachloran for insect control is limited. The drug containing 99-100% γ-isomers is called "lindane") – inadmissible, phostoxin (insecticide fumigant "Fostoxin" belongs to the 1st class of danger – extremely dangerous. They are used exclusively in warehouses; admission of people to treated premises - only after thorough ventilation) – 0.01; DDT (dust, dichlorodiphenyltrichloromethylmethane); insecticide used against mosquitoes, pests of cotton *Gossypium*, soybeans *Glycine max*, peanuts *Arachis hypogaea*. One of the few really effective means against locusts. Prohibited for use in many countries due to the fact that it can accumulate in the body of animals and humans) – 0.005. The State Standard allows the use of plant raw materials containing no more than 200 BC/kg of the isotope strontium-90 and 600 BC/kg of cesium-137.

4 Ash-content of plants

The total content of minerals in the still, that is, the **ash residue**, is 3-25. When analyzing raw materials, total ash and ash that does not dissolve in 10% hydrochloric acid solution are determined. The total part of mineral substances consists of all ash residues, which are formed as a result of ashing of vegetable raw materials. But the part of the ash that does not dissolve later in 10 % hydrochloric acid solution is silicate and characterizes the degree of silting of the plant (above-ground part) or rejection from the ground (underground organs). All the ash that went into the solution is considered the **natural ash** of the plant. According to the composition of the ash of the medicinal plant, macro- and microelements are evaluated as sources.

INDEPENDENT WORK

Theme 1 Peculiarities of harvesting medicinal plant raw materials

1 Harvesting and Primary Processing of Medicinal Plant Raw Materials
1.1 Harvesting Medicinal Plant Raw Materials
1.2 Drying Medicinal Plant Raw Materials
1.3 Standardization of Raw Materials
1.4 Packaging, Labeling, and Transportation of Medicinal Raw Materials
2 Protection of Wild Medicinal Plants and Their Resources in Ukraine

Literature and Internet resources:

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 32–54. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Constitution of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/254%D0%BA/96-%D0%B2%D1%80#Text

Law of Ukraine "On the Protection of the Environment". URL: https://zakon.rada.gov.ua/laws/show/1264-12#Text

Law of Ukraine "On the Nature Reserve Fund of Ukraine". URL: https://zakon.rada.gov.ua/laws/show/2456-12#Text

Law of Ukraine "On the Plant World of Ukraine". URL: https://zakon.rada.gov.ua/laws/show/591-14#Text

Law of Ukraine "Forestry Code of Ukraine". URL: https://zakon.rada.gov.ua/laws/show/3852-12#Text

Red Book of Ukraine (2009). URL: https://redbook-ua.org/item/adonis-vernalis-l/

Order of Enviremental Protection and Natural Resources of Ukraine' Ministry (2021) "On approval of lists of plant and mushroom species included in the Red Book of Ukraine (plant life) and plant and mushroom species excluded from the Red Book of Ukraine (plant life) ". URL: https://zakon.rada.gov.ua/laws/show/z0370-21#Text

Preamble. The quality of medicinal plant raw materials primarily depends on adhering to harvesting deadlines, employing optimal harvesting techniques, and ensuring proper drying conditions. During

harvesting, it is crucial to consider the biological characteristics of medicinal plants, the dynamics of accumulating bioactive substances (BAS), and the impact of harvesting on the condition of plant populations. Harvesters should follow instructions regarding the collection and drying of medicinal raw materials, as well as the conservation and sustainable use of plant populations. They must possess the ability to differentiate medicinal plants from all other species.

1 Harvesting and Primary Processing of Medicinal Plant Raw Materials

1.1 Harvesting Medicinal Plant Raw Materials

Medicinal plants are harvested during specific stages of vegetation when they accumulate the maximum number of active substances. The above-ground parts of the plant should be collected only in dry weather, during the middle of the day when the plants have dried from dew. Underground parts can be dug up even in wet weather; however, they must be washed before drying. Some plants are harvested at specific times of the day; for example, easily shedding fruits and seeds, such as caraway, are collected early in the morning ("with dew"). The purpose of primary processing is to rectify collection defects, remove impurities, defective plant parts, and prepare the raw material for drying. Collection purity is one of the key requirements for harvesting.

Harvesting should be done carefully, avoiding the inclusion of foreign impurities and other parts of the same plant in the collected material. The presence of impurities reduces the quality of the raw material and sometimes renders it completely unsuitable, as subsequent sorting can be challenging and costly. It is not advisable to harvest plants that are heavily dusted, contaminated, located near roads and railway tracks, or damaged by insects, rust, or fungal diseases.

To obtain high-quality raw materials and improve labor productivity, harvesters must have the necessary tools and knowledge of harvesting techniques.

Remember: • When collecting poisonous, highly active, and prickly medicinal plants (*Atropa belladonna*, *Hyoscyamus niger*, *Hippophae rhamnoides*), avoid touching your face and eyes with unwashed hands; hands should be thoroughly washed with soap. • Do not involve children in harvesting raw materials from poisonous, highly

active, and prickly plants. • Some types of medicinal plants may cause allergic reactions in certain individuals, leading to dermatitis, inflammation of the eye mucous membranes, etc. When using tools, adhere to safety procedures.

Each type of raw material has its calendar periods and peculiarities of collection. Let's consider general rules. It has been experimentally proven that in the above-ground parts of plants, the content of biologically active substances reaches its maximum during the flowering period and at the beginning of fruiting. In fruits, it occurs during full ripening, in roots after the above-ground parts of the plant wither, and in bark during the spring sap movement.

Buds are collected early in spring when they swell but have not yet burst. They are collected differently: pine buds are cut under the "corona," *Betula pendula* buds are usually collected when making brooms, stripping the branches. Before drying, remove foreign impurities and buds that have started to unfold.

Bark is harvested in spring, in April-May, during the sap movement when it easily separates. You need a knife with a very sharp end, with which several transverse incisions are made at a distance of 20–25 cm and 2–3 cm longitudinally. Afterward, the bark is pulled in the direction of the lower incision, not reaching it, and left for some time to dry slightly before peeling it off. For medicinal purposes, only bark from young branches is collected; bark from old branches and stems covered with a thick layer of dead tissue is not harvested. It is advisable to harvest bark and buds from felled, cut, or sawn-off branches in forest clearings rather than from trees and shrubs that are still growing.

Herbs are collected before or during flowering. They are mowed with a sickle or a knife at the level of the lower leaves. In some plants (*Artemisia* sp., *Bidens tripartita*, *Leonurus* sp., *Hypericum perforatum*), only flowering tops measuring 10–15 cm are cut or broken by hand, along with side branches. Perennial herbs should not be torn off with underground parts. A large number of herbs can be mowed after clearing them of weeds. To replenish stands, leave a few well-developed plants and young specimens for further growth per 1 m^2. The harvest of cultivated plants is collected with hay mowers.

Leaves are harvested before or during the flowering of plants when they are fully formed. In valuable species such as *Atropa belladonna*, *Digitalis* sp., they are manually clipped to avoid damaging

the plant. In other cases, the grass is collected, dried, and then the leaves are removed by hand or threshed (*Urtica* sp., *Mentha* sp., *Arctostaphylos uva-ursi*). If the raw material includes rosette leaves (*Hyoscyamus niger*), they are cut with a knife, trying not to damage the roots. When harvesting leaves from wild perennial plants, part of them should be left to prevent the death of the plant.

Flowers are collected depending on the flowering period but usually at the beginning to prevent the decay of the flower or inflorescence. In most plants, flowers are manually cut; sometimes entire inflorescences are collected, and after drying, they are sifted through a sieve to remove flower stalks (*Sambucus* sp.), or flower heads are manually removed from flower stems (*Tanacetum vulgare*). In some species, parts of the flower are collected, for example, in *Helianthus annuus* – ray florets. Flower baskets of *Matricaria recutita* (=*Chamomilla recutita*) are collected by combing them with a special rake.

Buds are collected before the flowers bloom (*Sophora japonica*). During the harvest of buds, flowers, and inflorescences from plants, leave attractive specimens for pollination and subsequent plant regeneration. When harvesting these types of raw materials from trees and shrubs, do not cut, saw, or break branches.

Fruits and seeds are harvested when fully mature, either entirely or at 60-70% maturity (Apiaceae, *Linum usitatissimum*, *Sinapis* sp.). When harvesting dry fruits and seeds, the above-ground part of the plant is mowed, dried, and threshed (*Carum carvi, Linum usitatissimum*). Juicy fruits (*Vaccinium myrtillus*, *Rubus idaeus*) are collected by hand, without stems, early in the morning or in the evening. It is better to collect fruits in baskets lined with cloth from the inside, as fruits collected in a bowl quickly spoil. Sea *Hippophae rhamnoides* berries or Juniperus berries are collected by shaking the branches.

Underground organs can be collected in spring but are preferably collected in autumn when the above-ground parts begin to wither, but the required species can still be identified. The advantage of autumn harvesting is that underground organs are larger due to the accumulation of starch and other valuable substances over the summer. Additionally, autumn harvesting allows for natural regeneration of plant populations through fallen seeds. Roots, rhizomes, bulbs are dug up with shovels, picks, forks, or rakes (for

Acorus calamus rhizomes). Afterward, the entire area should be carefully leveled.

From one unit of area, **harvesting** from the general biological stock **is allowed** on average within such limits: • Underground parts of plants (roots, rhizomes, bulbs, corms) – 15–20%; • Grass, leaves, flowers, inflorescences of herbaceous plants, trees, and shrubs – 30–40%. The frequency of harvesting should not exceed the following for each type: • Underground parts of plants – 5 years; • Herbs – 2 years; • Leaves, flowers, inflorescences, fruits, seeds – 1 year.

Collected leaves, flowers, berries, etc., should be placed in baskets as fluffy as possible; herbs, bark, and roots are placed in bags, but not densely, to avoid self-heating of the moist mass. The raw material should not be left overnight in the brought containers or piles, as this leads to the deterioration of active substances. If, for some reason, drying is delayed, spread the raw material in a thin layer on boards, canvas, or other surfaces protected from dew and rain. In this form, it can be stored for no more than 10–12 hours.

1.2 Drying of Medicinal Plant Material

Drying is a method of preserving plants by optimal dehydration. Freshly harvested medicinal raw materials typically contain 85–90% moisture, while dried ones contain 8–15%. Biochemical processes in the collected raw material initially proceed similarly to those in a live plant, with the synthesis of biologically active substances prevailing. Over time, as moisture and nutrients become inaccessible, the breakdown of these active substances occurs, leading to a reduction in their content in the raw material. However, in some cases, these processes can enhance the content of active compounds. For example, the accumulation of essential oils and cardiac glycosides is observed during slow drying (*Valeriana officinalis*, *Digitalis* sp.). The optimal drying regimen should be based on experimental data regarding its impact on the content of specific groups of biologically active substances.

General rules for drying include:

- Material containing essential oils should be dried at 30–45°C, spread in a layer of 10–15 cm to prevent volatilization.
- Material containing glycosides should be dried at 50–60°C to quickly inactivate enzymes that break down glycosides.
- For material containing alkaloids, the best temperature is up to 50°C.

- Material containing ascorbic acid should be quickly dried at 80–90°C.

It has been found that roots of *Berberis* sp.*, Panax ginseng,* herb of *Glaucium flavum, Leonurus* sp., *Convallaria majalis* and *Crataegus* fruits have higher levels of active substances when dried at temperatures between 80–90°C. For rhizomes and roots of *Inula helenium*, which contain essential oil and sesquiterpene lactones, the optimal temperature is 50°C.

Experimental studies have quantified the weight loss of various plant parts after drying: buds (65–70%), flowers and buds (70–80%), leaves (55–90%), herbs (65–90%), roots and rhizomes (60–80%), bark (50–70%), bulbs (50–70%), fruits (30–60%), seeds (20–40%).

Drying methods for medicinal plant material are divided into two groups: natural heat drying without artificial heating (air and shade drying, solar drying), and drying with artificial heating (hot air drying, vacuum drying, drying in a liquid nitrogen environment).

The method and conditions of drying are chosen based on the morphological and anatomical structure of the raw material, its chemical composition, the stability of active substances, and the capabilities of the enterprise.

Air and shade drying is conducted under canopies, in adapted attics, preferably under a metal roof or in specially equipped premises. The main requirements are maximum exposure to solar heat and good ventilation. Drying areas are usually equipped with racks with canvas or metal mesh. The material is spread in a thin layer on frames, placing on the upper shelves those that need quick drying (e.g., *Convallaria majalis, Adonis vernalis*), as well as those containing glycosides. Raw materials requiring low temperature for drying, such as essential oils, are placed on the lower shelves to prevent their odor from spreading.

Solar drying, using the heat of solar rays, is the simplest, most economical, and accessible method. However, chlorophyll is destroyed, and leaves take on a brown color, altering the color of many flowers. Although these changes do not always accompany the breakdown of active substances, the appearance of the raw material deteriorates, so leaves, herbs, and flowers should only be air and shade dried.

Solar drying is suitable for roots, rhizomes, and bark without harm, but it is not suitable for glycoside-containing and some alkaloid-containing raw materials (reduces the quantity of alkaloids in the

rhizomes of *Scopolia carniolica* and *Senecio platyphylloides*). This method is used for further drying of "grain" types of raw materials (left for 1-2 days in the field as bundles) and for drying berries and other juicy fruits, spreading them on canvas in advance.

Artificial heat drying is used to dry various morphological forms of raw materials. It ensures rapid dehydration and can be used in any climatic conditions. Convective and thermal radiation drying are distinguished.

Convective drying is carried out in periodic or continuous dryers. Numerous dryer designs can be divided into stationary and portable dryers. Stationary dryers, often found in specialized farms and large procurement points, have two compartments – a drying chamber and an insulated heating room. The drying chamber is equipped with racks and drying frames, an air duct system, and inlet-exhaust ventilation. Hot water, steam, or fuel gases circulate in the pipes. Portable dryers come in various designs. For drying juicy berries (*Vaccinium myrtillus*, *Rubus idaeus*), fruit and vegetable dryers are most suitable.

Individual collectors successfully use stoves for heat drying medicinal plant raw materials in rural areas. Dryers are divided into two types based on the nature of material loading and unloading and the conditions of the drying process: periodic and continuous action. Chamber, steam, fire, solar, and electric dryers mainly belong to periodic-action dryers, while belt dryers belong to continuous-action dryers.

Each type of medicinal raw material requires specific drying conditions, scientifically substantiated and described in respective instructions, but there are general rules for drying. Buds of plants, which usually contain resinous substances and essential oils in their external leaves, dry quickly at moderate temperatures, spreading in a thin layer and stirring frequently to prevent molding. In slow drying, the internal leaves of the buds darken, mold appears as a white coating at the break, and they acquire an unnatural odor, becoming unsuitable for use.

Compared to other plant parts, bark contains significantly less moisture. It is usually air-dried or dried in well-ventilated premises. When dried in the open air, it should be brought indoors to protect it from dew and rain, especially at night. Due to the oxidation of tannins, the bark almost always darkens, acquiring a brownish-brown color. Properly dried bark breaks with a crack, not bending.

Leaves are dried by laying them in 2–3 layers. Large leaves, such as coltsfoot (mother-and-stepmother), should be spread individually. If necessary, remove or cut off the stems. Flowers are spread in a thin layer so that they do not need to be mixed. When mixing, the petals fold, some of them darken, acquire an unpleasant appearance, and an unnatural color.

Herbs, with limited harvesting volumes, are often tied in small bunches and hung on ropes in well-ventilated premises or in attics under a metal roof. Although this method is convenient, under the most favorable conditions, the leaves inside the bunch often darken. Herbs are better dried by spreading them in a thin layer on shelves. Properly dried leaves and herbs easily crumble in the palm, and most importantly, the veins of the leaves and stems of the herbs break.

Dry fruits and seeds, such as *Pimpinella anisum, Carum carvi, Linum usitatissimum, Sinapis* sp., contain a small amount of moisture and largely lose it before threshing. Therefore, such raw materials should only be thoroughly dried in dryers, well-ventilated premises, or in the open air to prevent molding during storage.

Juicy fruits, such as *Fragaria vesca, Rubus idaeus*, and *Vaccinium myrtillus* are dried in ovens or dryers to prevent them from sticking together during storage.

Roots, rhizomes, bulbs, and corms are first cleaned from soil, dead parts, and those that have no use. Thick roots and rhizomes, if not cut into parts, are dried at a low temperature to allow the inner parts to dry as much as possible without changing their color and decomposing active substances.

1.3 Standardization of Raw Materials

This is done to remove impurities and eliminate defects caused by improper harvesting and drying, i.e., to bring the raw material to a liquid state where it fully complies with standard requirements in terms of purity. The main sorting operations include:

- Cleaning the raw material from unnecessary, mistakenly collected parts of the productive plant.
- Removal of defective (rotten, moldy) and parts of the plant that have lost their natural color.
- Sieving to remove excessively crushed parts.
- Cleaning the raw material from organic and mineral impurities.

Often, all these operations are performed simultaneously using mechanized screens with a set of sieves. Through a sieve that moves

back and forth, soil and crushed parts are screened out, while workers select large impurities and defective parts. Leaves, roots, and other raw materials are cleaned on screens.

Among the general sorting machines are various designs of winnowing-sorting machines. They are suitable for cleaning seeds and berries. Sorting machines of a special type, called "hills," are also used. These are sorters where strips can move at different angles, allowing impurities to be separated both by weight and size. This method is used to clean *Pimpinella anisum* seeds from *Coriandrum sativum* impurities.

1.4 Packaging, Labeling, and Transportation of Medicinal Raw Materials

Packaging ensures the preservation of the quality and quantity of raw materials during storage and transportation. Each type of raw material has corresponding packaging defined by standards, including single or double fabric bags, multilayer paper bags, single or double paper packets, elongated fabric bales, bundles covered with fabric, plywood boxes, corrugated cardboard boxes, and uncovered bundles.

The packaging must be strong, clean, dry, free from foreign odors, and consistent for each batch of raw material. The appearance of the packaging and the weight of the packed raw material are determined by the national standards for specific raw materials. Among the mentioned types of packaging, sack packaging and bundles are most commonly used.

Approximately 70% of medicinal plant raw materials (seeds, berries, small and cut roots, and rhizomes) are packed in sack packaging. Double bags are used for heavy raw materials or those requiring a particularly tough shell to protect against dust and moisture. The bag capacity is utilized as close as possible to the standard nominal – 50 kg.

Bundles are obtained by compressing the raw material using hydraulic, electric, or screw presses. All bundles, except for unpeeled licorice roots, are always covered with a protective fabric shell. This type of packaging, convenient for transportation, is used for bark, roots, rhizomes, herbs, leaves (except small ones), and even some flowers (such as linden blossom). The typical weight of a bundle is 100 kg, and it is reinforced with wire strips for strength.

The **labeling** of transport packaging is done according to the state standard, indicating information such as the sender's enterprise name,

the name of the medicinal plant raw material, the quantity of raw material (net and gross weight), harvesting time, batch number, and reference to analytical-normative documentation for specific raw material. Each package must contain an enclosed packing sheet specifying the sender's enterprise name, raw material name, batch number, and the packer's surname or number.

Transportation. Medicinal plant raw materials are transported in dry, clean, odor-free, and closed transport vehicles. Poisonous, highly active, and essential oil-containing raw materials are transported separately. Each batch is accompanied by a document indicating the quality of the raw material, issued by the sender.

Storage of Medicinal Raw Materials. Storage conditions should prevent the raw material from losing its appearance and active substances. During storage, the raw material is affected by external factors such as temperature and humidity fluctuations and sunlight exposure. Packaging materials are usually unable to protect it from air penetration. Moisture, in particular, has a detrimental effect, so warehouse premises should be dry, clean, well-ventilated, and free from pests.

Raw materials are stored in separate areas: poisonous and highly active, essential oil-containing, and fruits and berries – each in a separate room on shelves. The bottom layer should be at least 15 cm above the floor, and the stack height should not exceed 2.5 m for berries, seeds, buds and 4 m for other types of raw materials. Stacks should be placed at least 25 cm away from the walls, and the gaps between stacks should be at least 30 cm. Each stack should have a label measuring 20x10 cm indicating the raw material name, sender's enterprise name, harvesting time, batch number, and arrival date.

Stored raw materials are rearranged annually, and at the same time, premises undergo disinfection. The storage period for each type of raw material is determined by the corresponding regulatory document.

2 Protection of Wild Medicinal Plants and Their Resources in Ukraine

Relations in the field of protection, use, and reproduction of plant life are regulated by the Constitution of Ukraine, the laws of Ukraine "On the Protection of the Environment," "On the Nature Reserve Fund of Ukraine," "On the Plant World of Ukraine," "Forestry Code of Ukraine," and other regulatory legal acts. According to Ukrainian

legislation, the protection of plant life involves a complex of measures aimed at preserving the spatial, species, population, and cenotic diversity and integrity of plant objects, protecting the conditions of their habitats, preventing destruction, damage, protection from pests and diseases, as well as sustainable use.

The protection of plant life is ensured by:

- Establishing rules and norms for the protection, use, and reproduction of plant objects;
- If necessary, prohibiting and restricting the use of natural plant resources;
- Conducting environmental impact assessments and other measures to prevent the loss of plant objects due to economic activities;
- Protecting lands occupied by plant objects from erosion, flooding, swampiness, salinization, drying, pollution by industrial and household waste and effluents, chemical and radiation substances, and other adverse influences;
- Creating and declaring territories and objects as part of the natural reserve fund;
- Organizing scientific research aimed at the protection and reproduction of plant objects;
- Developing an information system about plant objects and educating citizens about their careful treatment;
- Establishing a system of state accounting and exercising state control over the protection, use, and reproduction of plant life;
- Including rare and endangered plant species in the **Red Book of Ukraine (2009)** and **Order of Enviremental Protection and Natural Resources of Ukraine' Ministry (2021)**;
- Establishing legal responsibility for violations of the rules for the protection and use of natural plant resources.

With proper and scientifically justified planning, harvesting, and rational use of forest stands, meadows, steppe pastures, and hayfields, the reserves of wild medicinal plants remain unchanged for a long time.

Enterprises in various branches of the pharmaceutical industry in Ukraine (7 plants (=large works), 27 pharmaceutical factories, pharmacies, private firms, educational institutions) require medicinal plant raw materials. The primary raw material base includes cultivated plants (*Mentha x piperita*, *Foeniculum vulgare*, *Digitalis* sp., *Atropa*

belladonna, etc.), wild plants (*Quercus robur*, *Leonurus quinquelobatus, Tussilago farfara, Taraxacum officinale*), or both sources (*Inula helenium*, *Matricaria recutita* (=*Chamomilla recutita*), *Plantago major*, *Althaea officinalis*). Ukraine imports a significant number of medicinal plant species, such as *Senna alexandrina* leaves, *Arctostaphylos uva-ursi* leaves, *Rauvolfia serpentina* roots, *Glycyrrhiza glabra* roots, *Orthosiphon stamineus*, and *Aerva lanata* herb or "pol-pala", which are not native to the country.

Medicinal plant raw materials are supplied by the consortium "Ukrphytotherapy," farmers, procurement authorities of various subordinate types, forestry enterprises, central district pharmacies, and individual gatherers.

In recent years, the state of wild medicinal raw material harvesting has significantly deteriorated. After the Chernobyl nuclear power plant accident, more than 1,100 thousand hectares were contaminated with radiation, greatly reducing the raw material base. During the Soviet era, the country harvested up to 12 thousand tons, half of which were grown on state farms, the rest consisted of wild plants. Now, specialized farms have been created on the basis of state farms, united in the consortium "Ukrphytotherapy." Six thousand hectares of sown area are allocated for medicinal crops in farms, and out of 62 species of medicinal plants that can be grown in the climatic zone of Ukraine, only 25 are cultivated. The consortium's plans include increasing this indicator to 60 species.

Ukraine has all the possibilities for the development of its own raw material base. Specialized farms growing medicinal plants are located in different soil-climatic zones of nine regions (Western Polissia, Central and Eastern Polissia, Western, Central, Northern and Southern Forest-Steppe, Western and Central Steppe, Carpathians).

Scientific research on the cultivation of medicinal plants has not stopped since the creation of the Lubensk Agricultural Society in 1916. Now, based on it, there is the Ukrainian Zonal Research Station, which conducts scientific developments on the preservation of natural ecosystems of medicinal plants, creation and implementation of new varieties of medicinal crops and their sowing systems; develops technologies for introducing new medicinal crops and improves the methods of growing traditional ones.

For the rational harvesting of medicinal plant raw materials and the preservation of their reserves, it is necessary to adhere to the following rules:

- Cut the grass in a way that does not damage the roots.
- Do not uproot perennial plants with their roots.
- Do not harvest all buds, flowers, and leaves from one plant.
- Collect underground organs only after seed dispersal, leaving some raw material for plant regeneration.
- Avoid harvesting in the same places year after year.

The reserves of raw materials for many wild medicinal plants in the forest-steppe regions of Ukraine, especially in the Left Bank, are rapidly decreasing and even disappearing. This has led to a shift in the main industrial harvesting towards forest and mountainous areas, where significant reserves of many medicinal plants still exist.

Scientifically justified protection of these plants and their raw material reserves can only be achieved through a comprehensive approach, which includes the following key measures:

Organizational – prospective and annual planning of the harvesting size and areas of medicinal plant raw materials, primarily for species with limited and small reserves.

Administrative – organization of reserves and reserves for rare species with very limited reserves. These activities are coordinated by Ukrainian state authorities.

Educational – awareness campaigns among the population about the importance of medicinal plants in medicine, the need to preserve their resources, which are a national treasure.

Research – resource-oriented study of the reserves of raw materials for the most important medicinal plant species, research on the dynamics of accumulation of biologically active substances, identification of stands of medicinal plants with the highest content of active substances for introduction into industrial cultivation.

Cultivation – cultivation of the best stands with significant industrial reserves of raw materials for the most important species (*Acorus calamus, Arnica montana, Vaccinium myrtillus, Vaccinium vitis-idaea*). It is practically important to plant species with high demand but small natural reserves (*Origanum vulgare, Hypericum perforatum, Rhamnus cathartica, Tilia cordata, Sorbus aucuparia, Rosa cinnamomea*). The most valuable species of wild medicinal plants should be introduced into industrial cultivation (*Astragalus dasyanthus, Adonis vernalis,*

Helichrysum arenarium, Inula helenium, Rhodiola rosea, Panax ginseng). Introduction and cultivation of medicinal plants in Ukraine are carried out by the Experimental Station of the National Academy of Agrarian Sciences (Lubny), botanical gardens, universities, and other educational institutions. The cultivation of valuable medicinal plant species (*Schizandra chinensis, Eleutherococcus senticosus, Hippophae rhamnoides, Tilia cordata, Aronia melanocarpa*) is also possible in schools, on backyard research plots.

Technical – rational harvesting of raw materials, taking into account established methods and terms, and preservation of mother plants and young specimens without commercial value.

Adhering to these measures for the protection and rational use of medicinal plants will contribute to the conservation and restoration of their reserves.

LABORATORY WORKS

Laboratory work 1

Theme: Chemical composition of medicinal plants

Goal: to get acquainted with different groups of chemical elements of plants and their plant sources.

Tasks

1. Get acquainted with the mineral substances necessary for the life of living organisms, and the physiological significance of the most important of them for the human body. Consider the proposed herbarium samples of medicinal plants. The results of the analysis by groups (macro-, micro- and ultra-microelements) should be presented in the form of a table.

Table 1.1

Mineral substance	Plant physiological value
Macroelements	
Microelements	
Ultramicroelements	

2. Consider the proposed herbarium samples of medicinal plants. Using the material of lecture 3 "Chemical composition of medicinal plants", compile a list of the most important mineral substances and plant sources for the human body. Present the results in the form of a table. Draw a conclusion about the medicinal plants enriched with minerals, give examples at least of 3 species.

Table 1.2

Mineral substance		Plant sources
Mineral element	Physiological significance for humans	

Self-control test

1. Macroelement ..... participates in water-salt exchange, regulates blood pressure, activates the activity of digestive enzymes. Celery *Apium graveolens*, carrots *Daucus carota* subsp. *sativus*, cucumber

Cucumis sativus, green beans *Phaseolus vulgaris*, persimmons *Diospyros kaki~Diospyros chinensis*, nuts *Juglans regia*, forest and garden berries are rich in it.

1) Potassium (K)
2) Calcium (Ca)
3) Magnesium (Mg)
4) Sodium (Na)

2. Macroelement ..... forms the basis of bone tissue, participates in metabolism, processes of transmission of neuromuscular excitation. Eating persimmons *Diospyros kaki~Diospyros chinensis*, plums *Prunus domestica*, lingonberries *Vaccinium vitis-idaea*, gooseberries *Ribes uva-crispa*, cabbage*Brassica oleracea*, and beets *Beta vulgaris* contributes to the entry of the element into the body.

1) Potassium (K)
2) Calcium (Ca)
3) Magnesium (Mg)
4) Sodium (Na)

3. The microelement ... stimulates immune protection and hematopoiesis, increases the resistance of teeth to caries, participates in the growth of the skeleton, prevents osteoporosis. An excess causes fluorosis. Lentils *Lens culinaris* and onions *Allium cepa* are relatively rich in it.

1) Iodine (I)
2) Manganese (Mn)
3) Strontium (Sr)
4) Fluorine (F)

4. Ultramicroelement ... has a bactericidal effect. It contains mother-and-stepmother *Tussilago farfara*, celandine *Chelidonium majus*, common lily of the valley *Convallaria majalis*, purple foxglove *Digitalis purpurea*, blue lingonberry *Polemonium caeruleum*, common lingonberry *Vaccinium vitis-idaea*, fragrant dill *Anethum graveolens*, swollen lobelia *Lobelia inflata*, ginseng *Panax ginseng*, mountain arnica *Arnica montana*, grayish yarrow *Erysimum diffusum*, melon tree~papaya *Carica papaya*.

1) Iron (Fe)
2) Selenium (Se)
3) Silver (Ag)

5. Provide energy and vegetable fibers:
   1) apricots *Prunus armeniaca*, bananas *Musa × paradisiaca*, dates *Phoenix dactylifera*, grapes and raisins *Vitis vinifera*, oranges *Citrus sinensis*, grapefruits *Citrus paradisi*, mangoes *Mangifera indica*, melons *Cucumis melo~Melo sativus*, peaches *Prunus persica~Amygdalus persica*, apples *Malus domestica*, plums (prunes) *Prunus domestica*, strawberries *Fragaria × ananassa* and tangerines *Citrus reticulata;*
   2) cereals and grain products *Triticum aestivum* (whole wheat bread, wholemeal bread, cereals and vegetable fibers, oat groats *Avena sativa*);
   3) almonds *Prunus dulcis~Amygdalus*, hazelnuts *Corylus maxima*, peanuts *Arachis hypogaea*, walnuts *Juglans regia*, sunflower seeds *Helianthus annuus;*
   4) tomatoes *Lycopersicon esculentum~Solanum lycopersicum*, potatoes *Solanum tuberosum*, carrots *Daucus carota* subsp. *sativus*, peas *Pisum sativum*, pumpkin *Cucurbita pepo* (zucchini *Cucurbita pepo* var. *giraumontia*), broccoli *Brassica oleracea* var. *italica*, turnips *Brassica rapa*, leafy cabbage *Brassica oleracea*, spinach, broad beans *Phaseolus vulgaris.*

Sources

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.20–26. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Laboratory work 2

Theme: Scientific basis of harvesting medicinal plant raw materials

Goal: to get acquainted with different types of medicinal plant raw materials, the rules of their harvesting, drying and storage.

Tasks

1. Familiarize yourself with the proposed types of medicinal plant raw materials and determine their methods of harvesting and drying, using the materials of the Independent work Theme 1. Present the results in the form of table.

Table 2.1

Medicinal plant raw materials	Harvesting period	Drying rules	Periodicity of harvesting
Buds			
Bark			
Grass			
Leaves			
Flowers			
Fruits and seeds			
Underground organs			

2. Consider the proposed list of medicinal plants (Supplement A). Make a calendar for the collection of 5 medicinal plants with different plant raw materials (table 2.2).

Table 2.2

Plant	Raw material	Months											
		1	2	3	4	5	6	7	8	9	10	11	12

3. Using the Red Book of Ukraine (translate from Ukrainian) and Supplement B, make a brief description of 3 rare and endangered species of Ukraine medicinal plants according to the plan: 1) Latin name of a plant species, 2) Taxonomic affiliation, 3) Conservation status of the species, 4) Scientific significance, 5) Reasons for changes in numbers, 6) General biomorphological characteristics, 7) Population conservation regime and protection measures, 8) Reproduction and breeding in specially created conditions, 9) Economic and commercial significance, 10) State of resources and Features of its best provision:

Adonis vernalis https://redbook-ua.org/item/adonis-vernalis-l/
Huperzia selago https://redbook-ua.org/item/huperzia-selago/
Rhodiola rosea https://redbook-ua.org/item/rhodiola-rosea-l/*)*

Self-control test

1. Select the rule for drying the medicinal plant:
   1). Raw materials containing essential oils are dried at a temperature of 30-45 °C, spreading them in a layer of 10-15 cm to prevent their volatilization;

2). Raw materials containing ascorbic acid are dried slowly at a temperature of 80-90 °C.
3). Raw materials containing glycosides are dried at a temperature of 40-45 °C - this allows for the rapid activation of enzymes that destroy glycosides;
4). For raw materials containing alkaloids, the best temperature is up to 30 °C.

2. Scientifically based protection of medicinal plants, as well as their raw material reserves, can only be comprehensive and consists of the following main measures.
1). Organizational, administrative, educational, research, cultivation, technical
2). Organizational, administrative, educational
3). Research, cultivation, technical
4). No option is wrong

3. When are the buds harvested and collected?
1). In the summer
2). Late in the spring
3). In the autumn
4). Early in the spring

4. During storage, raw materials are exposed to the environment…
1) temperature fluctuations
2) air humidity
3) exposure to sunlight
4). All of the above

5. For the rational harvesting of medicinal plant material and preservation of its reserves, the following rules should be observed.
1). Cut the grass so as not to damage the roots
2). Do not pull out perennial plants by the roots
3). Do not cut off all the buds, flowers, leaves of one plant
4). All of the above

Sources

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.32–44. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Constitution of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/254%D0%BA/96-%D0%B2%D1%80#Text

Law of Ukraine "On the Protection of the Environment". URL: https://zakon.rada.gov.ua/laws/show/1264-12#Text

Law of Ukraine "On the Nature Reserve Fund of Ukraine". URL: https://zakon.rada.gov.ua/laws/show/2456-12#Text

Law of Ukraine "On the Plant World of Ukraine". URL: https://zakon.rada.gov.ua/laws/show/591-14#Text

Law of Ukraine "Forestry Code of Ukraine". URL: https://zakon.rada.gov.ua/laws/show/3852-12#Text

Red Book of Ukraine (2009). URL: https://redbook-ua.org/item/adonis-vernalis-l/

Order of Enviremental Protection and Natural Resources of Ukraine' Ministry (2021) "On approval of lists of plant and mushroom species included in the Red Book of Ukraine (plant life) and plant and mushroom species excluded from the Red Book of Ukraine (plant life) ". URL: https://zakon.rada.gov.ua/laws/show/z0370-21#Text

Content module 2

ACTIVE SUBSTANCES OF MEDICINAL PLANTS

LECTURES

Lecture 4 MEDICINAL PLANTS AND PLANT RAW MATERIALS CONTAINING ALKALOIDS

1 Alkaloids structure and classification, physical and chemical properties

2 Distribution and biological functions in medicinal plants alkaloids

3 Medicinal plants and raw materials containing alkaloids

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 445-551. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/Фармакогнозія-з-основами-біохімії-рослин.pdf (in Ukrainian)

1. Alkaloid structure and classification, physical and chemical properties

Alkaloids are a group of organic nitrogen-containing substances, mainly of plant origin, which have an alkaline character and a high physiological effect on the human and animal body.

The term "alkaloids" was proposed by chemist-pharmacist **W. Meissner in 1819**. The name comes from two words: the Arabic *alkali* – alkali and Greek. *eidos* – appearance, *literally* – like meadows. For the first time, the alkaloid morphine was isolated from opium at the beginning of the 19th century.

Alkaloids are formed as a result of secondary metabolism. All of them contain nitrogen, more often as part of a heterocyclic ring.

When assigning the name of an alkaloid, use the species or generic name of alkaloid-bearing plants with the addition of the suffix "in", for example, atropine from *Atropa belladonna*, strychnine from *Strychnos nux-vomica*, cocaine - *Erythroxylon coca*. Sometimes a prefix is added to the name of an alkaloid to denote another alkaloid from the same plant source.

Classifications of alkaloids are based on different principles. Until recently, a modification of O. P. Orekhov's classification, based on the construction of the carbon-nitrogen skeleton, was widespread among specialists. The main types of alkaloids containing nitrogen outside the ring or in the **heterocycle** are distinguished: 1) pyrrolidine; 2) piperidine; 3) pyridine; 4) pyrrolizidine; 5) quinolizidine; 6) chinolaziness; 7) isoquinoline; 8) quinazoline; 9) indole; 10) dihydroindole, or betalain; 11) imidazole; 12) acridine; 13) purine; 14) isoprenoid alkaloids, or pseudoalkaloids; 15) exocyclic alkaloids, or protoalkaloids.

Alkaloids are also systematized according to the **botanical or phylogenetic principle**, combining into one group all compounds isolated from plants of the same genus (for example, ipecacuan alkaloid, colchicine alkaloids, securinega alkaloids, etc.). Plants that are closely located in the botanical taxonomy contain, as a rule, alkaloids that are similar in structure, forming a natural group. This is observed in a number of plants from the Solanaceae, Apocynaceae, and Papaveraceae families. The phylogenetic principle of searching for physiologically active substances helped O. P. Orekhov and his students to discover more than 100 new alkaloid-bearing plants in the flora at that time.

Sometimes alkaloids are combined according to their **pharmacological properties**: alkaloids are narcotic analgesics, m-cholinergics, alkaloids that stimulate the central nervous system, etc.

When considering alkaloids in the course of pharmacognosy, a classification is used that takes into account the **path of biosynthesis** and, accordingly, divides them into three groups:

- **true alkaloids** that have heterocyclic rings and are biosynthetically derived from alkaloidogenic amino acids, or from nicotinic or anthranilic acid;
- **protoalkaloids** containing nitrogen not in the composition of heterocycles, but formed from amino acids;
- **pseudoalkaloids** (isoprenoid alkaloids) that are formed without the participation of amino acids and are grouped together regardless of the presence of a heterocycle (almost all pseudoalkaloids are of terpenoid origin).

True alkaloids form groups of compounds that include heterocycles. They are biogenetically derived from amines, which are formed as a result of decarboxylation of amino acids. Currently, known

amino acids are the biogenetic precursors of six groups of alkaloids: the ornithine group includes pyrrolidine, pyrrolizidine, tropane and some pyridine alkaloids.

2. Distribution and biological functions in medicinal plants alkaloids

About 6,000 alkaloids are known, more than 50 of them were found in raw materials of animal origin. Alkaloids make up more than 10% of all plants. Alkaloids rarely occur in lower plants (*Claviceps*, *Penicillium mushrooms*), they are not often found among gymnosperms (genera *Ephedra* and *Taxus*), and the distribution is uneven among angiosperms. No alkaloids were found in the orders Salicales, Fagales, Cucurbitales and Oleales. They are most common in the families of the orders: Caryophyllales (Chenopodiaceae), Magnoliales, Laurales, Ranunculales (Berberidaceae, Menispermaceae, Ranunculaceae), Papaverales (Papaveraceae, Fumariaceae), Rosales, Fabales, Rutales, Gentianales (Apocynaceae, Loganiaceae, Rubiaceae, Gentianaceae, Menyanthaceae, Asclepiadaceae), Convolvulales, Solanales, Campanulales (Companulaceae, Lobeliaceae), Asterales.

In the course of evolution, higher plants developed the so-called metabolic extraction, or the ability to accumulate secondary compounds outside the metabolic centers — usually in vacuoles and the cell wall. It is better to illustrate this with the example of nicotine, which is synthesized in the roots of the tobacco plant *Nicotiana tabacum*, and from there reaches the leaves, where it accumulates. Secondary structural modifications often do not occur where primary synthesis occurs. For example, the cyclic system of tropane alkaloids is formed in the roots of *Datura stramonium* and from there it is transported to the leaves, where it undergoes significant modifications. Alkaloids accumulate mainly in four types of tissues: 1) in those that are actively growing; 2) in epidermal and hypodermal; 3) in the lining of vascular bundles; 4) in latex vessels. Alkaloids are located in vacuoles and therefore are not detected in young cells before vacuolization. They are rarely found in dead tissues, even in the bark of the cinchona tree they are found exclusively in the parenchyma. Alkaloids are localized mainly in certain plant organs, for example, in the cinchona tree *Cinchona officinalis* – mainly in the bark, in the aconite *Aconitum* – in the tubers, in the leaves of the cocaine

bush *Erythroxylum coca*, in the hemlock *Conium maculatum* – in the fruits, in the physostigma *Physostigma venenosum* – in the seeds.

Alkaloids found in animals are not always synthesized by the body itself: sometimes their origin is related to the nature of the food. Thus, beavers accumulate the alkaloid castoramine, which is very close to the alkaloid deoxynupharidine from the rhizomes of yellow pitcher plants *Nuphar lutea*, and it enters the animal's body together with food.

As a rule, the plant contains a mixture of several alkaloids, sometimes up to 15–20, often similar in structure (in the cornflower *Claviceps purpurea*, *Catharanthus roseus*, etc.), but in some plants only one alkaloid is found (for example, ricinine in castor oil *Ricinus communis*).

Many alkaloids, especially complex structures, are specific for certain genera and even families used in taxonomy and classification. The content of alkaloids in the raw material usually amounts to tenths and hundredths of a percent and rarely reaches 10–15% (bark of the cinchona tree *Cinchona officinalis*).

Alkaloids are sensitizers. They increase the sensitivity of plant cells to light and accelerate the phase of formation and development of generative organs.

Biological action and application. It is impossible to briefly describe all types of pharmacological activity of alkaloids. Let's highlight some of them. The mechanisms of action of some alkaloids on the human body are well studied. These substances act on specific receptors or affect the activity of enzymes.

Receptors got their name due to their sensitivity to natural mediators and their antagonists. For example, receptors sensitive to acetylcholine are called cholinergic, and receptors sensitive to adrenaline are called adrenergic. In turn, cholinergic receptors are divided into m-cholinergic receptors (those sensitive to muscarine) and n-cholinergic receptors (sensitive to nicotine). Different subtypes of adrenergic receptors are known, designated by the letters a_1, a_2, b_1, b_2. Alkaloids strongly influence the activity of enzymes. The action of some of them is associated with the induction or reduction of enzyme activity. For example, physostigmine, neostigmine and other anticholinesterase agents reduce the activity of acetylcholine. Analeptic alkaloids directly or reflexively stimulate the vital centers of the medulla oblongata. They are used in conditions associated with

depression of the central nervous system, asphyxia, collapse, heart failure, etc.

3 Medicinal plants and raw materials containing alkaloids

In plants, the so-called **biogenic amines** are formed during the dissimilation of amino acids (decarboxylation) and during the decomposition of proteins or alkaloids. Accordingly, amino acids that start the biosynthesis of alkaloids are called **alkaloidogenic**. The name "amine" comes from the word *ammonia*. Aliphatic amines in appropriate doses affect the nervous system, disrupt the permeability of blood vessel walls, cell membranes and liver function with the development of dystrophy. Aromatic amines cause the formation of methemoglobin, which depresses the nervous system. Some aromatic amines are carcinogens that cause bladder cancer in humans. Amines are present in many types of medicinal plant raw materials, but they are not classified as the main active substances. Amines are contained in ephedra grass *Ephedra* spp. – Herba Ephedrae, buckwheat grass *Capsella bursa-pastoris* – Herba Bursae pastoris, goat's-foot grass *Galega officinalis* – Herba Galegae, and milk thistle grass Betonica *officinalis* – Herba Betonicae, dog nettle grass *Leonurus quinquelobatus* – Herba Leonuri, etc. Putrescine and cadaverine are found in hornwort (*Secale cornutum*), mushrooms, belladonna (*Atropa belladonna*), blackberry (*Hyoscyamus* spp.), and *Datura* spp. Soybean sprouts (*Glycine hispida*) contain cadaverine, tyramine in cornflowers (*Secale cornutum*) and shoots of white mistletoe (*Viscum album*), tyramine in cornflowers, tomatoes (*Lycopersicon esculentum~Solanum lycopersicum*), spinach (*Spinacia* spp.) and yeast extract – histamine. Many flowers contain isoamylamine, which is formed as a result of decarboxylation of leucine, and isobutylamine – from valine. It is necessary to bear in mind the toxic and narcotic effect of certain amines in the pharmacological characteristics of medicinal plant raw materials.

***Alkylamines and quaternary ammonium compounds**

Dimethylamine is a volatile biogenic amine; found in mushrooms, flowers of hawthorn *Crataegus* spp. (Rosaceae), is also a breakdown product of choline. **Trimethylamine** is a very common biogenic amine; found in mushrooms and plants, is also formed during the breakdown of choline. **Colamine** is a liquid, oily, biogenic amine that is formed during the decarboxylation of serine. It is very common in the plant world as a component of some phospholipids (kephalins),

is part of lecithin. In a free state, it is contained in hawthorn *Crataegus* spp. **Choline** (trimethylethanolamine) is an important biological compound belonging to quaternary amines. It is a component of lecithins belonging to phospholipids. It is contained in the tissues of plants, animals, and humans (especially abundant in nervous tissue and muscles), mainly in the composition of cell membranes. Choline is found in dog nettle grass *Leonurus cardiaca*, bean sprouts *Phaseolus vulgaris* (Pericarpium Phaseoli), oilseeds, beets *Beta vulgaris*, egg yolks, etc. The daily norm of choline for an adult is **500–1000 mg**. Choline derivative – choline chloride belongs to group B vitamins. **Acetylcholine** is a natural substance, a chemical transmitter of nerve excitation in cholinergic synapses. It is synthesized in living organisms from choline and acetic acid with the participation of the enzyme choline acetyltransferase and decomposes under the influence of cholinesterase. It is contained in mushrooms, plants, for example, in sorrel *Capsella bursa-pastoris*, nettle *Urtica dioica*, etc. **Muscarine** is a quaternary amine. It has long been known as a component of the poisonous red mushroom *Amanita muscaria*. Medicines from the mushroom are used in homeopathy for atherosclerosis, neuralgia, and a decrease in general tone. Poisonous muscarine is also found in some lamellar mushrooms of the Inocybe species (*Inocybe patouillardii*, *I. fastigiata*), *Russula emetia*, etc.

***Phenylalkylamines**

β-Phenylethylamine is a physiologically active substance, bactericide, repellent against rodents; identified in white mistletoe *Viscum album* and hawthorn species *Crataegus* spp. **Dopamine** is an important physiologically active substance, belongs to catecholamines, is an intermediate product in the biosynthesis of norepinephrine from tyrosine. A decrease in the amount of dopamine in the nervous tissue leads to parkinsonism. Dopamine is found in *Sarothamnus scoparius*, bananas *Musa sapientium*.

Adrenaline is an extremely physiologically active hormone of brain tissue of adrenal glands, which is extracted from the glands of large animals or synthesized chemically. When interacting with adrenoceptors, it causes the narrowing of small blood vessels, an increase in blood pressure, strengthening of the heart, relaxation of the muscles of the bronchi and intestines. With emotional stress, especially in a stressful situation, muscle overload, and a drop in sugar levels, the amount of adrenaline in the blood increases sharply, which

ensures the body's adaptation to new conditions. Adrenaline hydrochloride and hydrotartrate are used in medicine for diseases of the cardiovascular system, shock, poisoning, allergic diseases, asthmatic attacks, etc.

Norepinephrine is formed from dopamine, similar to which is a mediator of nervous excitement in the sympathetic nervous system. Activates adenylate cyclase, which is starts the mechanism of glycogen splitting and lipolysis. Vasoconstrictor activity is stronger than adrenaline, but its antispasmodic effect is weaker; has less effect on metabolism (does not increase blood sugar level). It is found in trace amounts in bananas *Musa sapientium*, potatoes *Solanum tuberosum*, oranges *Citrus aurantium*.

L-ephedrine is a substance that is traditionally classified as an exocyclic alkaloid. Ephedrine was discovered in 1887 by the Japanese chemist Nagati. In 1893, German chemist Merck discovered pseudoephedrine. Ephedrine isomers are found in ephedra *Ephedra* spp., family Celastraceae, yew berry *Taxus baccata*, etc. Ephedrine stimulates the adrenoreactive systems and causes vasoconstriction, acceleration of the heart, increase in blood pressure, dilation of bronchi, pupils, inhibition of intestinal peristalsis, increase in metabolism. Ephedrine has an excitatory effect on the respiratory center. Ephedrine preparations are used as adrenomimetic agents, approaching the effect of adrenaline, but causing a longer effect.

D-norpseudoephedrine (cathine) is the main alkaloid of the leaves of the East African cat plant – Arabian tea *Catha edulis*. Kata leaves are used as a stimulant and doping agent in Arab countries and Africa. The effect is related to the presence of catin, which has excitatory and euphoric properties. Capsaicin was first obtained in 1875 from pepper fruits (Fructus Capsici), then synthesized. When the feather powder is burned, caustic smoke is released, which the Indians used as a "suffocating gas" in battle. **Mescaline** is a biogenic amine with hallucinogenic properties; found in some cacti, such as *Anhalonium lewinii* (peyote) and *Opuntia* spp. It is not used for medical purposes. **Tyramine** is a biogenic amine that has a structure similar to adrenaline. The presence of tyramine has been established in sorrel *Capsella bursa-pastoris*, white mistletoe *Viscum album*.

*Indolacylamines

Tryptamine is a biogenic amine plays an important role in the biogenesis of alkaloids as one of the precursors. Tryptamine is found

in stinging nettle *Urtica dioica* and some mushrooms. **Serotonin** interacts with the receptors of pre- and postsynaptic membranes, is a mediator of excitation in the central nervous system, affects the tone of blood vessels, increases the number of blood platelets, increases the stability of capillaries, participates in the regulation of the functions of the digestive, excretory and endocrine systems. The effect of hallucinogens (for example, diethylamide of lysergic acid) is associated with a disruption of serotonin metabolism. Serotonin adipinate is used in medicine. In microdoses, serotonin is extracted from bananas *Musa sapientium* and nettles *Urtica dioica*.

***Derivatives of histidine and guanidine**

Histamine is a product of decarboxylation of histidine. It is a very strong vasoconstrictor agent and mediator of allergic reactions, and is released in significant quantities from the depot during traumatic shock and in the area of inflammation. **Guanidine** comes from histidine and is biogenetically related to the purine base guanine. Found in some plants of the legume family – field pea *Vicia sativa*, soybean *Glycine soja*, etc. It is a structural fragment of nucleic acids, egg arginine, streptomycin, folic acid, etc. The nature of its action on the body is similar to histamine. Some guanidine derivatives have bactericidal and fungicidal properties. **Galegin** is a derivative of guanidine, has a hypoglycemic effect, which determines the hypoglycemic activity of *Galega officinalis*. **Spherophysin** is the main pharmacologically active compound of *Spherophysa salsula*, which was isolated in 1944 by colleagues of O. P. Orekhov. The alkaloid blocks n-cholinereactive systems of autonomic ganglia. It was produced by industry as a hypotensive and uterine remedy. In some plants, amino acids are completely methylated and converted into **betaines** during biosynthesis. They got their common name from a simpler representative formed from glycine – betaine, isolated from beetroot *Beta vulgaris*, tryptophan (hypopharine) – from the South American plant *Erythrina hypaphorus*, proline (stachydrin) – from plants of the genera *Capparis*, *Stachys*, *Lagochilus* and *Betonica*, from leaves of lemon and orange trees, etc.

Thus, physiologically active aliphatic, phenolic, cyclic, polycyclic carboline compounds containing nitrogen outside the rings are allocated to a separate group of protoalkaloids. Protoalkaloids are also called alkaloids without a heterocycle, or exocyclic alkaloids.

Colchicine alkaloids (tropolone alkaloids) include about 30 compounds. Colchicine alkaloids have antimitotic activity. Colchamine is less toxic than colchicine. Both compounds are karyoplastic poisons, block cell division at the metaphase stage and therefore can delay the development of malignant tissue. They also suppress lymphopoiesis and leukopoiesis. Previously, colchicine and its salicylate were used as pain relievers for gout and joint rheumatism. Colchicine is used in breeding to obtain polyploid forms of plants.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING PROTOALKALOIDS

FRUITS OF PEPPER PEPPER – FRUCTUS SAPSICI

One-year capsicum (red pepper) *Capsicum annuum* L., family Solanaceae; the name capsicum may be related to the Greek. *kapto* – I burn, because of the burning taste of the fruits, or from Latin. *capsa* – bag, in the shape of fruits.

*It is cultivated as an annual plant in two forms – sweet and bitter pepper, which also have a number of varieties. The stem is branched, erect, lignified below, 30–125 cm high. Contains burning compounds – capsaicinoids (0.1–1.9%). Chief among them are capsaicin, nordihydrocapsaicin, and homodihydrocapsaicin. Fruits are rich in vitamins minerals - C (0.5%), P, B_1, B_2, folic acid, nicotinic acid, carotenoids; found steroid saponins, glycoalkaloid solanine, flavonoids (apigenin, luteolin); coumarin scopoletin, salts of potassium, sodium, calcium, mercury, manganese, aluminum, iron. Capsicum preparations are used externally as an irritant for neuralgia and sciatica. Pepper tincture, pepper patch is released. Pepper tincture is a part of frostbite ointment, pepper-ammonia and pepper-camphor liniments, drugs capsin (a non-narcotic analgesic that acts on the central nervous system), capsitrin and espol. Tincture is used to stimulate appetite and improve digestion. It should be borne in mind that the ingestion of an overestimated dose can cause acute gastrointestinal upset. In homeopathy it is used a ripe pod with seeds for acute and chronic otitis, rhinitis, sinusitis, hyperacid gastritis, acute hemorrhoids, bronchitis and bronchial asthma.

EPHEDRA GRASS – HERBA EPHEDRAE

Horse ephedra (mountain ephedra, horsetail conifer) *Ephedra equisetina* Bunge, family Ephedraaceae; the family name comes from the Greek. *epi* – on and *hedra* – to sit, because strobilas sit on twigs; Latin *equisetinus,-a* – horsetail from *equisetum* – horsetail.

*Perennial, dioecious, densely branched bush up to 1.5 m tall. The fruit is a fake cone berry. The herb contains alkaloids (1.5–2%); the main L-ephedrine is mixed with other isomers, half of which sometimes consists of dextrorotatory pseudoephedrine. Its pharmacological properties are similar to ephedrine, but the activity is much lower. The herb also contains N-methylephedrine and about 10% of tannins. Ephedrine hydrochloride is used as an adrenomimetic agent. It is used for the treatment of diseases of an allergic nature (bronchial asthma, vasomotor rhinitis, urticaria, etc.) and stimulation of the central nervous system in case of poisoning with morphine, scopolamine and gangliolytics. Due to its effect on the central nervous system and increasing the tone of skeletal muscles, ephedrine is classified as a sports doping. It is part of theophedrine tablets, antastman, efatin aerosols, solutan drugs, broncholithin, which are used as bronchodilators. The drug ephedrine, which is used in a similar way to ephedrine, is produced from the waste from the production of ephedrine from the herb *Ephedra equisetina* and *Ephedra intermedia*. *Ephedra distachya* became known in 1889 as a remedy for the treatment of all types of rheumatism and dysentery, but this species is poorer in chemical composition and it is unprofitable to obtain ephedrine from it.

FRESH LATE FLOWERING BULBS – BULBOTUBERA COLCHICI RECENTIA

Late-flowering beautiful *Colchicum speciosum* Stev., late-autumn flower – *Colchicum autumnale* L., family Melanthiaceae; the name comes from the Greek. *Kolchis* – Colchis, from where, according to Dioscorides, this plant was brought; Latin *speciosus*, -*um* – beautiful.

*The plant is a perennial herb with a specific development cycle. The plant is poisonous. More than 10 colchicine alkaloids have been isolated: colchamine, colchicine, colchicein, colchicoside, glycoalkaloids, a number of colchicine alkaloids H, C, E, B, etc. The content of colchicine is 0.25%. In addition to alkaloids, bulbs contain flavonoids, phytosterols, carbohydrates, aromatic acids. Colchamine is used for malignant tumors in cases that are not amenable to surgical intervention. For the treatment of skin cancer, 0.5% colchamine ointment is used. In homeopathy, late-flowering autumn bulbs, dug up in the spring, are used. It is prescribed for neck and nape muscle stiffness, rheumatic and gouty joint diseases; dysentery and gastroenteritis. It is considered a capillary poison.

PYROLIDINE, TROPANE AND PYROLYZIDINE ALKALOIDS (ORNITINE GROUP)

The precursor of pyrrolidine, pyrrolizidine and tropane alkaloids is the amino acid ornithine, which at the first stage of biosynthesis is decarboxylated to form the corresponding amine, putrescine.

Tropane alkaloids can be divided into two groups: the tropine group (hyoscyamine, scopolamine, apoatropine, belladonnaine) and the ecgonine group (cocaine, α- and β-truxilins). The acidic component (especially in the Solanaceae family) is tropic acid. **Tropine** and **scopine**, which has an epoxy bridge, form hyoscyamine and scopolamine with tropic acid, respectively. Tropic acid is easily racemized, as a result of which l-hyoscyamine turns into l,d-hyoscyamine, which is called "**atropine**". In terms of biological activity, **hyoscyamine** is twice as strong as atropine, but in medical practice, atropine is more often used, which blocks m-cholineractive systems of the body and cholinesterase. The activity is manifested in a decrease in the tone of organs (eyes, bronchi, blood vessels, organs of the abdominal cavity), in a decrease in the secretion of glands (salivary, sweat, gastric, pancreatic). Atropine is used as an antispasmodic and anti-ulcer agent; it dilates the pupils and increases intraocular pressure.

Scopolamine also exhibits a m-cholinolytic effect, but unlike atropine, it does not excite, but depresses the central nervous system, which leads to drowsiness, therefore it is used as a sedative, used to treat parkinsonism. **Cocaine** is an alkaloid (*Erythroxylum coca* of the cocaine bush, family Erythroxylaceae). The plant comes from Peru, Bolivia, is cultivated. The leaves contain 0.7–1.5% alkaloids, including cocaine, cymanoyl-cocaine, truxilin. The ratio of these main alkaloids varies depending on the type of bush. Among other alkaloids, ecgonine and liquid alkaloids are found – hygrin, hygroline, cuskghygrin, dihydrocuskghygrin, tropacocaine. The leaves have a tonic effect in case of fatigue, support muscle energy and suppress the feeling of hunger. Cocaine and its salts (cocaine hydrochloride) were the first anesthetics, but now they are used only as local anesthetics in ophthalmology, surgery of the ear, throat, nose, and oral cavity. Constant excessive use of cocaine leads to drug addiction – in cocaine addicts the nervous system is destroyed, which leads to rapid death.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING TROPANE ALKALOIDS

BELLADONNA LEAVES – FOLIA BELLADONNAE,

BELLADONNA HERB – HERBA BELLADONNAE,

BELLADONNA ROOTS – RADICES BELLADONNAE

Atropa belladonna L., belladonna in Caucasian *Atropa caucasica* Kreyer., (sleeping sickness), family Solanaceae; the name *Atropa* – after the name of one of the three moiras – goddesses of fate; Latin *belladonna* from Italian. *bella* – beautiful, *donna* – woman.

*The plant is a perennial herb with a multi-headed rhizome and branches cylindrical root, the color of which is light brown, and the fracture is yellow. Stems are 1–2 m tall, divided into three branches from above. Wild belladonna is not harvested. The whole plant contains tropane alkaloids. The total amount of alkaloids: up to 1.3% in roots, up to 1.2% in leaves, up to 0.65% in stems, up to 0.6% in flowers, up to 0.7% in ripe fruits. The main alkaloid is the levorotatory hyoscyamine, which, after its isolation from the raw material, turns into the racemate atropine. Apoatropin, belladonna, kuskgigrin, scopolamine are contained in smaller quantities. Associated substances – flavonoids, coumarins, sterols. Belladonna preparations are anticholinergic agents, exhibit antispasmodic, broncholytic, and pain-relieving activity, reduce the secretion of salivary, sweat, and gastric glands, dilate the pupils of the eye, and cause tachycardia. Dry extract, tincture of belladonna, belastesin, besalol, belalgin, becarbon, belataminal – antispasmodic agents for diseases of the gastrointestinal tract; drops of Zelenin – for neuroses of the heart; beloid – with functional disorders of the autonomic nervous system; akliman – for vegetative dystonia, climacteric disorders; belaspon – for insomnia, climacteric neuroses, vegetative neuroses; anuzol and bethiol suppositories have a pain-relieving effect and are used in the treatment of hemorrhoids. In homeopathy, the whole plant, collected at the beginning of flowering, is used for arterial hypertension. Belladonna causes capillary spasm, which leads to the cessation of the inflammatory process, therefore it is prescribed for all acute inflammations and at the beginning of many infectious diseases (influenza, scarlet fever, etc.).

BLACK LEAVES – FOLIA HYOSCYAMI,

HERBA HYOSCYAMI – HERBA HYOSCYAMI

Black sedge, chicken blindness *Hyoscyamus niger* L., family Solanaceae; the name comes from the Greek. *hyoskyamos*: *hys* – pig, *kyamos* – beans; *niger* is black, because the flower head is black-purple.

The plant is a two-year herb pubescent. The stem is erect, branched, 20–60 cm high. Contains tropane alkaloids: hyoscyamine, scopolamine, etc. (0.05–0.1 %). The leaves are rich in flavonoids, especially rutin. Glycosides hyoscypicrin, hyoscyresin, methylesculin were also found. The leaves were part of Asthmatin cigarettes for asthmatics. Blackberry oil is used externally as a remedy for neuralgia and rheumatism. In homeopathy the whole fresh plant is used (collected in the second year of life during flowering) both when stimulating the central nervous system and when suppressing it. It is prescribed for white fever, hallucinations, mental disorders, during infectious diseases, as an antispasmodic agent – for spasms of the optic muscles, diaphragm, spasmodic cough.

DRUM LEAVES – FOLIA DATURAE

St. John's wort *Datura stramonium* L., family Solanaceae; the name *datura* is derived from the Latinized Sanskrit name *dhattura* or Arab. *tatura* from *tat* – to prick; *stramonium* – Latinized French. *stramoine* is a stinking weed.

*An annual herbaceous plant, with an unpleasant smell, up to 1 m tall. **A poisonous plant**. The amount of alkaloids is 0.25–0.4%, mainly contain hyoscyamine and scopolamine, there are volatile oils (0.04%), carotenoids, tannins. The leaves were part of the anti-asthmatic collection, asthmatin and asthmatol cigarettes. Datura oil is used as a rub for neuralgia, rheumatism, it is part of liniments. In homeopathy, the fresh flowering plant and fruits are used for infectious diseases or intoxications, which are accompanied by hallucinations and manic psychosis, with severe convulsions.

DRUM FRUITS OF INDIAN – FRUCTUS DATURAE INNOXIAE,

INDIAN DOPIUM SEEDS – SEMINA DATURAE INNOXIAE

Indian drug *Datura innoxia* Mill., family Solanaceae. *The plant is a perennial herb up to 1.5 m tall. The raw material contains alkaloids (0.2–0.4%), the main of which is scopolamine; there are also hyoscyamine, tropine, pseudotropine, nicotine, etc. The content of alkaloids depends on the phase of vegetation and the degree of ripeness of the seeds. The fruits are industrial raw materials for obtaining scopolamine hydrobromide, as well as scopolamine and

hyoscyamine camphoric acid for aeron tablets, which are used for sea and air sickness.

RHIZOMES OF SCOPOLIA – RHIZOMATA SCOPOLIAE CARNIOLICAE

Carniolian scopolia *Scopolia carniolica* Jacq., family Solanaceae; the family name comes from the name of an Italian botanist and doctor *J. Scopoli*, Latin. *carniolicus*, *-a* – Carniolian, Krainian.

*The plant is a perennial herb 30–80 cm tall, with a weakly branched rhizome. The whole plant poisonous. Only license fee is allowed. The plant is included in the Red Book of Ukraine, its range is shrinking. All parts of the plant contain tropane alkaloids hyoscyamine, scopolamine, etc. The rhizomes are the richest in alkaloids (0.55%). In addition to alkaloids, coumarins (scopoletine) are present. The rhizomes are used to extract atropine, hyoscyamine, and scopolamine, but due to the production of synthetic atropine, the need for raw materials has decreased. Small amounts of scopolia are harvested for export and for the needs of folk medicine.

***Pyrrolizidine alkaloids**

From the group of **pyrrolizidine alkaloids**, derivatives of retronetsin, heliotridin, platinetsin, and otonetsin are most often found in nature. They are present in plants of the Fabaceae, Orchidaceae, Santalaceae, and Scrophulariaceae families. The presence of pyrrolizidine derivatives reduces the possibility of long-term use of roots of comfrey *Symphytum officinale* (Radices Symphyti), borage herb *Borago officinalis* (Herba Boraginis), leaves of mother-and-stepmother *Tussilago farfara* (Folia Farfarae).

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING PYROLYZIDINE ALKALOIDS

RHIZOMES WITH ROOTS YELLOW WELL – RHIZOMATA CUM RADICIBUS SENECIONIS PLATYPHYLLOIDES

YELLOW WEED GRASS – HERBA SENECIONIS PLATYPHYLLOIDES

Broad-leaved yellow herb *Senecio platyphylloides*, syn. *Adenostyles platyphylloides* (Willd) M. Pimen., family Asteraceae; the name comes from Latin. *senex* – old; Latinized *platyphylloides* – from the Greek. *platys* – broad, *phyllon* – leaf and *oides* – similar.

The plant is a perennial herbaceous plant, with a thick, up to 20 cm long, horizontal, often hollow, gray-brown rhizome. Poisonous plants. All parts of the plant contain the alkaloids platyphyllin, seneciphyllin, saracin, neoplatiphyllin, and senecionine, mainly in the

N-oxide form. The total amount of alkaloids is: in leaves – 0.49–3.5%, in stems – 0.2–1.2%, in rhizomes with roots – 2.2–4%, in seeds – up to 5%. The amount of **platyphyllin** in the grass is 0.5–0.9%. Platyfilin hydrotartrate has an antispasmodic effect. Its activity is weaker than that of atropine, but its toxicity is much less. In ampoules, tablets and complex preparations, it is prescribed for bronchial asthma, angina pectoris, cholecystitis, etc. Due to the calming effect on the central nervous system, it is used in "sea sickness".

Pyridine alkaloids

The pyridine ring occurs quite rarely in the structure of alkaloids (nicotine, anabasine).

Nicotine is the most famous representative of this group. It is contained in the leaves and seeds of tobacco and shag (*Nicotiana* spp., Solanaceae), which are used for smoking. The homeland of shag is Mexico and Texas. Tobacco is an ancient Native American culture that spread throughout America before Europeans arrived there. It is cultivated in the Crimea, the Caucasus, and Central Asia. The leaves contain from 0.3 to 6% nicotine, depending on the variety, climate and other factors. Nicotine is a colorless liquid with a burning taste and no smell. It oxidizes in the air and acquires a tobacco smell, it is distilled with steam. Strong poison, inhibits the activity of the nervous system; in terms of the degree of action, it is close to hydrocyanic acid (toxic dose for humans is 50–100 mg). An aqueous solution of nicotine sulfate is used to combat harmful insects. Nicotinic acid and nicotinamide (vitamin PP) can be obtained from nicotine. In medicine, tobacco has no direct use. Nicotine is part of chewing gum, which is used to quit smoking. Nicorette is produced abroad. In homeopathy, dry tobacco leaves of the current year are used for disorders of the autonomic nervous system, mainly parasympathetic: dizziness with cold sweat, vomiting, seasickness, muscle cramps; optic neuritis, laryngitis with dry cough, hypertensive disease, collapse, obliterating endarteritis, toxicosis of pregnant women.

Anabasine is an alkaloid contained in leafless hedgehog *Anabasis aphylla* and tobacco *Nicotiana* spp. together with nicotine. It is a ganglionic poison, its effect on the body is similar to nicotine. In therapeutic doses, it stimulates the central nervous system, increases breathing, and increases blood pressure. Previously, a mixture of alkaloids from the leafless urchin called anabasine sulfate was used as

an insecticide for the treatment of lice and ringworm in animals, but now it is not used due to its high toxicity.

*PIPERIDINE AND QUINOLYZIDINE ALKALOIDS (LYSINE GROUP)

***Piperidine alkaloids**

About half of the known alkaloids contain a piperidine ring in their structure. Biosynthesis in plants can proceed in two ways: from lysine and its metabolites or from acetate. "Lysine" and "acetate" pathways are not isolated and function in parallel during the biosynthesis of some alkaloids. In nature, the "lyzy-new" way prevails.

The following groups are distinguished among **lysine alkaloids**: **piperidine** (lobelin from *Lobelia inflata*, piperine from *Piper nigrum*, sedamine from *Sedum* spp.); **coniine** (from *Conium maculatum*); **isopelletierin, peletierin** (from *Punica granatum*); **arecolin** (from *Areca catechu*); **ricin** (ricinin from *Ricinus communis*); **quinolizidine** (cytisine, pachycarpine from *Thermopsis lanceolata*, *Sophora pachycarpa*).

Lobeline, nicotine, cytisine, and **anabasine** belong to the "respiratory" analeptics that reflexively affect the respiratory center. They stimulate or restore the functions of the respiratory and vascular centers of the medulla oblongata, stimulate the ganglia of the vegetative part of the nervous system and the medulla of the adrenal glands, which leads to a significant increase in blood pressure. **Anabasine, lobeline, cytisine** are used to eliminate nicotine hunger and nicotine withdrawal, which helps to quit smoking. The uniformity of the biological action of alkaloids during nicotine starvation can be explained by the affinity of their chemical structure with nicotine, especially with the spatial arrangement of active centers — nitrogen and oxygen, which have unshared pairs of electrons. The analeptic properties of alkaloids are used in poisoning with carbon monoxide, morphine, and hypnotics.

Peletierine, isopelletierine, methylisopelletierine, as well as pseudopeletierine are alkaloids from the bark of the roots of common pomegranate (Cortex Granati radicis, from *Punica granatum*). The plant is cultivated in tropical and subtropical regions of Iran, Asia Minor, the Caucasus, and America. The bark of the roots contains 0.5–0.9% of liquid volatile alkaloids and about 22% of tannins. The skin of the fruit is rich in tannins and is used to treat dysentery. Pomegranate fruits are a source of citric acid.

Piperine and **piperitin** are alkaloids from the fruits of black pepper (Fructus Piperis nigri, from *Piper nigrum*). Pepper was the most expensive spice in the Middle Ages. It is cultivated in the Malay Archipelago, Ceylon, India, Indonesia, and South America. The fruits contain 5–9% alkaloids, 1–2.5% essential oil, diterpenes, resin. Black pepper is of great importance in the food industry as a spice that stimulates appetite and promotes digestion. Previously, the fruits were used to treat gonorrhea and chronic bronchitis. **Coniine** is the main volatile alkaloid isolated from the grass and seeds of the spotted hemlock (Herba et fructus Conii maculati, from *Conium maculatum*). The effect of coniine is similar to nicotine. A dose of 0.5–1 g causes death, which occurs as a result of reflex respiratory arrest. Grass and seeds contain 0.1% alkaloids (coniine, conhydrin, methylconiine, coniceine, etc.), essential oil, caffeic acid, flavonoids. In therapeutic doses, hemlock preparations have pain-relieving, anticonvulsant and hemostatic properties. In homeopathy, it is used as a remedy that dissolves benign tumors. **Ricinin** is isolated from the seeds of castor bean *Ricinus communis*. **It is a strong poison.**

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING PYRIDINE-PIPERIDINE ALKALOIDS

LOBELIA GRASS – HERBA LOBELIAE

Lobelia inflated, Indian tobacco *Lobelia inflata* L., family Lobeliaceae; the plant is named after *M. Lobel* (1538–1616), a Dutch doctor and botanist who lived in England and headed the royal botanical garden for some time; Latin *inflatus*, *-a*, *-um* – inflated from *inflare* – to inflate.

*The plant is an annual herb, with an erect four-sided, sparsely branched, slightly pubescent stem 40–70 cm tall, which contains milky juice. 14 alkaloids (0.25–0.4%) were found in the herb, among which the main one is lobeline, as well as lobelanine, lobelanidine, isolobeline, etc. The analeptic drug lobeline hydrochloride is produced from lobelia grass. Abroad, lobeline is used to treat bronchial asthma and chronic bronchitis; it is part of drugs that relieve nicotine withdrawal (lobesyl). In homeopathy, the entire fresh flowering plant is used for psoriasis, bronchial asthma, and rheumatic pain in the joints.

***Quinolizidine alkaloids**

Alkaloids of the quinolizidine group are synthesized from lysine or the corresponding amine cadaverine. They belong to the group of

nor-lupinan (quinolizidine) or **lupine alkaloids**, which form numerous derivatives. Found in many types of medicinal plants. For the first time, lupanine was isolated from lupine (*Lupinus* spp., Fabaceae). **Sparteine** is an alkaloid with high pharmacological activity due to its effect on the transmission of nerve impulses in synapses. It is used abroad as an antiarrhythmic agent. Found in many families: Berberidaceae (*Leontice*), Chenopodiaceae (*Anabasis*), Papaveraceae (*Chelidonium*), Ranunculaceae (*Aconitum*), Monimeaceae (*Peumus boldus*). The raw material for obtaining sparteine sulfate is *Sarothamnus scoparius*. Along with the common L (–)-spartein, D (+)-spartein (**pachycarpine**) is sometimes found, obtained from plants of the genus Sophora spp., Fabaceae. Pachycarpine affects the sympathetic ganglia, which leads to a decrease in the sensitivity of the chromaffin tissue of the adrenal glands to chemical stimuli. Pachycarpine increases tone and strengthens muscle contraction in myopathy, has the property of blocking H-cholineractive systems. Used for spasms of peripheral vessels. **Cytisine** is an analeptic drug that is similar in pharmacological activity to nicotine. It is contained in plants of the Fabaceae family: in the genera sea buckthorn (*Cytisus* spp.), thermopsis (*Thermopsis* spp.), golden rain (*Laburnum* spp.), gorse (*Genista* spp.). It is used as an anti-smoking agent (tabex drug). **Securinin** has an analeptic effect. It is used for asthenic condition, neurasthenia with rapid fatigue, vascular insufficiency and hypotension, chronic alcoholism, weakening of cardiac activity, paresis and flaccid paralysis after infectious diseases.

*****MEDICINAL PLANTS AND RAW MATERIALS CONTAINING QUINOLISIDINE ALKALOIDS

HERB OF THERMOPSIS LANCET – HERBA THERMOPSIDIS, SEEDS OF THE LANCETIUM THERMOPSIS – SEMINA THERMOPSIDIS

Thermopsis lanceolate, mysticum *Thermopsis lanceolata* R. Br., family Fabaceae; the name comes from the Greek. *thermos* - lupine and *opsis* - appearance, i.e. "*lupine-like*"; Latin *lanceolate,-a* – lancet, from *lanceta* – lancet. The plant is a perennial herb 50–150 cm tall. Poisonous plants. The herb contains up to 2.5% of alkaloids, mainly thermopsin, its isomer anagirin, homothermopsin, cytisine, methylcytisine, pachycarpine, as well as the glycoside thermopsilancin. Of all alkaloids, homothermopsin is the most hydrogenated compound. The grass also contains flavonoids,

saponins, tannins, resins, mucus, traces of essential oil, ascorbic acid. The seeds contain alkaloids, among which cytisine should be at least 2.5%. Cytisine is obtained in its pure form at pharmaceutical plants. Thermopsis grass was a substitute for the imported roots of senega and ipecacuanha – expectorants (emetics). Dry thermopsis extract, cough tablets, dry cough mixture for adults, herbal infusion are used as expectorants. The action is due to the presence of alkaloids and saponins. Thermopsis preparations in small doses stimulate the respiratory center, and in large doses cause vomiting, paralyze the centers of the medulla oblongata and brain. Codthermops is a combined preparation of thermopsis extract with codeine, used for cough. Cititon is a cytisine-based drug that exhibits an analeptic effect.

ALTERNATE FLOWERING THERMOPSIS GRASS – HERBA THERMOPSIDIS ALTERNIFLORAE

Thermopsis alterniflora Rgl. et Schmalh., family Fabaceae. The plant is a perennial herb, up to 90 cm tall. Poisonous plants. Thermopsis grass is processed at the enterprises of the pharmaceutical industry to obtain cytisine (alkaloid content not less than 1%). Cytiton (0.15% solution of cytisine) stimulates the respiratory center in case of asphyxia, shock, intoxication, respiratory arrest. "Tabex" tablets, which contain cytisine, are prescribed for the purpose of quitting smoking.

GRASS OF SOPHORA THOSCOPLODYA – HERBA SOPHORAE RACHYCARPAE

Sophora thick-fruited *Sophora pachycarpa* L., family Fabaceae; the name comes from the Latinized Arabic name of one of the species of *cassia* – sofera; Latinized *pachycarpus*, *-a* – thick-fruited, from Greek. *pachus* – fat and *karpos* – fruit. The plant is a perennial herb, with several erect, silky downy stems, with upwardly directed branches, 60–80 cm long. Poisonous plants. Herbs and seeds contain quinolizidine alkaloids (2–3%). The main one is pachycarpine (at least 0.5%) – a colorless thick oily liquid that quickly darkens and tarnishes in the air; Pachycarpine salts are crystalline. Except in addition, there is its optical isomer spartein, sophocarpine, anabasine, methylcytisine, pachycarpine oxide. The raw materials contain flavonoids kaempferol, quercetin, genistein (0.08%), organic acids. Biological action and application. Pachycarpine hydroiodide is referred to ganglioblocking agents. It is used to enhance labor and reduce blood loss in the postpartum period. Improves muscle function in myopathy.

PLAUNA LAMB GRASS – HERBA SELAGINIS (HERBA HUPERZIAE)

Common sheepshead, common baranets *Huperzia selago* (L.) Bernh. ex Schrank et Mert., syn. *Lycopodium selago* L., family Huperziaceae; named after the botanist *Huperz*; *selago* is the Latinized Celtic name of the plant. The plant is evergreen, spore-bearing, herbaceous, perennial, height 5 -25 cm, with poorly developed roots (rhizoids). The herb contains alkaloids (0.4–1.1%): selagin, lycopodine, pseudoselagin. Among other classes of natural compounds, flavonoids of the quercetin group are known. A 5% decoction of sheep grass is used for the treatment of chronic alcoholism in hospital conditions under the strict supervision of a doctor. After taking the decoction, the use of alcoholic beverages causes nausea, vomiting, excessive salivation, sweat, muscle tremors, a decrease in blood pressure, and a change in pulse. The essence of the treatment is to develop a conditioned reflex aversion to alcohol. Overdose and unskillful use of mutton ploughshare preparations can lead to severe poisoning and even death.

SECURINEGAE SHOOTS – CORMI SECURINEGAE

Bushy Securine, half-shrub *Securinega suffruticosa* (Pall.) Rehd., family Euphorbiaceae; from Latin *securis* – ax and *nego* – confrontation. A dioecious shrub 1.5 m tall, with straight, thin, bare branches. The main alkaloid is **securinine**. The largest amount of it (about 0.3%) accumulates in the leaves; alkaloids are much less in fruits. In addition to securinine, seven more alkaloids were found: sufruticodine, sufrutikonin, alosekurinin, dihydrosufruticonin, securinol A, B, C. The variety of alkaloids is due to the spatial arrangement of rings A, B, C, D, and the presence of hydroxy and methoxy groups in rings A and C With the presence of substituents, there is no double bond in ring C. Sekurinin nitrate is used as a tonic in asthenic states, paralysis, neurasthenia, in sexual impotence based on functional nervous disorders, as a CNS stimulant. A substitute for strychnine, which is produced from available raw materials and has lower toxicity.

Isoquinoline alkaloids (Tyrosine group)

Isoquinoline and its derivatives are the basis of a large number of natural compounds, including plant alkaloids. Alkaloids contain a residue of tetrahydroisoquinoline in the molecule, much less often – 3,4-dihydroisoquinoline. Plants from the orders Papaverales, Rutales, Ranunculales, Geraniales, Plumbaginales, Myrtiflorae and Rosales are

the richest in them. More than 1,000 isoquinoline alkaloids from 27 families are known, which are grouped into 12 types. Types of isoquinoline alkaloids used in medicine are given: Benzylisoquinoline (Papaverine, Rotundin; *Papaver somniferum, Stephania glabra*); Aporfin (Glaucin, Stepharin, Magnoflorin; *Glaucium flavum, Stephania glabra,* plants from the Ranunculaceae family); Protoberberine (Berberine, Hydrastin, Palmatine; *Berberis vulgaris, Hydrastis canadensis*, in many families); Benzophenanthredine (Helidonine, Sanguinarine, Chelerythrine, Nitidine, Hyndarin; *Chelidonium majus*, Macleaya spp., *Zanthoxylum* spp., *Sterhania grabra*); Protopin (Protopin (fumarin), Allocryptopin; *Chelidonium majus, Fumaria officinalis*); Morphine (Morphine, codeine, thebaine; *Papaver somniferum, Aristolochia clematitis*); Emetine (Emetine, psychotrine, cephaelin; Ipecacuanha (emetic root) *Cerhaelis ipecacuanha*); Phthalidiisoquinoline (Bicuculline; *Dicentra cucullaria*); Bis-benzylisoquinoline bases (Tubocurarine, Tetrandrine, Dauricine, talicarpin; species of chilibucha *Strychnos* spp.; *Thalictrum* spp., *Menispermum dahuricum*).

A type of benzylisoquinoline. Alkaloids belonging to this group may have a nucleus of tetrahydroisoquinoline (norlaudanosine) or isoquinoline (papaverine). **Papaverine** is a strong antispasmodic, isolated for the first time from opium, where it is present in an amount of about 1%. For medical use, papaverine is obtained by synthesis. Synthetic analogs of papaverine are widely used as antispasmodics: no-shpu, dibazol, tifen, etc. All alkaloids of **the aporphine type** are common in the Berberidaceae, Lauraceae, Magnoliaceae, Menispermaceae, Nymphaeaceae, Papaveraceae, Ranunculaceae and Rutaceae families. Pharmacological activity was found in glaucine (antitussive, antispasmodic), magnoflorin (hypotensive and curare-like), boldin (antitussive). **Type of protoberberine** alkaloids are mainly localized in plants from the Berberidaceae, Convolvulaceae, Menispermaceae, Papaveraceae, Ranunculaceae and Rutaceae families. Berberine, narcotine, hydrastine, palmatine, bicuculline, which belongs to phthalidiisoquinoline derivatives, have pharmacological significance. **Berberine** is a typical quaternary ammonium base that exists only in solutions. Salts have a yellow color. It is used in medicine as a choleretic agent. Berberine exhibits an antispasmodic effect, helps reduce pain syndrome, increases bile

secretion, has a sedative effect, lowers blood pressure, slows down heart activity, and causes contraction of the uterus.

Narcotine constitutes a significant part of opium alkaloids (about 10%). It stimulates the respiratory center, potentiates the analgesic effect of morphine and has no narcotic properties. **Hydrastin** is a compound extracted from the yellow root of the Canadian Hydrastis canadensis, Ranunculaceae; acts as a hemostatic agent. **Palmatin** is found in plants of the families Berberidaceae, Papaveraceae, Ranunculaceae, Lauraceae, etc.; has several types of pharmacological activity: antiarrhythmic, inotropic, analgesic and antibacterial. **Bicucullin** localized in plants of the genus *Dicentra* (Papaveraceae). Increases blood pressure, changes the amplitude of heart contractions, inhibits the action of acetylcholinesterase in the brain. Alkaloids of the **protopine** type usually occur in plants of the Papaveraceae family and sporadically in the Rutaceae and Berberidaceae families. Type of **emetine** alkaloids are known as alkaloids of the emetic root *Carapichea ipecacuanha* (Radix Ipecacuanhae) and constitute a separate biogenetic group. Emetine and cephaelin are the main alkaloids of ipecacuanha *Carapichea ipecacuanha*. They were isolated by Pelletier and Magendy in 1817, the structure was studied in the 1940s; emetine was synthesized in the laboratory of O.P. Orekhov in 1950.

A type of morphinan. **Morphinan alkaloids** include more than 40 representatives from the Papaveraceae, Menispermaceae, Euphorbiaceae, Liliaceae, and Melanthiaceae families. Morphine is the main alkaloid of opium, it has a phenolic character. The products of biochemical transformations of morphine are thebaine and codeine. Morphine is a narcotic analgesic, which is prescribed to patients in cases when other painkillers do not work. Abuse of morphine leads to drug addiction – morphinism, which is accompanied by deep mental disorders and damage to all internal organs.

During the study of opiate receptors, **endorphins** and **enkephalins** were discovered – endogenous substances with morphine-like action. They are pentapeptides that have a spatial structure similar to that of morphine. Endorphins cause euphoria. They are being researched in order to create non-toxic painkillers. **Codeine** is a methyl ester of morphine. Contained in opium in small doses (about 0.5%). The alkaloid is obtained by semisynthesis. It is not used independently as an analgesic. Used for cough. In therapeutic doses,

it causes weak euphoria, with long-term use, addiction to the drug is possible.

Bis-benzylisoquinoline alkaloids. They are most common in plants of the families Menispermaceae, Berberidaceae, Magnoliaceae, Annonaceae, Ranunculaceae and Combretaceae. **Curare alkaloids** are of the bis-benzylisoquinolinol type. Curare, or South American arrow poison, was obtained from a mixture of extracts of the bark or stems of chilibucha Strychnos spp., Loganiaceae and from Chondrodendron tomentosum, Menispermaceae. The term curare comes from the Native American words "woorari" or "urari" meaning "poison". At the end of the 19th century curare found use in medicine. They receive tubocurarine chloride and curarine chloride muscle relaxants, which are used during surgical operations and in some nervous diseases accompanied by convulsions. Close in structure to tubocurarine is an alkaloid of Stephania globii cycleanine.

Thalicarpin was isolated from the herb *Thalictrum dasycarpum*, which is being studied as a means of treating neoplasms. Fetidine from *Thalictrum foetidum* showed a high hypotensive effect in the experiment. It is better tolerated by patients than rauwolfia alkaloids, and has fewer side effects. **Dauricin** from the rhizomes of *Daurian menisperm* (Rhizomata Menispermi) has an antispasmodic effect, lowers blood pressure and blood cholesterol levels, which is why the raw material is widely used in Tibetan and Chinese medicine.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING ISOQUINOLINE ALKALOIDS

BOXES OF POPPY, OPI – CAPITATA RAPAVERIS, OPIUM

Soporific poppy *Papaver somniferum* L., family Papaveraceae; papaver is the Latinized name of poppy, from *papa* – baby porridge; Latin *somniferumer* – hypnotic from *somnus* – sleep and *ferre* – not to sleep. *The plant is an annual herb glabrous or sparsely bristly. The stem is erect, simple or branched at the top, 50–120 cm high. About 30 alkaloids of different subgroups of the isoquinoline series were identified: 1) morphine subgroup – morphine, codeine, thebaine; 2) subgroup of benzylisoquinoline and benzyltetrahydroisoquinoline – papaverine, narcotine, narcein. 80% of the weight of opium is made up of ballast substances. The one processed for medical purposes should contain at least 10% morphine. **Opium** contains 3–5% of meconic acid, which is found both in a free state and in the form of salts (meconates) with morphine, codeine and other alkaloids.

Meconic acid is easily determined in the free and bound state by its purple (red) color with ferric chloride. The presence of this acid confirms the presence of opium alkaloids. Omnopon (a mixture of opium hydrochlorides) and morphine are prescribed as pain relievers for injuries, long-term pain, etc. For to reduce the narcotic effect of morphine, morphilong was developed, which is a 0.5% solution of morphine hydrochloride in a 30% aqueous solution of polyvinylpyrrolidone. This drug is used as a pain reliever that does not cause addiction. **Codeine** (codeine phosphate and codeine base), codeterpin, cough tablets are prescribed to calm a cough. **Papaverine** is an antispasmodic agent used for spasms of blood vessels (hypertension, angina pectoris, migraine), spasms of the smooth muscles of the abdominal cavity, and bronchial asthma. Papaverine is part of the combined drugs: pafillin (papaverine + platyfillin), papazol (papaverine + dibazole), keliverin (papaverine + kelin), kelathrin (papaverine + kelin + atropine), bepasal, nicoverin, palufin, theoverin, tepafilin etc. In homeopathy, opium is used as a means that stimulates the respiratory center and restores blood circulation; with white fever, constipation, bladder sphincter spasm, stuttering, epilepsy, insomnia, with excitement of the nervous system.

YELLOW CAT HERBS – HERBA GLAUCII FLAVI

Yellow poppy *Glaucium flavum* Crantz, family Papaveraceae; the name comes from Latin. *glaucus* – gray; *flavus, -um* – yellow. *The annual, biennial or perennial plant is herbaceous, 30–50 cm tall. The root is vertical and contains milky juice. The sum of alkaloids in the mass phase flowering reaches 4%. The most valuable alkaloid is glaucine from the aporphine group. The content of glaucine is almost 50% of the total amount of alkaloids and sometimes reaches 2% of the mass of the terrestrial part. In addition, other alkaloids of the aporphine type were isolated from the yellow cat: coridine, isocoridine, an alkaloid of the protoberberine group annual, biennial or perennial plant isoboldine, from the protopine group annual, biennial or perennial plant alkaloids protopine, alocryptopine, alkaloids of the benzphenanthridine group annual, biennial or perennial plant sanguinarine, chelerythrine, hellerubine, norcheledonine, cheledonine, magnoflorin, etc. Among other compounds, the presence of fumaric (glaucic) and dioxymaleic acids, mucilage, flavonoids (rutin) is noted. Glaucine has an antitussive effect that exceeds codeine in terms of strength and duration and does not produce a side effect of

narcotics. Glaucin hydrochloride, glauvent, broncholithin are used as antitussives for diseases of the lungs and upper respiratory tract, bronchitis, pneumonia. Glaucin lowers blood pressure, has a sedative effect and relaxes smooth muscles. Appropriate use of glaucine preparations in cases of a combination of respiratory diseases and hypertension.

HERBA MACLEAYAE

Maclea heart-shaped *Macleaya cordata* (Willd.) R. Br., small-fruited maclea *Macleaya microcarpa* (Maxim.) Fedde, family Papaveraceae; named after the Scottish entomologist *A. Maclay*; *microcarpus*, *-a* – small-fruited; *cordatus*, *-a* – heart-shaped. *The plant is a perennial herb with yellow-hot milky juice and an unpleasant smell. The stems are erect, up to 2.5 m tall. The plant is poisonous. Maclea grass contains isoquinoline alkaloids (0.7–1.5%), including allocryptopine, sanguinarine, chelerythrine, protopine, berberine. As an anticholinesterase agent, it is prescribed for children with cerebral palsy, myopathies, spastic paresis of the facial nerve, and progressive muscular dystrophy.

HERB OF PURITY – HERBA CHELIDONII

Large chastity, wart-bearer *Chelidonium majus* L., family Papaveraceae; the name comes from the Latinized Greek name of the plant chelidonion from *chelidon* – swallow; Latin *major*, *majus* – big. *The plant is a perennial herb. All plant organs contain alkaloids (1.8–3%): chelidonine, homo-, oxy-, methoxychelidonine, chelerythrine, sanguinarine, protopine, α- and β-allocryptopine, sparteine, berberine, etc. Alkaloids are found in their pure form or bound to chelidonic acid. The herb contains saponins, flavonoids, ascorbic acid, carotene, and organic acids. An infusion of celandine grass, juice of fresh grass and roots is used to treat condyloma and papillomatosis of the throat. In small doses, celandine preparations are used internally for diseases of the liver and gall bladder. In the experiment, the growth of malignant tumors is delayed, fungistatic and bacteriostatic effects on pathogens are revealed tuberculosis. In homeopathy, the fresh flowering herb is used together with the roots for pain under the shoulder blade, bitter taste in the mouth, severe nausea, and externally for warts and polyps.

BARBERRY LEAVES – FOLIA VERBERIDIS,

BARBERRY ROOTS – RADICES VERBERIDIS

Common barberry *Verberis vulgaris* L., family Berberidaceae; the name comes from *berberis*, *idis* is the Latinized name of the plant; Latin *vulgaris* – common. * The branched deciduous prickly bush up to 2.5 m tall. All barberry organs contain alkaloids; the main one is berberine, the content of which in the roots reaches 1.5%. The largest amount of alkaloids accumulates in the bark of the roots. In addition, palmatin, columbamine, iatroricin, berberubin, oxycanthin, etc. have been identified in them. It also contains chelidonic acid, polysaccharides, anthocyanins, ascorbic acid, carotenoids, phenolic carboxylic acids. Berberine bisulfate (obtained from the roots) is used in medical practice as a choleretic agent for chronic hepatitis and gallstone disease. Tincture of barberry leaves is used for hypotonia of the uterus in the postpartum period, as a hemostatic agent for bleeding associated with inflammatory processes. In homeopathy, root bark is used for uric acid diathesis, passage of stones through the ureters, kidney or liver ring, gout and other manifestations of protein metabolism disorders.

TUBERS WITH THE ROOTS OF STEPHANIA – TUBERA CUM RADICIBUS STEPHANIAE GLABRAE

Stephania naked *Stephania glabra* (Roxb.) Miers, family Menispermaceae; from Greek *stephanos* – crown; Latin *glabra* – naked. *A dioecious perennial liana with a large rounded tuber and thin fibrous roots growing from it in the lower part. The amount of alkaloids is 6–8%. The main alkaloid from *Stephania tubers* of Indian origin is gindarin (up to 30% of the total), 15–18% is stefaglabrin (stepharin). Potatoes grown in Transcaucasia contain 6–7.5% of alkaloids, a third of which is hindarine and about 10% is cycleanine. Hyndarine hydrochloride belongs to tranquilizers and is used for functional disorders of the central nervous system, has a sedative, mild hypnotic and hypotensive effect. Stefaglabrin sulfate is an anticholinesterase agent.

FOLIA UNGERNIAE VICTORIS

Victor's Hungary *Ungernia victoris* Uved. ex Artjushenko, family Amaryllidaceae; named after botanist *F. Ungern Sternberg*; Latin *victoris* – named after the botanist Viktor Petrovich Bochantsev. *The plant is perennial, up to 40 cm tall, has bulbs with a diameter of 7–12 cm. The leaves contain galantamine and lycorine alkaloids. The main ones are galantamine, galantine, lycorine (0.05-0.1%). Galantamine alkaloid can be attributed to indolizidine derivatives. Galantamine

hydrobromide is a cholinesterase agent and is used for myasthenia, progressive muscular dystrophy (myopathy), radiculitis, etc. It is effective for residual effects of poliomyelitis, children's cerebral palsy, decreased tone of the digestive organs and urinary tract. Lycorine hydrochloride has a broncholytic effect. It is used as an expectorant for chronic and acute inflammatory processes in the lungs and bronchi, bronchial asthma. Alkaloids of the galantamine type can be obtained from the leaves of Sewertsov's ungeria (Folia Ungerniae sewertzowii), bulbs of Woronov's snowdrop (Bulbi Galanthi woronovii). Close to Voronov's snowdrop and promising for the creation of medicinal products is the genus Leucojum.

***Indole alkaloids (Tryptohane group**)

Indole alkaloids are widespread in the plant world and include more than 1,400 representatives from 40 families. Plants from the families Apocynaceae (about 600 substances), Rubiaceae, and Loganiaceae are the richest in them. Biogenetically, indole alkaloids originate from **tryptophan**, which at the first stage of biosynthesis is decarboxylated to form tryptamine. There are two main classes of indole alkaloids. Alkaloids with single indole groups belong to the first, relatively few. They are united in a group named "**harman type**" (b-carboline). But the more complex the structure of such substances, the less often they occur in nature. For example, garman was isolated from plants of 19 families, coenegin was found only in the family Rutaceae, nitrarin — only in the genus Nitraria, Zygophyllaceae.

The second class includes more than 1,200 alkaloids and is characterized by the presence of two structural units: indole and monoterpene. Among the alkaloids of this class, the main structural types can be distinguished: **yohimbane** (yohimbine, aimalicin, serpentine, corynantheine), **reserpine** (reserpine, deserpidine, rescinamine), **aspidospermatan**.

*****MEDICINAL PLANTS AND RAW MATERIALS CONTAINING INDOLE ALKALOIDS

HERBA PASSIFLORAE INCARNATAE

"Cavalry star" *Passiflora incarnata* L., Passifloraceae family; the name comes from Latin, *passio* – I suffer, which is connected with the "passions of Christ" and *flos* – a flower; Latin, *incarnatus*, *-a* – here "incarnated"; that is, a flower that embodies the suffering of Jesus Christ. A perennial herbaceous liana that reaches a length of 6 m in the conditions of the humid subtropics of the Caucasus. Passionflower

grass contains up to 0.05% of the total amount of alkaloids, among which harmine, harman, and harmol are the main ones. In addition to alkaloids, the herb contains pectin substances, phenolic compounds (flavonoids, coumarins, quinones), ascorbic acid. Passionflower preparations (liquid extract of passionflower, pasit, novopasit) are used as sedatives for neurasthenia, insomnia, chronic alcoholism, climacteric disorders. In homeopathy, the fresh herb is used as a hypnotic, mild antispasmodic, analgesic and antirheumatic agent.

RAUWOLFIA ROOTS – RADICES RAUWOLFIAE

Rauwolfia snake *Rauwolfia serpentina* Benth., Rauwolfia vomiting *Rauwolfia vomitoria* Afz., *Rauwolfia canescens* L., family Apocynaceae; the plant is named after the botanist and doctor *L. Rauwolf*, Latin, *serpentinus*, *-a* – serpentine, serpentine, in connection with the use of the plant in India against the bites of poisonous snakes. *A small evergreen shrub. About 100 indole alkaloids have been found in Rauwolfia species, the sum of which is 0.7-2.4%; in *Rauwolfia serpentina* – 0.8-1.3%, in *Rauwolfia vomitoria* – more than 1.5%. The bark of the roots contains ten times more alkaloids than the wood. The main biologically active substances are reserpine, rescinamine, aimaline, and serpentine. Raunatin, rauvazan, reserpine and the drugs it contains (adelphan, crystepin, brinerdin and others) are prescribed for hypertension, psychoneuroses. Rescinamine and drugs (canescin, recanescin) have a hypotensive effect, similar to reserpine, but without side effects. Aimaya't shows antiarrhythmic activity. In homeopathy, rhizome with roots is used as a hypotensive agent.

HERBA VINCAE MINORIS – HERBA VINCAE MINORIS

Small periwinkle *Vinca minor* L., Arosunaceae family; the name comes from Latin, *vincere* – to win (refers to evergreen leaves) or from Latin, *vincire* – to wrap around, because the stems of plants are flexible and twisted and *minor* – small. Evergreen small polycarpic subshrub. Shoots of two types: vegetative self-rooting, lying and generative flowering erect, 20-40 cm long. The grass is rich in indole alkaloids. Minorin (vincamine) was identified first, followed by isovincamine and other derivatives of eburnan. It was later established that isovinkamin is a mixture of vincamine, vinkaminin, vincin and vincinin. The physicochemical properties of these alkaloids are similar to reserpine. In addition, vincaminorin, its isomer vincaminorein, pervicin, and vincamidine were extracted. In addition to alkaloids, periwinkle grass contains ursolic acid, flavonoid robinin,

leucoanthocyanins. Devinkan, vincapan, vinkatpn are used for hypertension, spasms of brain vessels. In homeopathy, the whole fresh plant, collected at the beginning of flowering, is used for exhaustingly long uterine bleeding, wetting eczema on the hair part of the head.

LEAVES OF PINK CATHARANTHU – FOLIA CATHARANTHI ROSEI

Pink catharanthus, pink periwinkle *Catharanthus roseus* G. Don, syn. *Vinca rosea* L., Apocynaceae family; the name comes from *catharos* – clean and *anthos* – flower; Latin, *roseus*, -a – pink; vinca is a shortened form of *Latin*, the name of the plant vinca perivinca. *In the tropics, it is a perennial, evergreen semi-shrub 30-60 cm tall with a straight or slender stem. Cultivated as an annual crop. More than 80 alkaloids of the indole group, including 26 dimeric bases that have an indole-indoline structure, have been extracted from catharanthus grass. The main monomeric alkaloid is aimalicin (raubazin, 0.1%), in addition, serpentine, vindolinine, lochnerine, etc. were isolated. High pharmacological activity is shown by four dimeric indole-indolin components: alkaloids vinblastine (pinkoleukoblastine, 0.005%), vincristine (vincoleukocristine, 0.001%), leurosine (vinleurosine), leurosine! (iziiikoziidkn), as well as vindesin, leiikocristin, rovidin, lei-rosyvin. Of the monomer bases, catharanthine and vindoline are the most valuable. Vinblastine was isolated in 1958 p., later, in 1963, vincristine was studied. The alkaloid composition of the roots is significantly different from the composition of the aerial part of the catharanthus. Catharanthus leaves are used to obtain drugs rosevin, vinblastine, vincristine (sulfates of alkaloids), which have an antitumor effect. It is used in the complex therapy of leukemias and malignant neoplasms.

CHILIBUHA SEEDS – SEMINA STRYCHNI (VOMIT NUT – NVX VOMICA)

Chillibukha, vomit nut *Strychnos nux-vomica* L., Loganiaceae family; the name comes from the Greek. *strychnos* is the name of some poisonous plant: Latin, *nim* is a nut, *vninictds*, *-a* – vomiting. *Deciduous small tree with opposite oval leaves. All parts of the plant contain alkaloids, but most of all – seeds (1-2%). The main ones are strychnine and brucine. The content of other alkaloids reaches 30% of the total amount. Reserve substances are starch and proteins, chlorogenic acid accumulates, loganin iridoid derivative – loganic acid. Tincture and dry extract of chilibukha are obtained from imported raw

materials. they are used for reflex excitation of the central nervous system as tonics. Homeopathy uses dried and powdered seeds. The remedy is for patients in a state of overexcitation. It is considered a regulator of the gastrointestinal tract and is used for spastic intestinal conditions and enteritis with painful tenesmus: it is prescribed for alcoholism, impotence, headache with nausea, trigeminal neuralgia, atrophy of the optic nerve, glaucoma, etc.

RESISTANCE OF ERGOTAMSH (ERGOTOXIN) STRAIN –
CORNUA SECALIS CORNUTISTAM ERGOTAMINI (ERGOTOXINI)

Purple claviceps (uterine horns) *Claviceps purpurea* Tulasne, family Clavicepitaceae, class marsupial mushrooms Ascomycetes; from Latin, *clava* – mace and *sarut* – head; *purpureus*, *-a*, *-um* – purple, indicates the color of the sclerotia. *The purple spore is a parasite on many types of cereals, both cultivated and wild, it is especially common on rye, it also affects wheat, especially durum, barley, wheatgrass and other grasses. The development cycle includes three successive stages: sclerotial, marsupial, and conidial. Sclerotia (horns) are used as medicinal plant raw materials. Alkaloids are contained only in the sclerotia of the mushroom in the amount of 0.01-0.2%. But there are known races in which more than 1% of alkaloids accumulate. A great variety of ratios of the main groups of alkaloids is observed. Classical ergot alkaloids are derivatives of lysergic and isoli-sergic acids (ergoline alkaloids). Among other chemical compounds, simple amines should be noted: histamine, tyramine, acetylcholine, amino acids, imidazole alkaloids, fatty oil (30-35%), ergosterol (about 0.1%), fungisterol. Ergot also contains milk sugar, xanthone derivatives. The purple color of sclerotia is the result of the combination of anthocyanin pigments, the so-called ergochromes, with yellow pigments. Liquid and thick extracts of spore ergotal (a mixture of phosphates of alkaloids of the ergotoxin strain), ergometrine maleate, ergotamine hydrotartrate are used in motor therapy and are part of combined preparations. They are used in obstetrics and gynecology as uterotonic agents (mainly ergometrine derivatives), Ergotamine is also used as an adrenolytic agent in neurology. The obtained semi-synthetic derivatives are characterized by low toxicity and a stronger adrenolytic effect. they are used for spasms of blood vessels and hypertension (dihydroergotamine and dihydroergatoxin). Ergocriptine is used for the production of the semi-synthetic drug parlodel (bromocriptine), which suppresses the secretion of prolactin and is used in breast

tumors. In homeopathy, dried sclerotia are used for central and peripheral blood circulation disorders, paresthesias. deep disturbance of blood circulation in arteries, atherosclerosis of cerebral vessels, cataract, obliterating endarteritis, gangrene.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING PURINE ALKALOIDS

CHOCOLATE TREE SEEDS – SEMINA CACAO

Chocolate tree – *Theobroma cacao* L., Sterculiaceae family; the name comes from the Greek. *theos* is god and *broma* is food: Latinized *cacao* is a twisted Mexican name for the seeds of this plant – *kakahuate*. *The core and shell of the seeds contain 0.9-3% theobromine. 0.05-0.36% caffeine is also found in the seeds. 43-53% fat, 5-10% water-soluble polyphenolic substances (epicatechin, leucoanthocyanins and anthocyanins). Theobromine stimulates 1INS less than caffeine, but is stronger as a diuretic. Cocoa powder has a stimulating and diuretic effect. has great nutritional value. Cocoa butter is used in pharmacy as a base for suppositories.

COFFEE SEEDS – SEMINA COFFEAE

Arabian coffee tree *Coffea arabica* L., family Rubiaceae; the name comes from the Latinized English *coffee* – coffee; tour. quahveh: Arabic, *guahuah*: patin, *ambicus*, *-a, -um* – Arabic. *A semi-shrub or a small tree 8-10 m tall, with greenish-gray bark. The seeds contain 1-2% caffeine, theobromine, theophylline. 3-5% tannins. I.i % of glucose and dextrin. 10-13% fatty oil, 10-13% proteins. When ripening, coffee fruits acquire a characteristic smell and a dark brown color. The smell of the fruits is given by an oil called "caffeol", which contains 50% furfural and a small amount of valerian acid, phenols and pruvelin. In unripe fruits, caffeine is bound to chlorogenic acid. At the time of full fruit ripening, it is released. Then the content of chlorogenic acid exceeds 5%. From ripe fruits, caffeine can be partially sublimated during drying. In most cases, caffeine is obtained from the sublimate of dried ripe fruits. Coffee is used as a stimulant for mental fatigue, headache and first aid for poisoning. The effect on the central nervous system is caused by the presence of caffeine. Decaffeinated coffee is obtained by extracting caffeine from beans while preserving the taste qualities of coffee drinks. Such coffee contains up to 0.08% caffeine. Dried, but not fried, beans are used in homeopathy, and in pediatrics for insomnia due to overexcitation, for teething, which is

accompanied by pain and dyspepsia; with a headache that is aggravated by noise; neurosis of the heart with a strong heartbeat.

TEA LEAVES – FOLIA TNEAE

Chinese tea *Thea sinensis* L. (Camellia – *Camellia sinensis* O. Ktzc), Theaceae family; from Chinese *te* – tea kush; Camellia is named after the English botanist *Camel*. *Tea contains 5% caffeine ("theine") and a small amount of theophylline, theobromine, adenine, xanthine, hypoxanthine, and isatine. Tannins in tea make up 15-30% and are represented by catechin and its derivatives (vitamin P). Essential oils give tea a strong aroma and specific smell. Vitamins C, B, B, were also found. PP. mineral salts. The healing properties of unfermented tea are due to a complex of biologically active substances. Given the stimulating properties of caffeine, tea should be drunk in case of fatigue, reduced mental activity, and when providing first aid. Tea is given for poisonings that cause suppression of the central nervous system, weakening of heart activity and breathing, as well as for alcohol poisoning. Due to the presence of theophylline and theobromine, tea has a diuretic effect. It should be remembered that strong tea is not recommended for consumption in case of increased excitability, insomnia, organic diseases of the cardiovascular system, atherosclerosis, hypertension, glaucoma. Even healthy people should not drink too strong tea, because it can cause overexcitation of the central nervous system, increased heartbeat, feelings of restlessness, terror.

FOLIA STERCULIAE PLATANIFOLIAE (FOLIA FIRMIANAE SIMPLIC1S)

Sterculia platanofolia (firmiana simple) *Sterculia platanofolia* L., syn. *Firmiana simplex* (L.) W. Wight., family Sterculiaceae; the plant is named after the governor of Lombardy *K. Firmianus*; Latin, *simplex* – simple. *Sterculia plata nolista is sometimes called the Japanese lacquer tree. A tall, fast-growing deciduous tree, 10-30 m tall. The leaves contain purine alkaloids, choline, betaine, tannins (4%), mainly of the pyrocatechin group, organic acids, traces of essential oil. Caffeine is stored in the seeds. Tincture of sterculii leaves is used as a stimulating and tonic agent for physical and mental fatigue, hypotonia. The seeds are used as a substitute for coffee.

Lecture 5 MEDICINAL PLANTS AND RAW MATERIALS CONTAINING VITAMINS

1 Vitamins, their importance for human life.
2 Classification of vitamins by physical and chemical properties.
3 Medicinal plants and raw materials containing vitamins.

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.552–592. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/Фармакогнозія-з-основами-біохімії-рослин.pdf (in Ukrainian)

Vitamins in the plant world: educational manual / Yu. I.Kornievskyi, V. V. Rossikhin, A. G. Serbin and others. Zaporizhzhia: ZDMU, 2019. 372 c. ISBN 966-417-181-6 (in Ukrainian)

Vitaminology: a textbook / S.A. Petrov and others; under science ed. S. A. Petrova; Odessa national University named after I. I. Mechnikova. Odesa: WWII, 2013. 227 p. ISBN 978-966-413-377-4 (in Ukrainian)

1 Vitamins, their importance for human life

Vitamins are low-molecular organic compounds of various chemical structures that are necessary for the normal functioning of living organisms.

Although before the discovery of vitamins, it was believed that a person only needed proteins, fats, carbohydrates, water and mineral salts for normal life, observations showed that a monotonous diet without fresh vegetables and fruits leads to the emergence of various diseases. Thus, during long voyages, sailors fell ill with scurvy, the mortality from which was 70-80%, and in Asian countries, where the main dish was polished rice, a large part of the population was affected by beri-beri (a form of polyneuritis).

The beginning of the development of vitaminology was laid by the doctor M. I. Lunin in 1880. The term "vitamins" was proposed in 1912 by the Polish scientist K. Funk, who first isolated from yeast a crystalline substance that contained an amino group in its structure (from the Latin *vita* – life and *aminus* – nitrogen). Diseases that arise due to the lack or absence of these substances in the body are called hypo- and vitaminosis. Later it was proved that not all vitamins contain

an amino group, but this class of natural compounds is traditionally called vitamins all over the world.

Vitamins are synthesized mainly by plants and partly by microorganisms. In some cases, they are formed from so-called provitamins (for example, vitamin A from carotenoids, some sterols, under the influence of UV rays, are transformed into vitamins of group D).

Human and animal bodies do not synthesize vitamins or synthesize them in insufficient quantities. Currently, about 30 vitamins are known, of which approximately 20 enter the human body with plant and animal food. Vitamins have high biological activity and are needed by the body in very small doses – from a few micrograms to tens of milligrams per day.

2 Classification of vitamins by physical and chemical properties

There are three classifications of vitamins. One of the first ones proposed was the letter one. With the discovery of individual vitamins, they were marked with capital letters of the Latin alphabet (A, B, C, D, etc.) and named according to their biological role in the body: vitamin D (calciferol) regulates the ratio of calcium and phosphorus in bones; vitamin E (tocopherol) supports the body's reproductive capacity (from the Greek "*tokos*" – birth of children,"*fero*" – the one who carries); vitamin A (axerophthol) – if contained in insufficient quantities, causes xerophthalmia (eye disease), etc. With the selection of new vitamins in the individual state, the similarity of their structure and the difference in their biological structure began to be noticed actions, therefore digital indices began to be added to the letters – A_1, A_2, B_1, B_2, K_1, K_3, D_2, D_3, etc.

After the chemical structure was determined for many vitamins, names began to acquire a chemical meaning, for example, thiamine (B_1), riboflavin (B_2), pyridoxine (B_6), etc. Then it turned out that some of the long-known organic substances have their own activity of vitamins (nicotinic acid, flavonoids, etc.).

Vitamins are also classified according to physical and chemical characteristics. According to their **solubility**, they are divided into fat-soluble and water-soluble. Vitamins of group A (retinols) and provitamins – α-, β-, γ- carotenes are **fat-soluble**; vitamins of group D – ergosterol and other phytosterols; vitamins of group E – α-, β-, γ-, σ-tocopherols; vitamins groups K – phylloquinone and menaquinone

(K_1 and K_3, respectively); factor F – highly unsaturated fatty acids and prostaglandins.

Water-soluble vitamins: B_1 – thiamine, B_2 – riboflavin, B_3 – pantothenic acid, B_6 – pyridoxine, B_9 (B_c) – folic acid, B_{12} – cyanocobalamin, PP – nicotinic acid, C – ascorbic acid, H – biotin; U is methylmethionine sulfonium chloride.

Along with vitamins, the need for which for humans and animals is undoubtedly established, food contains some biologically active compounds, the deficiency of which does not lead to obvious metabolic disorders, because their functions are closer to food substances (essential aminoacids, polyunsaturated fatty acids). Such substances are called vitamin-like. These include bioflavonoids (vitamin P), choline, inositol, carotenes (vitamin B_t), lipoeva, orotova and pangamic acids (vitamin B_{15}) and n-aminobenzoic acid.

The given classifications have drawbacks. Yes, they do not reflect the chemical and pharmacological properties of vitamins. Moreover, after the synthesis of various vitamin derivatives, classification by solubility is conditional, because after the introduction of lipophilic groups into water-soluble vitamin molecules, they can turn into fat-soluble ones and vice versa.

The **most rational** is the classification of vitamins according **to their chemical structure**. It was adopted by the Nomenclature Commission of the Biochemical Section of the International Union of Pure and Applied Chemistry. In accordance with this nomenclature, vitamins are divided into the following groups: aliphatic, alicyclic, aromatic, heterocyclic.

In addition to vitamins, there are compounds in nature that are converted into vitamins in the body of animals and people, these are **provitamins**. These include carotenoids involved in the synthesis of vitamin A. **Antivitamins** are compounds that are close to vitamins in terms of their chemical structure, but lack their biological properties. Once in the body, antivitamins are included instead of vitamins in metabolic reactions and inhibit or disrupt their course. This leads to vitamin deficiency even when the corresponding vitamin comes with food in sufficient quantity or is formed in the body. Antivitamins are known for almost all vitamins. For example, the antivitamin of vitamin B_1 (thiamine) is pyrithiamine, which causes the phenomenon of polyneuritis. Some medicines are also antivitamins. For example,

sulfonamide drugs – antagonists of n-aminobenzoic acid, aminopterin and methotrexate (antitumor drugs) – folic acid.

The specific function of water-soluble vitamins (except ascorbic acid) in the body is the formation of coenzymes and prosthetic groups of enzymes. Enzymes combined with various vitamins participate in the most important metabolic processes: energy (thiamine, riboflavin, vitamin PP), biosynthesis and conversion of amino acids (vitamin B_6, B_{12}), fatty acids (pantothenic acid), purine and pyrimidine bases (folicin), the formation of many important compounds – acetylcholine, steroids, etc.

Aliphatic vitamins

Vitamins of this group are water-soluble. These include ascorbic acids, pangamic acids, pantothenic acids and methylmethionine sulfonium chloride.

Ascorbic acid (vitamin C, antiscorbutic) chemically represents a group of compounds – derivatives of L-gulonic acid. The most important of them are the physiologically active isomer L-ascorbic acid and dehydroascorbic acid, which easily convert into each other under appropriate conditions.

*Ascorbic acid takes part in oxidation-reduction reactions, processes of carbon metabolism, blood coagulation, tissue regeneration, formation of steroid hormones and normalization of capillary permeability, as well as improves appetite and increases the vitality of the body. The biochemical mechanisms of action of vitamin C are diverse and have not been fully elucidated.

*Ascorbic acid is not synthesized and cannot accumulate in the body. This explains the rapid onset of primary and secondary hypovitaminosis and the development of scurvy. With hypovitminosis, rapid fatigue, heart failure, propensity to bleeding is observed, resistance to infections decreases.

Vitamin C is a synergist of cortin, a gonadotropic hormone, thiamine, vitamins of the P-group and an antagonist of thyroxine (thyroid hormone).

*Ascorbic acid is synthesized by all plants containing chlorophyll. It is rich in the fruits of rose hips *Rosa canina*, mountain ash *Sorbus aucuparia*, currants *Ribes nigrum*, ripe walnuts *Juglans regia*, juicy fruits, berries, vegetables (potatoes *Solanum tuberosum*, cabbage *Brassica* sp.), needles, etc. During cooking, drying, canning of fruits and vegetables, vitamin C can be destroyed due to oxidation by traces

of iron and copper, especially by oxidizing enzymes, so it is better to cook vegetables by immersing them in boiling water or by steaming. The daily requirement is **70–100 mg**.

Pangamic acid (vitamin (B_{15}) is chemically an ester of D-gluconic and dimethylaminoacetic acids (dimethylglycine).

It is found in rice bran *Oryza sativa* and seeds of many plants. Improves lipid metabolism, increases tissue absorption of oxygen, glycogen content in muscles and liver, eliminates the phenomenon of hypoxia, increases diuresis.

Vitamin B_{15} is used to treat various forms of atherosclerosis, cardiovascular diseases, chronic hepatitis, pulmonary emphysema, etc. The daily requirement is **2 mg**.

Pantothenic acid (vitamin B_3, antidermatitis) is contained in pea *Pisum sativum*, rice *Oryza sativa*, liver, fats, egg white, fish liver, yeast, etc. In the human body, this vitamin is produced by Escherichia coli. Hypovitaminosis B_3, unlike in animals, has not been detected in humans. *Pantothenic acid participates in carbon and lipid metabolism, synthesis of acetylcholine and hormones, stimulates the formation of corticosteroids. It is used for metabolic disorders, neuralgia, polyneuritis, allergies, eczema, toxicosis, etc. The daily requirement is 10–12 mg.

Methylmethionine sulfonium (vitamin U, anti-ulcer) was first found in the juice of cabbage, *Brassica oleracea*, Brassicaceae, got its name from Latin. *ulcus* is an ulcer. It is contained in many vegetables (parsley leaves *Petroselinum crispum*, onion *Allium cepa*, salad *Lactuca sativa*, pepper *Piper* sp, carrot *Daucus carota* subsp. *sativus*, turnips *Brassica rapa*, asparagus *Asparagus officinalis*, tomatoes *Lycopersicon~Solanum lycopersicum*). Asparagus roots (100–160 mg/100 g) and white cabbage (80–85 mg/100 g) are considered its richest sources. It is a donor of CH_3 groups in biological methylation.

Vitamin **U** has a healing effect on the function of the stomach, intestines, liver, gall bladder, because it helps to reduce gastric secretion, heals ulcers. This vitamin is used for chronic cholecystitis, ulcerative colitis, gastric and duodenal ulcers. The daily requirement is **15–20 mg**.

Vitamins of the alicyclic series

Retinols (vitamin A, antixerophthalmic). This group includes compounds consisting of 20 carbon atoms. Vitamin A is a derivative

of the trimethylcyclohexane nucleus connected to an aliphatic chain that ends with an alcohol group.

The main source of its production is fish oil. Retinol does not occur in plants, but many of them (carrot *Daucus carota* subsp. *sativus*, parsley *Petroselinum crispum*, green onion *Allium cepa*, sorrel *Rumex* sp., red pepper *Capsicum frutescens*, black currants *Ribes nigrum*, rose hip *Rosa canina*, gooseberry *Ribes uva-crispa*, tomato *Lycopersicon~Solanum lycopersicum*, apricot *Prunus armeniaca~Armeniaca vulgaris*, etc.) contain carotenes, retinol provitamins.

Carotenes are one of the main groups of carotenoids, which by their nature are tetraterpenes (C_40H_{64}). Carotene in plants can be in the form of three isomers: α-, β- and γ-carotene. They are carriers of active oxygen. This explains the presence in plants numerous oxygen derivatives of carotenes, including epoxides in carotene rings, which easily split off their oxygen.

*In plants, carotenes are found in chromoplasts – plastids of fruits, flowers and other plant parts, in chloroplasts together with chlorophyll in the form of water-soluble protein components or in droplets of fatty oil. The β-isomer is the most common carotene. In the body, the β-carotene molecule is hydrolytically split into two symmetrical halves, as a result of which two molecules of vitamin A are formed. This transformation takes place in the intestinal walls under the influence of the carotenase enzyme.

Only one molecule of vitamin A is formed from α- and γ-carotenes, because these isomers have one β-ionone ring each. The most valuable is β-carotene, from which two molecules of retinol are formed.

The content of carotenes in plants depends on the vegetation period, external conditions, climate, temperature, and types of fertilizers. Those plants in which it accumulates in significant quantities are valuable as a source of carotene. Some of them (carrot *Daucus carota* subsp. *sativus* and pumpkin *Cucurbita pepo*) are industrial raw materials for obtaining carotenes in their pure form, others are raw materials for obtaining total preparations.

In its finished form, vitamin A enters the human body only when animal fats are oxidized. Lack of vitamin A is accompanied by dryness and pallor of the skin, brittle nails and hair, degenerative changes in

the mucous membranes, increased fatigue, and damage to the organs of vision. The daily requirement is **1–2.7 mg**.

Vitamin D (anti-rickets) is a collective concept that unites several substances (vitamins D_1, D_2, D_3, D_4) with similar chemical and biological properties. Predecessors of group vitamins and D are **phytosterols**. With vegetable food, they enter animal organisms, turn into cholesterol, from which certain vitamins are then formed. For example, ergosterol, which is found in yeast, is transformed into vitamin D_2 in the animal body.

Other vitamins of group D are formed in a similar way. Natural vitamins D_2 and D_3 accumulate in significant quantities in the liver and fatty tissue of cod *Gadus morhua* and marine animals.

The biochemical role of vitamin D is related to the regulation of calcium and phosphorus metabolism. Its lack in the body leads to rickets (in children) and osteomyelitis (in adults).

The daily requirement is **400 IU** (1 International Unit corresponds to 0.025 μg ergo – or cholecalciferol).

Aromatic vitamins

The aromatic series includes vitamins of group K, which are derivatives of 2-methyl-1,4-naphthoquinone and have antihemorrhagic activity. Higher plants contain only vitamin K_1.

Phylloquinone (vitamin K_1, antihemorrhagic) has in its structure naphthoquinone core. According to C-3 provision, the attached balance of sokomolecular aliphatic diterpene alcohol phytol, which is also part of chlorophyll. Plants in which vitamin K accumulates in significant quantities are of great value. These are nettles *Urtica dioica*, corn cobs *Zea mays*, viburnum *Viburnum opulus*, *Capsella bursa-pastoris*, alfalfa *Medicago sativa*, spinach *Spinacia oleracea*, etc. The physiological role of vitamin K_1 is related to the formation of prothrombin and the cessation of bleeding. The daily requirement of an adult is **0.2–0.3** mg.

Heterocyclic vitamins

The heterocyclic series includes vitamins of groups E, P, PP, B and some others.

Tocopherols (vitamin E, reproduction vitamin) are chemically derived from chroman. Tocopherols are contained in vegetable oils – corn *Zea mays*, soybean *Glycine max~Soja hispida*, sunflower *Helianthus annuus*, cottonseed *Gossypium hirsutum*, peanut *Arachis hypogaea*, sea buckthorn *Hippophae rhamnoides*,

rosehip *Rosa canina*, etc., as well as in the green parts of plants, especially in the young sprouts of cereals *Poaceae*. This practically excludes the possibility hypo- and avitaminosis, due to the intake of vitamin E in sufficient quantity with food.

It is known that tocopherols regulate the normal development and function of the gonads, as well as the development of the embryo. In addition, β- and γ-tocopherols exhibit significant antioxidant activity. The daily requirement is **15 IU** (1 IU corresponds to 1 mg of D, L-α-tocopherol).

Bioflavonoids (vitamins of the P group, permeability vitamins) act most actively in combination with ascorbic acid, so they are sometimes called vitamin C_2. Vitamins P include a large group of natural substances: flavones, flavonols, flavans, catechins, flavanones, anthocyanins, etc.

Natural sources of flavonoids are tea leaves *Camellia sinensis* (catechins, flavonols), citrus peel *Citrus* (flavanones, flavones), rosehip fruits *Rosa canina* (anthocyanins, flavones, flavonols), chokeberry fruits *Aronia melanocarpa* (anthocyanins, flavonols, flavones), buckwheat grass *Fagopyrum esculentum*, navel Japanese sophora *Styphnolobium japonicum*~*Sophora japonica* (flavones, flavonols), blueberries *Vaccinium myrtillus*, viburnum *Viburnum opulus*, strawberries *Fragaria × ananassa* (anthocyanins), etc. In an individual state, rutin, quercetin, as well as combined drugs are used. The daily requirement is **15–20 mg.**

Vitamin PP (nicotinic acid, nicotinamide, niacin, antipelagic) is found in vegetables, fruits, buckwheat *Fagopyrum esculentum*, common beans *Phaseolus vulgaris*. Yeast and animal organs (especially liver) are rich in nicotinamid.

Nicotinic acid and its Nicotinamide are prosthetic groups of co-enzymes cadehydrase I and cadehydrase II, which are hydrogen carriers, i.e. participate in metabolic processes of the body. Nicotinic acid normalizes the functions of the skin and nervous system, stimulates peripheral blood circulation. Some researchers believe that it is a provitamin, and nicotinamide is a true PP vitamin. The daily requirement is 15–30 mg.

Vitamin B_6 (pyridoxine, antidermatitis) includes several similar substances: pyridoxol (pyridoxine), pyridoxal and pyridoxamine, which are mutually converted:

Pyridoxol → Pyridoxal → Pyridoxamine

These compounds are found in rice husks *Oryza sativa*, wheat *Triticum* and corn *Zea mays* germs, pea *Pisum sativum*, soybean *Glycine max~Soja hispida*, and oatmeal *Avena sativa*. There are many of them in yeast, liver, meat, fish, etc. Vitamin B_6 affects the nervous system, skin and digestive organs. It has been proven that it plays a significant role in the utilization of fatty acids and lowers blood sugar levels by activating insulin production. The daily requirement is **1.8–3.0 mg.**

Thiamine (vitamin B_1, antineuritis) is based on two heterocycles: pyrimidine and thiazole, connected to each other by a methyl radical.

Thiamine is found in yeast, plant pollen, germs and shells of cereal crops (wheat *Triticum*, buckwheat *Fagopyrum esculentum*, corn *Zea mays*, oat *Avena sativa*), as well as peanuts *Arachis hypogaea*, nuts *Juglans regia*, grape *Vitis vinifera*, bean *Phaseolus vulgaris*, onion *Allium cepa*, carrot *Daucus carota* subsp. *sativus*, etc.

Vitamin B_1 is especially necessary for people engaged in heavy mental and physical work, with physical and nervous overload, pregnant women and women who are nursing babies. Not enough – the steady intake of this vitamin in the body leads to the accumulation of lactic and pyruvic acids, which disrupts cardiac activity, causes polyneuritis, etc. The daily requirement is **1.5–2.6 mg.**

Riboflavin (vitamin B_2, growth vitamin) is based on the heterocyclic system of isoalloxazine, which consists of two heterocycles: pyrazine and pyrimidine. This is a very specific structure, and even minor changes in it lead to the loss of vitamin activity or the formation of antagonists.

Vitamin B_2 is found in significant quantities in plant pollen (about 1.5 mg/100 g) and saffron columns *Crocus sativus* (Stigmata Croci), is in wheat germ *Triticum*, oat *Avena sativa*, corn *Zea mays*, rice bran *Oryza sativa*, alfalfa *Medicago sativa*, green pea *Pisum sativum*, beans *Phaseolus vulgaris*, tomatoes *Lycopersicon~Solanum lycopersicum*, hazelnuts *Corylus maxima*, yeast, as well as in products of animal origin.

Riboflavin improves the metabolism of carbohydrates, fats, and amino acids. It plays some role in the prevention of allergic conditions. Vitamin B2 is part of enzyme systems. The daily requirement is **1.5–3.0 mg.**

Biotin (vitamin H_1, antiseborrheic) has a skeleton of biophenol and imidazole in its structure (carbon atoms in the C-3 and C-4 positions are common), the side chain is represented by valeric acid. Of the eight optical isomers and four racemates, only D has biological activity -(+) biotin. It is found in rice brans *Oryza sativa*, soybeans *Glycine max*~*Soja hispida*, beans *Phaseolus vulgaris*, peanuts *Arachis hypogaea*, onions *Allium cepa*, raisins *Vitis vinifera*, etc., but the liver and kidneys are the richest in it (200–250 μg /100 g), and from plant products – rye grain *Secale cereale* (46 μg) and cauliflower *Brassica oleracea* var. *botrytis* (17 μg). *It is part of the prosthetic group of a number of enzymes, participates in the processes of carboxylation, decarboxylation, and deamination of such vital amino acids as serine, threonine, aspartic acid. Promotes the synthesis of unsaturated fatty acids in the liver. Biotin deficiency causes neurotrophic disorders, seborrheic dermatitis, lethargy, loss of appetite, and muscle pain. The daily requirement is **150–200 μg**.

Folic acid and its derivatives (vitamin B_c, vitamin B_9, folacin, antianaemic) are contained in green leaves of plants (from the Latin *folium* – leaf). Cofactor forms of folacin are involved in the biosynthesis of purine bases (adenine and guanine), which are part of DNA and RNA. This determines the important role of this vitamin in the biosynthesis of nucleic acids, processes of growth and development, hematopoiesis and embryonic development. Its deficiency causes severe forms of anemia. Folic acid enters the human body with food and is synthesized by intestinal microflora. It is a derivative of pterin and glutami – a new acid.

Vitamin B_c is very common in the plant world. It is found in all fresh vegetables, especially in green leaves of spinach *Spinacia oleracea*, lettuce *Lactuca sativa*, cereals Poaceae, bean *Phaseolus vulgaris*, cabbage *Brassica oleracea*, parsley, onion *Allium cepa*, black currant *Ribes nigrum*, corn *Zea mays*, etc. The daily requirement is **200 μg**, during pregnancy and breastfeeding, the dose increases 2-3 times.

Cyanocobalamin (vitamin B_{12}, antianemic) is a complex porphyrin-like a compound in which cobalt is coordinatively linked with a cyanogroup and a peculiar nucleotide. It is part of the coenzymes of certain enzymes involved in methylation and some other reactions. It is synthesized in nature by microorganisms, mainly by bacteria, as well as by microscopic fungi and algae. Synthesis of vitamin B_{12} in the human body carried out by the microflora of the digestive tract,

supplemented by food of animal origin. It is practically absent in plants, but there is information that analogs of this vitamin were found in kelp *Laminaria* sp. and soybean seeds *Glycine max~Soja hispida* in the amount of 1 mg/100 g. The daily requirement is **3 µg**.

3 Medicinal plants and raw materials containing vitamins

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING CAROTINOIDS

- *Calendula officinalis* – FLORES CALENDULAE
- *Hippophae rhamnoides* – FRUCTUS HIPPOPHAËS
- *Sorbus aucuparia* – FRUCTUS SORBI

CALENDULA FLOWERS – FLORES CALENDULAE

Marigolds (calendula) – *Calendula officinalis* L., Asteraceae family. *Annual or perennial herbs, pubescent, glandular, with yellow or orange flowers. Baskets multi-flowered, apical; wrapper of 1-2 rows of elongated leaves. The outer (false-lingulate) flowers are pistillate, fertile, with a linear stigma; the inner flowers are tubular, bisexual, but sterile, with a capitate stigma. The achenes are arranged in 2-3 rows, they are curved (to ring-shaped), heteromorphic: the outer ones differ in shape and surface structure from the middle and inner ones. It reaches a height of 95cm. Calendula is native to the Middle East, Southern Europe and Asia. Light-loving plant. Repels pests. Chemical composition of raw materials. Marigold flowers contain xanthophylls, carotenoids (carotene, lycopene, violaxanthin, citraxanthin, rubixanthin, flavoxanthin – only 3%); vitamin C, flavonoids, triterpenoids, essential oil, resins, mucus, inulin, organic acids, phytosterols, enzymes. Medicinal marigolds have anti-inflammatory, bactericidal, wound-healing properties. Tincture and ointment are used for cuts, purulent ulcers and burns, and for gargling with sore throats. Carophyllene, which contains a sum of carotenoids, is an anti-inflammatory agent.

FRUITS OF BUCK-BUCKLE – FRUCTUS HIPPOPHAËS

Hippophaë rhamnoides L., Elaeagnaceae family, sea buckthorn gravel-like; the name comes from the Latinized Greek name *hippos* – horse and *phaos* – shine; Latin *rhamnos* is the name of a thorny shrub and oides is similar. * Shrub or small tree up to 6 m tall. A dioecious plant with prickly branches covered with gray bark. The leaves are alternate, narrow, linear or linear-lanceolate, almost sessile, up to 8 cm long and 0.5 cm wide, dark green above, silver below. The flowers are small, develop on last year's shoots, unisexual, brownish, with a

two-lobed calyx, with a simple perianth. Male flowers are collected in inflorescences in the lady of a short ear, which turns into a tassel at the top; female – in tufted inflorescences. The fruit is an oval or almost spherical juicy drupe 4–12 mm long with a short peduncle, yellow, yellow-hot or yellow-hot – red color, sweetish-sour taste, with a characteristic smell reminiscent of pineapple. It grows wild in Ukraine in the Danube Delta. As a decorative and fruit crop, it is grown throughout the territory of Ukraine, especially in the southwestern regions. Fruits are collected at the stage of full ripeness, plucking them with special wire tweezers, and after the onset of frost, they are shaken on a tarpaulin or other fabric placed under the bush. The pulp of sea buckthorn fruits contains fatty oil (1.7–8%), which includes glycerides of oleic, palmitic, palmitoleic, stearic and other fatty acids, phospholipids (up to 1%), carotenoids (0 ,31–20 mg%), which include α-, β- and γ- carotenes , lycopene, zeaxanthin , etc.; tocopherols (up to 110 mg%); phyllo-quinone (0.8–1.5 mg%); vitamins B_1 (0.02–0.08 mg %), B_2 (0.03–0.05 mg %), C (50–1000 mg %), choline, serotonin and betaine (up to 700 mg %), nicotine acid, inositol, folic acid; flavonoids: leucoanthocyanins, catechins, flavonols (isoramnetin, quercetin, rutin, kaempferol) flavonoids; coumarins, phenolic acids (caffeic, chlorogenic); sterols (up to 2%); phospholipids; triterpenic acids (ursolic, oleanolic); organic acids (malic, tartaric, tartaric, oxalic, succinic – a total of 3%), mono- and disaccharides, traces of tannins. Fatty oil (12.5%), which is obtained from the seeds, contains a complete set of fat-soluble vitamins and glycerides linoleic and linolenic acids; belongs to drying oils.

Sea buckthorn oil and suppositories with it have anti-inflammatory, bactericidal, epithelizing, granulating and pain-relieving properties. In medical practice, combined preparations containing sea buckthorn oil are used: olazol, hyposol and olebol plates, medical cosmetic cream "Talita". There is information about the effective treatment of patients with atherosclerosis with sea buckthorn oil. Sea buckthorn fruits are widely used in medical and dietary nutrition for stomach ulcers, hypo- and vitamin deficiency.

ROWBERRY FRUITS – FRUCTUS SORBI

Common rowan *Sorbus aucuparia* L., Rosaceae family; the name comes, perhaps, from the Latins. *sorbere* – absorb, since most species are edible, *avis* – bird, *capere* – attract, catch. *A tree or shrub with gray smooth bark. The leaves are alternate odd-feathered, dark green

on the upper side, gray below. The leaves are oblong or elongated-lanceolate, saw-toothed. The flowers are bisexual, regular, five-petalled, white, in a dense multi-flowered shield-shaped inflorescence. Fruits are false, apple-shaped, two- to five-lobed, spherical or oval-spherical, up to 9 mm in diameter, shiny, with a cup that has five inconspicuous closing teeth. It grows in the forest and forest-steppe zones of Ukraine in forests, on shrubs, on the slopes of streams, limestones, high sandy and stony banks of rivers. It is grown as an industrial and decorative plant. Fruits are harvested from both wild and cultivated trees in autumn (September-October), during the period of full ripening, before the onset of frost. Rowan berries are a multivitamin raw material. They contain carotenes (3–15 mg %), folic acid (0.18–0.25 mg %), vitamins C (40–100 mg %), B_2 (0.05–0.07), K (0, 4 mg %) and E (0.8–5.1 mg %), phenolic compounds (catechins, anthocyanins, flavonoids), organic acids (malic, tartaric, succinic, oxalic, sorbic), sugar (5.9–8%), sorbitol alcohol, pectin and tannins, mineral salts, etc. Rowan fruits it is used, first of all, as a multivitamin remedy for hypo- and avitaminosis. Fresh berries are processed into vitamin syrup, dry ones are included in vitamin collections. In addition, the fruits have an astringent, laxative, diuretic, choleretic, hemostatic and estrogenic effect. Preparations made from lipophilic substances of mountain ash reduce the amount of cholesterol in the blood and fats in the liver, which makes them useful for obesity. Infusion, decoction or fruit juice are used for digestive disorders, hepatitis, hepatocholecystitis, difficult bile secretion, stones in the kidneys and bladder, senile atony of the large and small intestines, dysentery, hemorrhoids, uterine bleeding in the climacteric period. Fresh rowan fruits are useful for atherosclerosis, hypertension and kidney stone disease.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING VITAMIN K_1

- *Urtica dioica* – FOLIA URTICAE
- *Zea mays* – STYLE CUM STIGMATIS ZEAE MAYDIS
- *Capsella bursa-pastoris* – HERBA BURSAE PASTORIS

NETTLE LEAVES — FOLIA URTICAE

Dioecious nettle *Urtica dioica* L., Urticaceae family, Nettle duplex; the name comes from Latin *urere* – to smoke; Latin *dioicus* – from the Greek *di* – twice, *oikos* – home. *The plant is a dioecious perennial

herb, covered with stinging hairs. The rhizome is creeping, branched, at the nodes covered with bundles of accessory roots. The stem is erect, obtuse-triangular, 50-170 cm tall, branched. The leaves are opposite, up to 20 cm long and up to 9 cm wide, ovat-lanceolate or broadly ovate, pointed, toothe –serrate, with large teeth wrapped to the top. The flowers are yellow-green, small, unisexual, in branched spike – like racemes, slightly longer than the petioles of the leaves, in the axils of which they are contained; perianth four-parted. It grows throughout the territory of Ukraine in moist places, among bushes, in forests, near fences, along roads, in littered places where there are **a lot of nitrates**. The main harvest is carried out in May-July, because later some of the leaves, especially the lower ones, wither. Nettle leaves contain vitamin K_1 (0.2%), carotenoids (β-carotene, xanthophyll, xanthophyllepoxide, violaxanthin – only 50 mg/%), chlorophyll (5%), vitamin C (0.6%), B_2, B_3; organic acids, glycoside urticin, oxycinnamic acids, flavonoids (quercetin, etc.), tannins (2%), gums, sitosterol, phytoncides, micro- and macroelements (silicon, iron, copper, manganese, etc.). The cell juice of hairs contains formic acid, histamine and acetylcholine. Hydrophilic substances of the roots have the character of lectins and polysaccharides; among lipophilic substances there is a lot of β- sitosterol and other phytosterols. Dioecious nettle has hemostatic, diuretic and tonic properties, it has a weak choleretic effect. In addition, St. Nettle preparations increase the amount of hemoglobin and erythrocytes and normalize the blood composition, reduce the amount of sugar in the blood, have an anti-inflammatory effect, increase the regeneration of the mucous membranes of the gastrointestinal tract, have a vasoconstrictive effect, and contribute to the normalization of the disturbed menstrual cycle. Nettle is mainly used as a hemostatic agent in the form of infusion and liquid extract for pulmonary, intestinal, uterine and other bleeding. Along with this, preparations from nettle leaves are effective remedies for atherosclerosis, iron deficiency anemia, cholecystitis, gastritis, peptic ulcer disease of the stomach and duodenum, diabetes, kidney stone disease, ascites, edema, etc. Nettle leaves are a part of vitamin, gastric, laxative and some other preparations, as well as choleretic drugs Alochol and Phyton-SD. A decoction of nettle leaves is used to wash the head to strengthen the hair, a liquid nettle extract is included in the medicinal shampoo "Fitoval". The young shoots of the plant are eaten. Chlorophyll can be obtained from nettle leaves,

which has tonic properties, stimulates granulation and epithelization of affected tissues and is used in the pharmaceutical and food industries. Water-alcohol extract from nettle roots is used abroad for prostatitis with complicated urination.

COLUMNS WITH CORN RECEIVERS – STYLE CUM STIGMATIS ZEAE MAYDIS

Common corn – *Zea mays* L., Poaceae family, the name comes from the Greek. *zeia* – names of fodder cereals; *mays* – from the Mexican folk name mahiz; Ukrainian – from the Spanish *cucurucho*. *The plant is an annual, monoecious herb. The stem is straight, from 50 cm to 3 m tall, with well-defined nodes and internodes filled with loose parenchyma tissue. The leaves are alternate, broad – leaved, with a wavy edge. The flowers are unisexual, collected in separate inflorescences, which differ significantly in their appearance: male flowers are collected in the apical spread of panicles; female ones are located in the axils of the lower leaves, in the beginnings, covered by the leaf – a visible envelope. Fruits are yellow-yellowish grains, collected in a cob in vertical rows. Comes from Central and South America. It is grown throughout Ukraine as one of the most important grain and silage crops. Corn cobs with receivers contain vitamin K_1 (1600 biological units per 1 g), carotenoids, ascorbic and pantothenic acids, vitamins B_1, B_2, B_6, D, E, alcohol inositol, saponins (3.18%), bitter glycosides (1.5%), flavonoids, traces alkaloids, essential (0.12%) and fatty (3%) oils, sterols – stigmasterol, sitosterol; resins, gums, trace elements (selenium accumulates in large quantities) and other substances. Grains contain starch, carotenoids, vitamins E, B_1, B_2, B_3, B_6, biotin, fatty oil with a significant amount of linoleic and linoleic acid derivatives, pentosans (up to 7%). The liquid extract of corn cobs has choleretic, diuretic and hemostatic properties. The raw material is part of choleretic and diuretic teas, as well as the combined drug "Poliphytol-1". In homeopathy, columns with corn poultices are used for edema of cardiac origin.

BUCKWHEAT GRASS – HERBA BURSAE PASTORIS

Common buckwheat *Capsella bursa-pastoris* (L.) Medik., Brassicaceae family, Capsella is a diminutive from Latin. *capsa* – a bag that characterizes the shape of the fruit; Latin *bursa pastoris* is a shepherd's bag. *It is an annual herb, 10–50 cm tall. The stem is erect, simple or branched, with a ribbed surface, bare or slightly pubescent in the lower part. Basal leaves – in a rosette, elongated-

lanceolate. The flowers are bisexual, small, regular, white, four-petalled in apical tassels. Fruits are pods, inverted-triangular-heart-shaped, slightly notched at the top, flattened, with two flaps that open. Blooms and bears fruit at the same time – from March to May and almost all summer; the fruits ripen before the onset of frost. It grows throughout the territory of Ukraine as a weed in fields, near roads and near houses.

The herb contains vitamin K_1, ascorbic acid, oxycinnamic acids, coumarins, flavonoids (glycosides of quercetin, luteolin, diosmetin, etc.), tannins, amino acids, amines (choline, acetylcholine, tyramine, etc.), saponins, organic acids (fumaric, malic, oxalic, citric, tartaric), essential oil, macro- and microelements (potassium, calcium, iron, copper, etc.). Recently, the opinion has spread that biogenic amines should be considered the main active substances of this plant. Galenic drugs have a pronounced hemostatic effect, lower blood pressure, increase stomach motility and accelerate intestinal peristalsis, stimulate the motor function of the uterus, so they are used for postpartum bleeding, uterine atony, pulmonary, gastrointestinal, and renal bleeding. The leaves of the plant show high phytoncide activity. It is used in the form of an infusion, a liquid extract, and as part of collections. In homeopathy, the entire fresh flowering plant is used in the treatment of gallstones and urolithiasis, uric acid diathesis, hematuria, and uterine bleeding.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING VITAMIN C

- *Rosa cinnamomea*, *Rosa rugosa*, *Rosa canina*, *Rosa villosa* – FRUCTUS ROSAE
- *Ribes nigrum* – FRUCTUS RIBIS NIGRI, FOLIA RIBIS NIGRI
- *Fragaria vesca* – FOLIA FRAGARIAE
- *Primula veris* – RHIZOMATA CUM RADICIBUS PRIMULAE, FOLIA PRIMULAE

FRUCTUS ROSAE

Rosehip cinnamon, syn. rosehip of May *Rosa cinnamomea* L., rosehip wrinkled *Rosa rugosa* Thunb., thorndog tire *Rosa canina* L., rosehip *Rosa villosa* L., Rosaceae family. The name comes from the Greek. *rhodon*, which is possibly related to Celtic – who *rhod* means *red*, Latin. *cinnamomea* – because of the brown color of the branches, similar to cinnamon. The rosehip family is divided into two sections:

Cinnamomeae (cinnamon rosehips) and *Caninae* (dog rosehips). *Types of cinnamon rose – prickly bushes with a height of 0.5–2m. Branches are brownish-red, with numerous small, somewhat bent spines, which usually sit two at a time at the base of the leaves. Fruits (hypanthia) are fleshy, spherical, oval or ovoid (rarely spindle-shaped), glabrous, glabrous, 0.7–3.0 long, 0.6–1.7 cm in diameter, from yellow – tawny to brownish – red color; inside, the fruits are densely covered with long, very stiff, bristly hairs; the seeds are small, hard, shaped like angular nuts. Blooms in May-June, fruits ripen in August – sprin.

The species of the Cinnamomeae section contain a particularly large amount of ascorbic acid in their fruits (cinnamon rosehip – up to 14%, wrinkled rosehip – up to 6%), the vitamin C content in the fruits of Caninae section species does not exceed 1%. Rosehip fruits also contain carotene (0.7–8 mg%), vitamins B1, B_2, PP, K_1, pantothenic acid, flavonoids (quercetin, kaempferol and their derivatives; anthocyanins; catechins), phenolic acids, pectin substances (1.5–4%), sugar (0.9–18%), organic acids (0.9–3.7%), tannins, salts of iron, manganese, phosphorus, magnesium, calcium. The seeds contain a fatty oil rich in carotenoids and vitamin E. The fruits of rose hips have an anti-singing, anti-sclerotic, anti-inflammatory effect, activate enzyme systems and redox processes in the body, have a beneficial effect on carbohydrate metabolism, enhance the synthesis of hormones and tissue regeneration, stimulate the body's resistance to adverse environmental factors, increase bile secretion, increase diuresis. Rosehip fruits are used for the prevention and treatment of hypo- and vitamin C and R deficiency, atherosclerosis, nephritis, acute and chronic diseases of the liver, intestine, peptic ulcer, hemorrhagic diathesis, hemophilia, bleeding (pulmonary, uterine), overdose of anticoagulants, hyperthyroidism and adrenal insufficiency, traumatic shock. Rosehip fruits are part of the vitamin collection, as well as the hypoglycemic collection "Arfazetin". A syrup made from a concentrated aqueous extract of the fruits of the rose hip – holosas is prescribed for cholecystitis and hepatitis. Vitamin syrup with the addition of sugar and ascorbic acid is also prepared from the juice of the fruits of high-vitamin species of rose hips.

Oil is made from rosehip seeds, which is used as an external remedy for wound healing, for cracked nipples, bedsores, trophic ulcers of the leg, dermatoses, in dental practice, and in the form of

microclyses for non-specific ulcerative colitis. Carotolin is an oil extract of carotenoids from the pulp of koti fruits, used similarly. Kanefron is a sum of carotenoids from the fruits of rose hips without nuts, has a similar application to carotolin. A group of drugs was developed from the waste of the holosas production under the general name "Lipochromin", which is considered a means for the prevention and treatment of radiation sickness. It is also used in chemotherapy of malignant neoplasms of various localization, post-radiation disorders of the gastrointestinal tract, hematopoietic system and immune status. It is recommended to use this tool to adapt the body to dangerous environmental conditions.

BLACK CURRANT FRUITS – FRUCTUS RIBIS NIGRI

BLACK CURRANT LEAVES – FOLIA RIBIS NIGRI

Black currant *Ribes nigrum* L., Grossulariaceae family, the name comes from the Latinized Arabic *ribas* – sour in taste; Latin *niger*, - *gra*, - *grum* – black. *Plant. A small, 0.6–2 m tall perennial bush. The stems are dark brown or red-brown, the bark of young stems is yellowish-gray. Lower branches sometimes lie on the ground. The leaves are petiolate, alternate, up to 10 cm long. Fruits are berries in panicles, spherical, black, 7–10 mm in diameter, with a whitish tip membranous cup; the surface is covered with patches with essential oil; the pulp contains numerous small seeds. Blooms in May-June, fruits ripen in July-August. The fruits contain ascorbic acid (up to 500 mg %), vitamins of groups B, K, E, carotene; sugar (17%), pectins, fatty oil, anthocyanins – derivatives of cyanidin and delphinidin, flavonols kempferol, quercetin, myricetin and their derivatives, coumarins oxycinnamon acids, organic acids (malic, tartaric, citric, oxalic, etc. – only 4%), essential oil, enzymes (emulsin), mineral substances. Essential oil (0.75%) containing linalool was found in the leaves. geranium, limonene, cymol, sabinene, etc.; flavonoids (quercetin, isoquercetin, rutin, kaempferol, astragalin, myricetin), oxycinnamic acids, tyrosol, gallic acid, methyl gallate, coumarins, phytosterol, pentosans, organic acids, vitamin C (400 mg%), carotenes, sugar, enzyme emulsin and dusty substances. All types of raw materials have diuretic, diaphoretic, antimicrobial, capillary-strengthening, astringent and tonic properties, increase immunity. Fresh and dried fruits are useful for hypochromic anemia, periodontitis, diseases of the gastrointestinal tract, glomerulonephritis, heart rhythm disorders, hypertension,

cardioneurosis, hemorrhagic vasculitis, colds and infectious diseases. Raw materials are mainly used in assembly. At the Department of Pharmacognosy of the National Academy of Sciences of Ukraine, blackcurrant leaves made the antiallergic drug glucoribin, as well as the tincture of the leaves – *riflan* for use in proctology as a regenerative and anti-inflammatory agent.

STRAWBERRY LEAVES – FOLIA FRAGARIAE

Forest strawberries *Fragaria vesca* L., Rosaceae family, Forest strawberry; name comes from the Latins. *fraga*, - *orum* – the fruit of strawberries, *fragara* – which is fragrant; Latin *viscus*, -a – edible, from *vescor* – to eat. *The plant is perennial, herbaceous, with a short horizontal or oblique root and long creeping shoots rooted in the nodes. The stems are erect or ascending, 5–20 cm high, slightly exceeding the base of the leaves, covered with truncate hairs on the bottom, and compressed hairs on the top. Leaves trifoliate, basal – onlong, deviated hairy petioles; Flowers are regular, bisexual. Blooms in May-June, fruits ripen in June-July.

The leaves contain ascorbic acid (up to 280 mg in fresh leaves), flavonoids, alkaloids (traces), organic acids, sugar, tannins. Galen preparations made from strawberry leaves dilate peripheral blood vessels, lower blood pressure, slow down the rhythm and increase the amplitude of heart contractions, increase the tone and strengthen the contraction of the uterus, promote the excretion of salts from the body, have diuretic, choleretic, diaphoretic, anti-inflammatory and hypoglycemic properties. Strawberry fruits and leaves are widely used in dermatology and cosmetics. In homeopathy, fresh fruits are used for urticaria-like rashes, weakening of digestive activity and blood circulation disorders.

RHIZOMES WITH PRIMROSE ROOTS – RHIZOMATA CUM RADICIBUS PRIMULAE

PRIMULA LEAVES – FOLIA PRIMULAE

Spring primrose *Primula veris* L., syn. medicinal primrose *Primula officinalis* Jacq, Primulaceae family, primrose spring (primrose medicinal); the name comes from Latin. *primus* – the first; *veris* – from *ver* – spring. *A perennial herbaceous plant. It has a short horizontal dark brown rhizome, 6–8 cm long, with juicy cord–like roots. The flower arrow is straight, leafless, 5–20 cm high. The leaves are collected in a shallow rosette. Flowers regular, bisexual. The fruit is an egg-shaped capsule as long as the calyx. Blooms from mid- April

to June. Fruits ripen in June-August. Rhizomes with primrose roots are dug in the spring before the plant blooms or in the fall, when the leaves have faded. The leaves are collected at the beginning of flowering of the plant. All parts of the spring primrose contain a significant amount of ascorbic acid (up to 6% in the leaves). The roots of primrose contain up to 10% triterpenes saponins, the aglycones of which are primulagenins A, D and SD, glycosides (primulaverine, primverine, essential oil (0.08%) and carotene. The leaves contain saponins (up to 2%), flavonoids, carotene (up to 3 mg), macro- and microelements; flowers contain saponins, flavonoids and essential oil.

Leaf infusion is used for the prevention and treatment of hypo- and vitamin deficiency; decoction of rhizomes is mainly used as a good expectorant for diseases of the lungs and respiratory tract. It is included in the British Herbal Pharmacopoeia as a sedative, antispasmodic and hypnotic agent. The plant is edible and honey-bearing.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING DIFFERENT GROUPS OF BIOLOGICALLY ACTIVE SUBSTANCES

Kalanchoe pinnata – CORMUS KALANCHOES RECENS

Sedum maximum – HERBA SEDI MAXIMI RECENS

Inonotus obliquus – FUNGUS BETULINUS

Bryonia alba – RADICES BRYONIAE RECENS

Symphytum officinale – RADICES SUMPHYTI

Phaseolus vulgaris – PERICARPIUM PHASEOLI, HERBA PHASEOLI

Arctium lappa – RADICES BARDANAE

Arthemisia vulgaris – HERBA ARTHEMISIAE VULGARIS

Lamium album – FLORES LAMII ALBI

Levisticum officinale – RADICES LEVISTICAE

ADDITIONAL PRODUCTS OF BEEKEEPING

Bee glue – PROPOLIS

BEE POLLEN

FRESH KALANCHOE SHOOTS – CORMUS KALANCHOES RECENS

Kalanchoe *Kalanchoe pinnata* (Lam.) Pers., syn. *Bryophyllum pinnatum* Lam., family thick-leaved Crassulaceae; the name comes from the Chinese name of the plant –*kalanchoë*; bryophyllum – from the Greek *bryein* – to grow and *phullon* – a leaf. *The plant is a perennial herbaceous evergreen succulent. The stem is erect, strong,

fleshy, 50–150 cm tall, often woody at the base. The leaves are opposite, short-petiolate, thick, juicy. Comes from tropical Africa. Cultivated in the tropics of Asia, America, Australia. In Ukraine, it is grown as an annual crop in greenhouses. The aerial part of the plant contains polysaccharides, lectins, catechins, flavonoids, organic acids (malic, oxalic, citric, acetic), enzymes (dehydrase, carboxylase, etc.), ascorbic acid, trace elements. Kalanchoe juice has an antiseptic and anti-inflammatory effect, promotes tissue regeneration. It is used for the treatment of non-healing wounds, bedsores, in surgical, stomatological and obstetric-gynecological practice.

HERB OF THE LARGE FRESH CHERRY – HERBA SEDI MAXIMI RECENS

Sedum maximum (L.). Hoffm, family broad-leaved Grassulaceae; the name comes from Latin. *sedare* – to tire, soothe the pain; *maximus*, *-a*, - *um* – very large, the largest. *The plant is a perennial herb succulent. You believe the roots – rather thickened. The stems are powerful, straight or arcuately bent at the base, branched at the top, green or purple, 40–80 cm tall. Leaves are juicy, fleshy, flat, opposite. The corolla is white-pink. Grows in forests among shrubs, scattered in Polissia and Forest Steppe, mainly west of the Dnieper. The herb contains piperidine alkaloids (one of which is sedamine), flavonoids (quercetin, kaempferol, myricetin, isorhamnetin and their glycosides), catechins, coumarins (coumarin, esculetin); phenolic acids, arbutin, tannins, organic acids, vitamin C, polysaccharides (15.4%), specific sugar sedogep – tulose; trace elements. Biosed is an aqueous extract from preserved fresh grass, which exhibits a biostimulating, general tonic and anti-inflammatory effect.

CHAGA (BIRCH MUSHROOM) – FUNGUS BETULINUS

Sterile form of the phytopathogenic fungus *Inonotus obliquus* (Pers.) Pil., Hymenochaetaceae family, Chaga, black birch mushroom. *A perennial parasitic fungus that develops on the trunk of a birch in the form of growths, the shape of which depends on the nature of the damage that caused the tree to become infected. Spores of the fungus penetrate into the wood and destroy it at the hidden places of the bark of trees. Hard, black growths appear at the site of tree infection, which gradually increase in size and have a hilly surface with numerous shallow cracks. Most often, they are rounded, elongated or globular, with irregular contours, up to 30–40 cm long, 10–15 cm wide. Three layers are visible on the section: the outer one is black,

very hard, 1–2 mm, which cracks a lot; medium – dense, brown-brown, with small yellow veins of varying thickness, the number of which increases towards the inner part of the growth – that, most often stretches along the entire growth to the trunk of the tree; internal – rotten, brown or yellowish, spreads inside the tree in the form of rotten wood. The growth period of the mushroom is 10–15 years. The weight can reach 5 kg. Occurs throughout the forest zone of Europe and Asia. It develops on living adult trunks of birch, less often alder, rowan, elm, maple.

The chaga main biologically active substances are considered water-soluble intensely colored chromogens, which were formed from a complex of active aldehydes, polyphenols, hydroxyphenol-carboxylic acids and quinones. All compounds are genetically related to hydroxyaromatic precursors of the biosynthesis of tannins and lignans of birch bark and wood. The fruit body of the mushroom includes polysaccharides, free phenols, and triterpenoid inontodiol, sterols, organic acids, lignin, cellulose. Humic substances consisting of high-molecular oxycarboxylic aromatic acids were also isolated. The antitumor effect is associated with the content of pterins, which are derivatives of pteridine. Free pterin is a fragment of folic acid, some pigments. Befungin is a semi-thick extract with the addition of cobalt salts, used as a general tonic and pain reliever for chronic gastritis, dyskinesia of the gastrointestinal tract with atony, and peptic ulcer disease. It is also prescribed to cancer patients to improve their general condition.

FRESH BRYONIAE ROOTS – RADICES BRYONIAE RECENS

Crossing white *Bryonia alba* L., Cucurbitaceae family; the name comes from the Greek. *bryein* – grow, turn green (for green non-drying shoots); Latin *albus*, - a, - um – white. *Perennial herb – a slender monoecious liana with a thick, fleshy turnip-like root, up to 50–70 cm long and 3–4 cm in diameter, yellowish on the outside, white on the inside. The stems are numerous, climbing, with spirally twisted tendrils 5–6 cm long. The leaves are alternate, petiolate, ovate. The flowers are unisexual (the plant is monoecious), regular. Blooms in June-July. Fruits ripen in July– September. The roots contain triterpenoids: cucurbitacins B, L, D (elatericin A), E (α-elaterin), I (elatericin B), etc.; alkaloids (0.24%), essential oil (0.34%); choline, 3-hydroxyoctadecadienoic acids, lipids, steroids, flavonoids, coumarins, polysaccharides, sucrose. Loshtak (tablet form)

is used as a tonic, radioprotective and immunomodulating agent. Tincture of fresh roots has pain-relieving and local irritant properties, it was included in the drug Akofit, which is used to treat sciatica, rheumatism, and neuritis. In homeopathy, fresh roots are used for inflammatory processes of the joints, abdominal and meninges, croup pneumonia, pleurisy, peptic ulcer disease.

THE ROOTS OF LIKARISKYO'S LIVESTOCK – RADICES SYMPHYTI

Medicinal periwinkle *Symphytum officinale* L., Boraginaceae family; the name comes from the Latin transcription of the Greek name of the plant symphyton from *symphyein* – to grow together, which most likely indicates the thickened thickets of the plant. *The plant is a perennial herb. It has a short rhizome with a rough (up to 2 cm thick at the top), fleshy, branched, wrinkled black-brown root, grayish-yellow at the fracture. The stem is straight, 40–100 cm tall, branched, ridged below. The leaves are large, alternate. The flowers are regular, drooping, collected in curls at the top of the stem and branches. Throughout Europe, in the Caucasus, in Siberia, Central Asia, it grows on moist soil along the banks of rivers, in meadows, among shrubs. In the spring, at the beginning of the growing season (April-May), or in the fall, when the above-ground part dies, the roots are dug up. The roots are rich in allantoin (up to 6%), which is similar in structure to purpurin; contain pyrrolizidine alkaloids (0.3%) viridiflorine, echinatine and others in the form of N-oxides; there are triterpenes, phenolcarboxylic acids, carbohydrates (16%), mucous glucofructosans.

Roots were also used by Paracelsus to treat wounds, ulcers, and various bone diseases. The raw material is official in the countries of Eastern Europe. It is used only externally in the form of compresses, ointments for bone fractures, dislocations, sprains and rupture of ligaments (due to the regenerating effect of allantoin). In homeopathy, fresh roots, collected before the beginning of flowering of the plant, are used for bone injuries, as well as gastritis, peptic ulcer disease, and hemorrhoids. Roots of a close species – rough comfrey (*Symphytum asperum*) is a component of the collection according to Zdrenko's prescription.

BEAN SHELL – PERICARPIUM PHASEOLI, HERBA PHASEOLI

Common bean *Phaseolus vulgaris* L., legumes Fabaceae family, the name comes from the Greek. *phaseolos* – beans; Latin *vulgaris* is common. *The plant is an annual herb. The stem is erect, branched,

untwisted, 30–80 cm tall (bush form). The leaves are long-petioled. Comes from South or Central America. In Ukraine, it is grown as a food crop. The herb contains flavonoids (kaempferol-3-glucuronide, quercetin-3-glucuronide, robinin); caffeic, ferulic, chlorogenic and neochlorogenic acids; coumarins (umbelliferon, scopoletin, isoscopoletin, esculetin; amino acids, trace elements (copper, cobalt, nickel, silicon). The husk is rich in nitrogen-containing compounds (amino acids, choline, trigonelline, piperidine alkaloid, pipercolinic acid, allantoin), higher fatty acids and unsaturated dicarbonate traumatic acid. Toxalbumin is present in fresh unripe fruiting bodies Fazin. Bean grass is a raw material for the manufacture of the drug glifazin, which is used in mild and moderate forms of diabetes and edema caused by kidney diseases. Lush-drinking reveals the properties of "vegetable insulin" – it reduces the concentration of glucose in the blood, it is part of the antidiabetic collection Arfazetin.

BURDHY ROOTS – RADICES BARDANAE

Burdock large *Arctium lappa* L., syn. *Lappa major* Gaertn., Asteraceae family; the name comes from the Latinized name of the plant *arktion* – burdock; *lappa* is the Latin name for burdock. *The plant is a two -year-old herb. The roots are branched, fleshy, spindle-shaped, grayish-brown outside, pale gray inside. The stem is erect, up to 2 m tall. It occurs almost throughout Ukraine, occasionally in the southern steppe areas. It grows in gardens, orchards, garbage dumps, near houses, near roads, along the banks of rivers and streams, in forests. In autumn, the roots of plants of the first year of vegetation are harvested, in spring, at the beginning of vegetation, roots of the second year.

The roots contain many polyacetate-linoleic hydrocarbons, the main of which are C_{17}-alkynes, acetyl-linoleic acid, etc. The raw material contains essential oil, bitter sesquiter – a foamy lactone of the germacranolide type – arctiopicrin, flavonoids, inulin (about 20%), fatty oil, compounds containing sulfur. Specific lignan glycosides were isolated from the seeds, one of which is arctiin. Burdock roots have a diuretic, choleretic, disinfectant and diaphoretic effect, stimulate the formation of proteolytic enzymes and insulin, actively influence metabolism. Some polyacetylenes have a strong antibiotic and fungistatic effect, but they are unstable in their individual state. An infusion of the roots with Provencal oil is used externally *Oleum Bardanae* under the name "*burdock oil*" for the treatment of circular

or nested baldness, lichen planus of the face, seborrhea, baldness, for better hair growth. "*Burdock oil*" is also obtained from other types of burdock: cobweb burdock (*Arctium tomentosum* L.), small (*A. minus* L.) and wood (*A. nemorosum* L.).

COMMON WORMONY GRASS – HERBA ARTHEMISIAE VULGARIS

Common wormwood, Chernobyl *Arthemisia vulgaris* L., Asteraceae family, named so in honor of *Artemisia, wife* of the Carian king Mausolus (about 352 BC). *The plant is a perennial herb. The rhizomes are almost vertical, multiheaded, lignified, cylindrical, with numerous brown adventitious roots. Stems several. The edge flowers of the baskets are female, with a narrow-tubular and two-toothed corolla, the middle ones are bisexual. The grass is harvested at the beginning of flowering (July-August).

The herb contains essential oil (0.1–0.3%), which contains phellandrene, pinene, cineole, camphor, cadinene, thujone and its esters; bitter sesquiterpene lactone psilos – tachyine, flavonoids (glucosides of quercetin, isorhamnetin), rutin, chalcones with an isoprenoid radical (cordoin, isocordoin and their derivatives); coumarins (umbelliferon, scopoletin, esculin, esculetin, etc.), polysaccharides, resinous and tannic substances. The herb is official in many European and American countries as a bitter that stimulates the appetite. In the experiment, it shows antitumor and antiulcer effects. It is used in oriental medicine. In homeopathy, fresh grass with roots is used for epilepsy, in gynecology for uterine bleeding, threat of miscarriage.

WHITE DEAF NETTLE FLOWERS – FLORES LAMII ALBI

Stinging nettle is white *Lamium album* L., clear-leaved Lamiaceae family (deaf nettle). *The plant is perennial, herbaceous, rhizome, soft pubescent. The stems are four-sided, straight, 15–50 cm high. The leaves are opposite, petiolate. Flowers 6–16 in axillary rings, almost sessile, with linear – acuminate bracts. The corolla is double-lipped, white or yellowis-white, pubescent on the outside. The most important class of flowers biologically active substances are flavonoids (isoquercitrin, quercetin, kaempferol, astragalin); they also contain a significant amount of mucus (up to 10%), iridoids (lamiol, lamioside), saponins, tannins, essential oil, ascorbic acid, traces of alkaloids, chlorogenic and gallic acids. Choline, histamine, tyramine make a certain contribution to the pharmacological activity of raw materials. The raw material is imported to the countries of Western Europe,

where it is used as a diuretic and hemostatic agent for hemorrhoids, urethritis, nephritis, cystitis; it also has a weak hypotensive effect, which is associated with the content of triterpene saponins.

LABORATORY ROOTS – RADICES LEVISTICAE

Medicinal lovage *Levisticum officinale* Koch., umbrellas Apiaceae family, the name comes from the Greek name of the plant *liby* – stikon; Latin *officinalis*, *-e* – pharmacy, medicine. *A perennial 1–2 m tall plant, with a thick rhizome up to 5 cm long and large, branched, fleshy roots up to 40 m long and about 3 cm wide. The stem is erect, branched in the upper part. The flowers are bisexual, regular, whitish-yellow, small, collected in complex umbrellas at the top, which are surrounded by multi-leaf envelopes at the base. It comes from the mountainous regions of Southern Europe. In Ukraine, it is cultivated as a spicy, essential oil, decorative plant. The roots are dug up in autumn, when the plant reaches three or four years of age.

The content of essential oil in the roots exceeds 1 %. Its main components are phthalides (70%), among which ligustilid, 3-butylphthalid, cnidium lactone, sedanolid are identified; α- and β-pinene, α- and β- phellandrene, etc. In addition, the raw material contains coumarins (psoralen, bergapten), caffeic and chlorogenic acids, β- sitosterol glucoside. The raw material is official in European countries, has diuretic activity; the extract is included in the drug canefron, which is used in chronic kidney diseases.

Additional products of beekeeping

*PROPOLIS – PROPOLIS

Propolis (bee glue) is a wax-resinous substance produced by worker bees. They collect it from trees, mainly poplars, birches and willows, to seal and disinfect hives. During the summer, one hive contains 100–150 g of propolis. Fresh propolis has a dough-like consistency, dark yellow or red color, pleasant smell and bitter taste. As a result of oxidation and condensation, the raw material hardens, changes color to dark brownish-green. At a temperature of 40 °C, propolis is plastic; becomes brittle after cooling to 15 °C; the heating temperature is within 80–100 °C; easily mixes with wax; insoluble in water, soluble in alcohol.

Propolis has a heterogeneous composition that approaches the chemical composition of poplar, birch or willow buds and depends on the ratio of tree species near the apiary. Contains a lot of resinous substances (40–53%), essential oil (8–10%) and wax (23–30%), as

well as phenolic compounds (14–16%), polysaccharides (2–2.5%), impurities pollen, volatile substances. The biological effect is provided by flavonoids (flavonones pinobanksin, pinocembrin, flavonoids chrysin, flavanol-galangin, etc.), sesquiterpenoids (betulene, betulenol), enzymes. Microelements contribute to activity: manganese, copper, zinc, cobalt, etc. Propolis has a wide spectrum of pharmacological activity: bacteriostatic and bactericidal properties are in the first place, its antimicrobial, antiviral, antimycotic, anti-inflammatory and antispasmodic effects have been proven. Medicines increase the immune defense of the body. Propomisol and proposol aerosol preparations, and proposeum ointment are used as anti-inflammatory, antimicrobial, and reparative agents.

Some people are hypersensitive to propolis.

*BEE POLLEN

Pollen belongs to additional products of beekeeping. It contains proteins, amino- and nucleic acids, nucleoproteins, enzymes, hormone -like substances, fatty acids (linoleic and linolenic), lipids and lipoids (among them phospholipids, sterols), vitamins (carotenoids, tocopherols, ascorbic, pantothenic, folic, nicotinic acid), phenolic and triterpene compounds, mineral elements. Pollen is pollen that bees collected and processed with the secretion of their salivary glands. Bees form balls from such pollen, carry them on their legs to the hive, place them in wax shells and fill them with honey. Under the action of enzymes and acids that contain honey and bee saliva, honey turns into perga, or "bee bread". The number of simple sugars, lactic acid, simple peptides and amino acids that are formed after the breakdown of complex proteins increases in the pulp. Pollen has a regenerating effect on the functions of the liver, kidneys, digestive tract, and stimulates hematopoiesis. Pollen and pollen regulate lipid metabolism. It is advisable to take pollen, beetroot, and perga as food supplements for exhausted patients, children, and the elderly. Polenapin – tablets that contain obnezhe. The drug is used for the treatment of diseases of the stomach and liver, as well as as a tonic. Micropol, apicomplex – contain pollen, royal jelly, propolis, honey. It is used for general weakness in elderly people, children, patients, and chronic infectious diseases. In the form of tablets, capsules, extracts, it is used as a food supplement that has a tonic effect. Preparations, which include flower pollen, are contraindicated in case of a tendency to allergic reactions.

Independent work

Theme 2 MEDICINAL PLANTS AND RAW MATERIALS CONTAINING CARBOHYDRATES

1. Physicochemical properties, biological action and use of monosaccharides
2. Physicochemical properties, biological action and use of oligosaccharides
3. Physicochemical properties, biological action and use of polysaccharides
4. Medicinal plants and raw materials containing carbohydrates

Literature and Internet resources:

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.56–95. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/Фармакогнозія-з-основами-біохімії-рослин.pdf (in Ukrainian)

Carbohydrates (glycides) are a group of primary products of photosynthesis consisting of carbon, hydrogen, and oxygen. The name "carbohydrates", i.e. the combination of carbon and water, is associated with their general formula $C_m(H_2O)_n$. Carbohydrates are divided into monosaccharides, oligosaccharides and polysaccharides according to their molecular size and the ability to hydrolyze to form different amounts of monomers.

1. Physicochemical properties, biological action and use of monosaccharides

Monosaccharides (monosaccharides, sugars) are polyhydroxyaldehydes or polyhydroxy ketones with the general formula $C_nH_{2n}O_n$ (n = 3–9). According to the presence of aldehyde or ketone groups, monosaccharides are divided into aldoses and ketoses. Most monosaccharides contain a straight chain of carbon atoms, but branched sugars are also known, for example, in the glycoside apiin, from the roots and leaves of parsley (*Petroselinum crispum*, synonym for *Petroselinum sativum*, Apiaceae); apiose is found in seaweed, and streptose is found in the antibiotic streptomycin.

Monosaccharides occur in the free state or are part of oligosaccharides, polysaccharides, and mixed compounds containing carbohydrates, such as glycosides and glucoproteins. They are

involved in the secondary biosynthesis of glycosides, amino acids, and polyphenols. These transformations usually involve nucleoside diphosphosaccharides.

In plants, monosaccharides are found in the free state and in the form of high molecular weight polysaccharides, such as pentosans and hexosans. The most important repr esentatives of **pentoses** are D-xylose, L-arabinose, D-arabinose and D-ribose, and methylpentoses are L-rhamnose and L-fucose.

D-xylose (wood sugar) is a component of the common disaccharide primrose, involved in the synthesis of polysaccharides (xylans), gums, pectins and hemicelluloses. L-Arabinose is a component of natural gums, glycosides (arabinosides) and polysaccharides (arabans, mucilage). D-Arabinose is rarely found in nature. D-Ribose is involved in the synthesis of nucleic acids and vitamin B12. Methylpentoses can be considered as 6-deoxyhexoses. L-Rhamnose is a part of glycosides and polysaccharides. L-Fucose forms milk oligosaccharides, plant and animal polysaccharides.

Hexoses – glucose and fructose – are used in the form of excipients or independent drugs.

D-Glucose (dextrose, grape sugar), $C_6H_{12}O_6$, is a carbohydrate of the monosaccharide group, which belongs to the aldoses. In the free state, it is found in the cytoplasm of plant cells and animal blood; in the bound state, it is a component of sucrose, starch, fiber, glycogen, dextrins, and many glycosides; the main source of energy for most organisms.

In case of hypoglycemia, infections, intoxication, hemorrhagic diathesis, cardiac decompensation, kidney disease, pulmonary edema, isotonic (4.5-5%) and hypertonic (10-40%) glucose solutions are used. It is a component of blood substitutes and a nutrient.

D-Fructose (levulose, fruit sugar, fruit sugar) is a carbohydrate from the group of monosaccharides, which belongs to ketone hexoses. Fructose is the sweetest sugar; it is 2.5-3 times sweeter than glucose and 1.5 times sweeter than sucrose. It is found along with glucose in fruits, flower nectar, green parts of plants, and is the main component of bee honey. Fructose in the form of D-fructofuranose is a component of the disaccharide sucrose and raffinose, as well as many polysaccharides called fructans. The most famous fructan is inulin.

Fructose is involved in carbohydrate metabolism; it can be converted into glucose. It is better absorbed by diabetics than glucose, so it is used as a sugar substitute in medical nutrition. Fructose makes up more than a third of honey.

2 Physicochemical properties, biological action and use of oligosaccharides

Oligosaccharides (oligosides) are polymeric low-molecular weight carbohydrates. Depending on the number of monosaccharide residues that make up the molecule, disaccharides or bioses, threesaccharides or trioses, tetrasaccharides or tetrozes, pentasaccharides or pentoses, hexasaccharides or hexoses, as well as heptoses, octoses, nonoses and decoses are distinguished, respectively. Compounds containing more than 10 monosaccharides are referred to as polysaccharides. Oligosaccharides, mainly in the form of di- and threesaccharides, are very common in the free state and as structural components of complex proteins, mucopolysaccharides, glycolipids, glycosides and other substances of microorganisms, plants, animals, which are of great biological importance. The properties of oligosaccharides depend on the properties of the monosaccharides that make up their composition. Most oligosaccharides are a source of energy. Some of them are obtained in large quantities, for example, sucrose from sugar beet (*Beta vulgaris* var. *saccharifera*, family Amaranthaceae), sugar cane (*Saccharum officinarum*, family Poaceae), lactose from milk, etc.

Sucrose (beet sugar, cane sugar), $C_{12}H_{22}O_{11}$, is a carbohydrate of the disaccharide group, disaccharide, the most common sugar of plant origin. Sucrose is formed in plant leaves as a result of photosynthesis from D-glucopyranose and D-fructofuranose. Sugar beet roots (up to 24%) and sugar cane stalks (up to 20%) are the richest in sucrose. Sucrose is well absorbed by the body and is a valuable food product. Sugar syrup is used to make medicines as a corrective agent and powdered sugar is used to make tablets. The industry produces syrups of rose hips *Rosa majalis*, marshmallow root *Althaea officinalis*, and aloe with iron *Aloe arborescens*. There is a complex preparation called Alsucral (Venture, sucralfate), in which sucrose sulfate is combined with aluminum oxide hydrate.

Maltose (malt sugar) is produced by hydrolysis of starch in the form of molasses, disaccharide, which is used in the food industry and

for technical needs. Cellobiose differs from maltose in the β-glycosidic bond between glucose molecules. It is obtained from cellulose.

Other homodisaccharides are known, which are built from D-glucose residues, but with a different type of bond, for example, sophorose (1 → 2), genziobiose (1 → 6). They are often found in flavonoid glycosides.

Rutinose is a disaccharide that forms the sugar part of the well-known and widespread flavonol rutin in plants. Primrose is a disaccharide isolated from the hydrolysis products of many phenolic glycosides.

3. Physicochemical properties, biological action and use of polysaccharides

Polysaccharides $(C_nH_{2n-2}O_{n-1})_m$ are natural polymeric high molecular weight carbohydrates built from monosaccharides connected by glycosidic bonds and forming linear or branched chains.

Polysaccharides are divided into homopolysaccharides, which are built from a single sugar, and heteropolysaccharides, which include residues of different monosaccharides (from two to six). The most common plant polysaccharides are hexoses: glucose, galactose, mannose, galacturonic acid; pentoses: arabinose, xylose; deoxyhexoses: rhamnose, fructose; 2-amino sugars: glucosamine, galactosamine. Many polyols have non-carbohydrate substitutes – residues of sulfuric or phosphoric, organic acids, most often acetic acid.

Polysaccharides are part of the tissues of all living organisms. According to their physiological role in plant life, polysaccharides are divided into: metabolites – monosaccharides and oligosaccharides involved in biochemical processes and are derivatives of secondary synthesis; reserve substances – groups of polysaccharides that perform a reserve function (starch, inulin, some galactomannans, pectin substances, sometimes mono- and oligosaccharides); structural substances – cellulose, hemicellulose and pectin, which are the supporting material of cell membranes in higher plants; the cell membrane of fungi is built of chitin.

The biological functions of polysaccharides are diverse: energy reserve of cells – starch, glycogen, laminarin, inulin, some plant mucus; protective – capsular polysaccharides of microorganisms, hyaluronic acid and heparin in animal tissues, gums in plants; water balance is maintained by anionic compounds (mucus, pectin, algal

polysaccharides), as well as selective ionic permeability of cells; ensuring specific intercellular interactions and immunological reactions: complex polysaccharides form cell surfaces and membranes; glycolipids are the most important components of nerve cell membranes and red blood cell membranes; cell surface carbohydrates often cause cell interaction with viruses.

The high molecular weight structure and complexity of polysaccharides make them poorly understood. The study of polysaccharides consists of three stages: extraction, purification, and analysis. The extraction is carried out with cold or hot water. The extract is contaminated with proteins, mineral salts, and water-soluble dyes. To purify the extract, dialysis, fractional precipitation with alcohol or quaternary ammonium bases, ultrafiltration, enzymolysis, etc. are used. There is a standard method for the study of polysaccharides developed by Jermyn and Isherwood. Dried plant material is extracted for 12 hours with boiling water. The resulting extract is sometimes referred to as pectins without regard to their structure. This complex is precipitated with alcohol and separated by centrifugation. The remaining plant material is chlorinated under mild conditions. This leads to the complete extraction of lignin and the breaking of any bonds between cellulose and cell membrane polysaccharides, which are called hemicelluloses. After that, the hemicelluloses are extracted with a 4 M alkaline solution at room temperature for several hours. The insoluble cellulose is removed by centrifugation.

The study of the structure of polysaccharides includes the determination of molecular weight, monosaccharide composition, the nature of the bonds between monosaccharide residues, the order of their location in the chain, and the type of branching of the molecule. Chemical and physicochemical methods of analysis are used. Modern methods for determining the structure of polysaccharides include infrared spectroscopy, NMR spectroscopy, lectin, and immunochemical methods.

In pharmaceutical practice, polysaccharides are used as independent medicines and as an auxiliary material in the technology of drug manufacturing. Polysaccharide-based medicines have emollient, wound healing, anti-ulcer, enveloping, expectorant, analgesic, laxative effects, etc. Exogenous polysaccharides, when introduced into the body, reduce inflammation, accelerate reparative

processes, affect the immune system, and inhibit tumor growth. The protective effect of polysaccharides on the digestive system, especially sulfated glycans, is due to their ability to form substances with new physicochemical properties with proteins that can limit the digestive activity of pepsin. Carbohydrates, due to their interaction with heavy metal ions, are used to treat and prevent lead poisoning and toxicosis caused by radiological isotopes.

Polysaccharide complexes with proteins and biogenic elements that have immunomodulatory effects have been isolated from the vegetative organs of plants of the Asteraceae, Fabaceae, Periwinkle, Apocynaceae and Rutaceae families. There have been attempts to create antitumor drugs based on polysaccharides from medicinal dandelion *Taraxacum officinale*, poppy seeds *Papaver somniferum*, and black currant leaves *Ribes nigrum*. In the experiment, the hypoglycemic effect of glycans from aloe leaves *Aloe arborescens*, corn stalks *Zea mays*, and sparrow root *Lithospermum officinale* was proved. Corn polysaccharides have a hypocholesterolemic effect. As auxiliary raw materials containing biologically active polysaccharides, it is proposed to use meals (solid residue of oilseeds after oil extraction), for example, from sea buckthorn *Hippophae rhamnoides* after oil extraction, from flowers of sandy carnation *Helichrysum arenarium* in the process of producing the drug flamin.

Compared to synthetic polymers, polysaccharides have advantages in use: plant glycans are subject to microbiological and enzymatic degradation and are completely excreted from the body; they are mostly non-toxic, their metabolites do not harm the body; most polysaccharides used in medicine are water-soluble; if insoluble, they can easily become soluble or swell in water to form gels through simple chemical transformations; polysaccharides have a wide variety of structures and forms (fibers, lamina, granules, powders, pellets, or viscous solutions), which is why they are used to create various medicines: tablets, pills, bases for coating tablets and capsules, ointment bases, stabilizers of suspensions and emulsions, solvents in ocular forms and injections.

Gums are used mainly as emulsifiers, in solutions as an enveloping agent, and in enemas to reduce irritation in inflammatory and ulcerative processes in the stomach and intestines. Gums reduce the local irritating effect of certain drugs, slow down the absorption of a number of medicinal substances and have many other valuable

properties: increased viscosity, stickiness, and pelletizing, which is why they are used as binders, thickeners, and stabilizers in the food industry. Mucilage is used in medicine as an enveloping and emollient.

Pectin substances and **hemicelluloses** are found in every plant, so it is important to take into account their influence in the overall therapeutic effect of consuming cranberries *Oxycoccus palustris*, rose hips *Rosa* ssp, viburnum *Viburnum opulus*, chamomile flowers *Matricaria recutita~Chamomilla recutita*, linden *Tilia cordata*, marigolds *Calendula officinalis*, licorice roots *Glycyrrhiza glabra* and string grass *Bidens tripartita*. In its pure form, pectin is used as an emulsifier, stabilizer, base for ointments, and as an independent medicine. Pectin has a hemostatic effect, lowers blood cholesterol, affects the metabolism of bile acids, has an anaphylactic effect, reduces the toxicity of antibiotics and prolongs their effect.

Drugs containing pectin stimulate wound healing. For example, a complex of pectin substances of chamomile *Matricaria recutita* (camilazide) has an anti-ulcer effect due to its effect on the secretory function of the stomach and trophic processes in tissues. Polysaccharides of aloe *Aloe arborescens* and *Kalanchoe pinnata* with pectin substances have a positive effect on wound and burn healing. Pectin is used to prolong the action of the main substance and as an additive that reduces side effects. Thus, aspirin in combination with pectin is less irritating. There is an anti-tuberculosis drug with pectin that has a depot effect. Ukraine has developed quercetin and pectin granules with a wide range of pharmacological effects.

Pectins, as a component of medicines and food, can bind radionuclides, toxic chemicals, salts of heavy and alkaline earth metals and turn them into water-soluble compounds. The number of drugs, food products and biologically active food additives containing plant fibers is growing. Previously, they were referred to as so-called "ballast substances". The term "dietary fiber" includes pectin substances, reserve polysaccharides like inulin, fiber, hemicellulose, and gum. In addition, they include non-carbohydrate formations, such as lignin.

The use of plant fibers causes the following pharmacological effects: suppression of appetite and increased feeling of satiety; reduced energy requirements; normalization of intestinal motor function; slowing the growth of putrefactive microbes; normalization of intestinal microflora; reduced fat absorption in the small intestine; lower blood cholesterol levels; positive effect on the metabolism of

vitamins and lipids in the intestinal and hepatic circulation system. This reduces the risk of chronic constipation, hemorrhoids, appendicitis, colon cancer, cholelithiasis, obesity, coronary heart disease, hypertension, and diabetes mellitus.

In medical nutrition, plant fibers are recommended to be used as enterosorbents in the amount of 25 g daily for physiological detoxification of the body. Detoxification properties against salts of heavy and alkaline earth metals and toxic chemicals are manifested when pectins are consumed in a prophylactic dose of 2 g daily.

Homopolysaccharides are polysaccharides built from identical monosaccharides. Depending on the carbohydrate component, they are divided into glucans (amylose, amylopectin, cellulose, glycogen, dextrans, chitin, etc.), fructans (inulin, flein, triticin, etc.), galactans (agar-agar, carrageenan).

Cellulose, or fiber $(C_6H_{10}O_5)_n$, is a component of plant cell membranes. Its content depends on the type of plant. Cotton seeds *Gossypium hirsutum* consist of 98% cellulose, wood of deciduous and coniferous trees – 40-50%, wheat grain *Triticum durum* – 1.9%.

Cellulose is a linear polysaccharide constructed from β-D-glucopyranose residues connected by $1 \rightarrow 4$ glycosidic bonds. The repeating link in the fiber chain is a cellobiose residue. Cellulose is a rigid helix with a pitch equal to 2-3 elementary links. Hydroxyl groups are involved in the formation of intra- and intermolecular hydrogen bonds. Each cellulose macromolecule (micelle) consists of about 60 glucose molecules. The micelles are oriented in such a way that they form a net-like structure. The basis of the supramolecular structure of cellulose is elementary highly ordered microfibrils associated in aggregates – cellulose fiber. On average, a cellulose microfibril contains several hundred units of macromolecules.

Cellulose is a white substance. It does not dissolve in most known solvents, but dissolves with partial destruction in concentrated solutions of mineral acids and some salts, such as beryllium perchlorate. After the acid hydrolysis of cotton pulp, microcrystalline pulp is produced (crystallinity 70-85%). It consists of individual aggregates of macromolecules that have a certain ratio between length and thickness. This cellulose is used to clarify juices, accelerate the extraction of essential oils, as a filler in the manufacture of medicines (tablets, emulsions), as a catalyst, stabilizer, etc.

Raw materials for pulp production include wood, grasses, and agricultural waste. The chopped biomass is heated with chemicals (acid, alkaline, combined) that convert lignin and hemicelluloses into solution or partially destruct them. Insoluble cellulose is separated, bleached and used in the production of paper, cardboard, artificial fibers, for synthesis, in the pharmaceutical and food industries.

Cellulose has a positive effect on intestinal motility and normalizes digestion. It is not absorbed in the human digestive tract and has a high adsorption capacity. Various types of cotton are rich in cellulose. The cotton genus *Gossypium* ssp. includes 30 wild species growing in tropical areas and 5 cultivated species.

Among cultivated species, the most common is rough cotton *Gossypium hirsutum*, which is grown on all continents. The best quality fiber is produced by Barbados or Peruvian cotton *Gossypium barbadense*. It is grown mainly in Egypt, southern Turkmenistan, Tajikistan, and Uzbekistan. It produces about 10% of the world's raw cotton. Raw cotton consists of 30-40% fiber, the rest is seed.

To be used in medicine, raw cotton is picked, degreased, bleached, washed and combed using special devices. Medicinal raw materials, cotton wool, are divided into hygroscopic ophthalmic, hygroscopic surgical, and compressive according to the degree of degreasing and purity. It contains 98% cellulose. It is a classic surgical and dressing material. Fluid absorption is facilitated not only by the structure of microfibrils but also by the capillarity of the fiber itself. Cotton wool and bandages are sometimes impregnated with antiseptic solutions. Cotton wool is used to produce colodiol and various cellulose derivatives (methyl cellulose, carboxymethyl cellulose, etc.), which are used as an excipient in the manufacture of certain dosage forms. Cotton seeds are used to produce fatty oil, gossypol and its derivatives. Gossypol is a toxic sesquiterpene dimer. It is also isolated from the roots. A 3% gossypol liniment is used as an antiviral agent for tinea and psoriasis.

Dextrins are low-molecular-weight glucans formed as a result of the partial breakdown of starch or glycogen under the influence of enzymes (amylases, phosphorylases), acids, or heating to 180-200°C. They have a variable composition. Thermolysis and glycolysis lead to the random depolymerization of polysaccharides to form a wide range of compounds. Dextrin is a white or yellowish powder with a sweetish taste, soluble in cold water, insoluble in dilute alcohol, and insoluble

in absolute alcohol. Aqueous solutions deflect the plane of polarized light to the right, hence their name (dexter). Dextrins dissolve in alkalis when heated. When heated, they turn yellow in color. Amylodextrins, the products of the initial stages of starch hydrolysis, turn blue with iodine, and dextrins with a medium molecular weight turn red. Further decomposition of dextrin leads to the appearance of disaccharides, mainly maltose, and subsequently glucose. Dextrins are formed in animal and plant organisms during the enzymatic breakdown of storage carbohydrates.

A mixture of amylose and amylopectin glucans contains starch. The Pharmacopoeia allows the use of several types of starch: potato starch – *Amylum Solani*, which is obtained from potato tubers *Solanum tuberosum*; wheat starch – *Amylum Tritici* from summer wheat, or soft wheat *Triticum aestivum*, corn starch – *Amylum Maydis* from kernels of common corn *Zea mays*; rice starch – *Amylum Oryzae* from kernels of sowing rice *Oryza sativa*. In addition, starch is obtained from sweet potatoes and sago palm. Starch is formed as a result of photosynthesis in the leaves of green plants, where it is converted into soluble compounds by amylase and phosphorylase enzymes and enters other organs (seeds, fruits, tubers, trunks), being deposited in the form of starch grains specific in shape and size for each plant species. Most starch is found in rice grains (62-86%), wheat (57-75%), corn (62-70%), and potato tubers (14-24%). Global starch production is about 20 million tons per year.

Potato starch is produced mechanically. Tubers are washed and crushed using mechanical graters. The resulting pulp is mixed with water and filtered through special sieves several times. Starch in the form of "starch milk" passes through the holes, while fiber is retained. The starch slurry is settled in vats; due to its high specific gravity (1.5-1.6 g/cm^3), the starch settles; the contaminated water is drained. For better purification, the starch is shaken with water a second time, settled, centrifuged, and dried in dryers to a moisture content of about 20%.

Cereal grains contain more starch, but its production is difficult due to the high content of protein substances (gluten). Cereal starch is produced by fermentation, which destroys gluten while leaving starch intact. Soluble starch is obtained by partial hydrolysis of starch with a 7% hydrochloric acid solution or by heating with glycerin to 90 °C.

Starch is a white or yellowish crispy, hygroscopic powder without taste and odor; it consists of simple and complex grains. They have a characteristic appearance that makes it possible to identify starch by microscopic examination. Starch is insoluble in alcohol, chloroform, cold water (up to 55°C); in hot water (55-70°C) forms a viscous colloidal solution; turns into a glue at temperatures specific to each type of starch; hydrolyzes with acid solutions to dextrin and then to D-glucose; the enzyme amylase breaks down starch into maltose and isomaltose. Soluble starch dissolves in boiling water to form a clear solution that does not thicken to the consistency of glue after cooling; Fehling's solution recovers slowly; it forms a blue color with iodine solution; when heated with α-naphthol and concentrated sulfuric acid, it turns red-violet. Starch consists of two polysaccharides, amylose and amylopectin.

In pharmacy, starch is used as an enveloping agent: externally in the form of powders and powders with zinc oxide or talcum powder, internally and in enemas as a glue to protect vulnerable nerve endings from irritants and to slow down drug absorption. Starch and soluble starch are used in the manufacture of tablets as a binder, powdering agent and filler, and in surgery for fixed dressings. Starch is an indicator in iodometric analysis.

Fructans are polysaccharides built from D-fructose residues. They accumulate in the tissues of monocots and dicots, green algae, and bacteria. They are the products of sucrose phosphorylation, so each molecule contains one D-glucose residue and, by the type of compound, lacks reducing properties. Only primary OH groups are involved in the formation of glycosidic bonds, and all fructose residues have a furanose form and a β-configuration of the glycosidic center. Due to the presence of three primary hydroxyls in sucrose, three different trisaccharides can be formed, which are the source of three types of fructans. The degree of polymerization of inulin does not exceed 100 (usually 30-45); molecular weight – 5000-6000. Inulin is sometimes accompanied by so-called inulides, which have only 10-12 fructose residues and are therefore highly soluble in water. Fructans dissolve poorly in cold water and well in hot water. The macromolecule is easily hydrolyzed due to the furanose form of fructose. Complete acid hydrolysis of the polysaccharide produces 94-97% fructose and 3-6% glucose. Inulin and inulides are not colored by iodine.

In plant cells, fructans accumulate in vacuoles and act as a reserve material, osmoregulator, and antifreeze. The content of fructans sometimes reaches 30% of the dry weight of the leaves. Their reserve in specialized organs can exceed 60%.

Inulin accumulates mainly in plants of the Asteraceae family and *Allioideae* subfamily. Jerusalem artichoke tubers (tuberous sunflower, earthen pear *Helianthus tuberosus)* and pinnate dahlia *Dahlia pinnata* are rich in inulin. It is also found in the roots of chicory *Cichorium intybus*, medicinal dandelion *Taraxacum officinale*, tall elecampane *Inula helenium*, and purple echinacea *Echinacea purpurea*. Its amount depends on the season and climatic conditions. The maximum inulin content is observed in autumn and winter.

Fructans are used for the industrial production of D-fructose. Inulin is used in therapeutic and preventive nutrition to normalize carbohydrate metabolism, as well as an immunomodulator and enterosorbent. Daily consumption of inulin significantly increases the number of bifidobacteria in the intestine, reduces the number of pathogenic and enteropathogenic bacteria. It is believed that the immunomodulatory properties of inulin are associated with its bifidogenic activity. Inulin enhances glycolysis, regulates lipid metabolism, and is especially useful for diabetics. We have developed a series of food supplements with inulin and juices of berries, vegetables, and extracts of medicinal plants.

Gummies are formed in plants as a result of mucous degeneration of the membranes of old and young cells of the heartwood or wood located near the cambial layer, when a tree or bush is injured. In arid areas, plants produce a significant amount of gum, which retains moisture.

Gums are polysaccharides that contain calcium and magnesium salts of uronic acids and neutral monosaccharides that are partially esterified. Their final structure is unknown, so their systematization is somewhat complicated. Gums are classified by chemical composition and solubility.

According to their chemical composition, they are divided into acidic, whose acidity is due to the presence of glucuronic and galacturonic acids (e.g. acacia gum *Acacia dealbata*, apricots *Prunus armeniaca~Armeniaca vulgaris*); acidic, whose acidity is due to the presence of sulfite groups; neutral (glucomannans, galactomannans). By solubility, they are distinguished: Arabin – gums that dissolve in

cold water (Arabian gum *Vachellia seyal*, apricot *Prunus armeniaca~Armeniaca vulgaris*, plum *Prunus domestica*, cherry *Prunus avium*, silver acacia *Acacia dealbata*, Siberian larch *Larix sibirica*, or humilaryx gums); bassorin – gums that are slightly soluble but swell strongly in water (tragacanth gum *Astragalus*, narrow-leaved *Elaeagnus angustifolia* sucker gum); cerazine – insoluble in cold water, partially soluble when boiled and not swelling (cherry gum *Prunus cerasus~Cerasus vulgaris*).

The structure of individual gums was studied and described. Gums are hydrophilic colloids. They are insoluble in fatty oils, alcohol, ether, chloroform, and other organic solvents. This is what makes them different from resins, rubber, and gutta-percha, which also flow from cuts and cracks in tree trunks. Resins and rubber are insoluble in water, but easily soluble in alcohol; resins give off a fragrant odor when burned, and gums give off the smell of burnt paper. Gums are polysaccharides, and resins, rubbers, and gutta-percha are terpenoids. With a solution of lithium chloride and iodine in potassium iodide, gums turn purple, and with Dragendorff's reagent, they produce differently colored precipitates, ranging from pale red (gum arabic) to dirty green (tragacanth). The gum is under great pressure in the trunks.

If the bark is damaged and cracks appear, it flows out through the core rays and fills the wounds. To extract gum, cuts are made on the trunks. The suction is carried out in calm weather so that the raw material is not contaminated with dust and sand. Gum appears as a viscous mass. It is harvested 5-6 days after the soaking and sorted by color. White varieties are used for the pharmaceutical industry, while yellow and brown varieties are used for technical needs. The amount of gum released depends on the plant's growing season and its age: most gum is released before flowering, and the gum yield increases with the plant's age. Despite the use of synthetic polymers, gums have not lost their importance. They are still harvested on a large scale for the needs of the food, textile, paint, leather, and pharmaceutical industries.

Mucilages (Mucilago) are heteropolysaccharides that accumulate in certain intact plant organs: tubers, roots, seeds, etc. They are formed as products of normal metabolism and are a food reserve or water retaining substances, especially in the tissues of

succulents. According to the origin and formation, mucus is divided into the following groups: mucus formed in plants by mucous degeneration of cell membranes; mucus formed by sloughing off living cells; algal mucus; bacterial mucus.

Mucilages are less complex in structure than gums. According to their chemical composition, they can be divided into four groups: glucomannans, galactomannans, gum-like mucus, and cereal mucus. Glucomannans are found in various representatives of aroid, lily, cockscomb, and orchid families (in particular, in salepa tubers). These polysaccharides have a linear structure, with glucose and mannose residues linked by a β-1 → 4 bond alternately, sometimes with acetyl groups. Galactomannans are reserve polysaccharides of legume seeds. Some of them, such as guaran from the seeds of guar (guargum) or the polysaccharide of the ergot Ceratonia siliqua (locust beangum), are produced on an industrial scale and used as thickeners or stabilizers of suspensions and emulsions. There is a guaram preparation in the form of microgranules of gel-forming fibers used as a hypoglycemic, hypocholesterolemic, and antihypertensive agent.

Camelliform mucilages are found in plants such as flax, plantain, elm, and the celery family. The structure of these polysaccharides is more complex. Cereal mucilage is a grain gum. They are extracted from wheat, rye, barley, and other flours during water extraction. The structure of these arabinoxylans has not been fully established.

Pectin substances, pectin (Pectinum), are polyuronides that are extremely common in the aerial parts of plants and a number of algae. They are especially abundant in fruits (apple, quince, plum, etc.), tubers (beets, carrots, radish) and stems (flax, hemp). The decomposition of pectin substances is associated with the softening of fruits during ripening and storage, as their insoluble forms are converted into water-soluble pectin. Insoluble pectin substances are called protopectins. They are contained in the primary cell membrane. During treatment with dilute acids, water-soluble pectic acids containing methoxyl groups are formed. Acid salts are called pectinates. The substances formed after the methoxyls are removed are called pectic acids, and their salts are called pectates. Pectin substances are important components of cell membranes and intercellular structures of all higher and lower plants. They are also found in plant sap. In the cell membrane, pectins are associated with

cellulose, hemicelluloses and lignin. There are few or no pectins in the secondary cell membrane.

Pectin substances, which are hydrophilic colloids, are associated with the water-holding capacity and turgor of plant tissues. Pectin substances fill the intercellular space. If flax, jute or hemp stalks are moistened with water, the pectin substances dissolve and the bast fibers are easily separated. Different amounts of galacturonic acid residues have been found in pectin isolated from different types of fruits and vegetables: 92.1% in orange pectin, 90.4% in lemon pectin, 88% in apple pectin, 82.3% in sugar beet pectin, and 76.7% in carrot pectin. In their pure form, pectins are amorphous powders with a molecular weight of 25,000 to 50,000, white or yellowish, sometimes brown or gray, almost odorless, poorly soluble in cold water, and form colloidal solutions when heated. The solubility of pectin depends on the degree of polymerization and the degree of esterification. Solubility in water improves with a high degree of methoxylation and a decrease in molecular size. Pectin is insoluble in alcohol and other organic solvents; it does not melt but decomposes at higher temperatures. Pectin solutions are optically active, they rotate the polarization plane to the right. A characteristic property of pectin is the ability to form gels in the presence of sugars and acids in a certain ratio. Such gels are best formed at pH 3.1-3.5 with the addition of sucrose or hexose.

4. Medicinal plants and raw materials containing carbohydrates

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING FRUCTANS

ROOTS OF CHICORY – RADICES CICHORII

Wild chicory, chicory whips *Cichorium intybus* L. (family Asteraceae) is a perennial or biennial (cultivated varieties) herb. The roots contain carbohydrates (40%), including inulin, free fructose; the milky juice also contains bitter sesquiterpene lactones (lactucin, lactucopicrin), phenolic acids (chicoryl), taraxasterol, choline, methoxycoumarin, chicoryl; ascorbic acid, protein and resinous substances. Galenic preparations of chicory are used to improve appetite and digestive system function, especially in gastritis, enteritis, colitis; they activate metabolism, and are used in dermatological diseases. A decoction of the roots has a hypoglycemic effect, and preparations made from it have a thyroid-stimulating effect. Chicory is a component of the drug gastrovitol.

ECHINACEA HERB – HERBA ECHINACEAE PURPUREAE

RHIZOMATA AND ROOTS OF ECHINACEA – RHIZOMATA AND RADICES OF ECHINACEA PURPUREAE

Echinacea purpurea (L.) Moench. (from Greek *echinos* – hedgehog), family Asteraceae, is a perennial herb. Together with purple echinacea, narrow-leaved echinacea *Echinacea angustifolia* DC and pale echinacea *Echinacea pallida* Nutt are used. Both species are widely cultivated. The polysaccharides contained in all parts of the plant belong to heteroxylans, arabinorhamnogalactans, and fructans (inulin). Phenolic compounds of the herb are represented by hydroxycinnamic acids (chicorylic, ferulic, coumaric, caffeic), the phenolic glycoside echinacoside, which is hydrolyzed into pyrocatechin, caffeic acid, ethanol, two glucose molecules and one rhamnose; in addition, there are flavonoids, tannins, saponins, polyacids, echinacin – an amide of polyunsaturated acid and echinolone – an unsaturated ketone alcohol, essential oil (0.04-0.22%). Carbohydrates of underground organs are represented by low-molecular weight fructans and inulin, the content of which reaches 6%; there is also glucose (7%), fatty oil, betaine, phenolic carboxylic acids, and resins. The plant is rich in enzymes and trace elements: selenium, cobalt, silver, molybdenum, zinc, manganese, etc. Echinacea tincture and immunal have immunostimulating antioxidant and membrane-stabilizing effects, promote healing of wounds, burns, ulcers, and are used for infectious and viral diseases, especially of the upper respiratory tract.

In homeopathy, the fresh flowering herb of three species of *Echinacea* is used to make a tincture, which is used in appropriate dilutions externally, internally, in the form of injections for boils, poorly healing wounds, purulent and ulcerative processes, as well as insect and snake bites.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING HETEROPOLYSACCHARIDES

APRICOT GUM – GUMMI ARMENIACAE

Common apricot *Armeniaca vulgaris* Lam. (the name comes from Latin *armeniacus*, -a, -um - Armenia), Rosaceae family, is a deciduous tree, less often a shrub. The highest gum yield is observed in trees aged 10-15 years, especially after fruit ripening. Sucking increases gum flow. In Central Asia, from 0.5 to 1.5 kg of gum is harvested from one tree per season. The weight of the sagging can reach 80-100 g.

Freshly harvested gum is light yellow and transparent; old pieces lose their transparency and become yellow-brown in color. When hydrolyzed, apricot gum forms 43% galactose, 41% arabinose and 16% glucuronic acid; it also contains protein and minerals. Apricot gum replaced imported gum arabic. It forms viscous solutions with emulsifying and enveloping properties. It is used to make oil emulsions and enveloping solutions.

TRAGACANTH – GUMMI TRAGACANTHAE

Various species of the tragacanth *Astragalus* genus, which belong to the subgenus Tragacanthae of the legume family Fabaceae. The subgenus Tragacanthae contains more than 240 species, of which 12-15 are commercially important, including the felt-branch *Astragalus piletocladus* Frein et Sint., the gummiferous *Astragalus gummifer* Z., the small-headed *Astragalus microcephalus* Willd., Andrey's *A. andreji* Rzazade, a. naked *A. denudatus* Stev., leafy *A. pycnophyllus* Stev., denser *A. densissimus* Boriss., multifoliate *A. multifoliatus* Boriss. are perennial herbaceous plants with a bushy life form.

Tragacanth is an air-dried gum that flows out of cracks or incisions in the trunk and branches of astragalus. Tragacanth was known to the ancient Greeks and Romans, and in the Middle Ages to the Arabs, who introduced it to European pharmacy. Initially, tragacanth was imported from Iran. In the 1930s, tragacanth astragalus reserves were found in Turkmenistan and their exploitation was established. Tragacanth gum is used as an emulsifier in the production of emulsions, tablets, pills, but the main consumers of tragacanth are the textile, food, perfume, cosmetics, and paper and printing industries.

FLAX SEEDS – SEMINA LINI

Common flax *Linum usitatissimum* L. (from Latinized Greek *linon* - thread; Latin. *usitatissimus*, -um – the superlative of usitatus – used, common), Linaceae family, is an annual herb with a bare, cylindrical stem. The seeds contain mucilage (6%), drying fatty oil (30-48%), as well as the linamarase enzyme, the cyanoglycoside linamarin (1.5%), protein (2.5%), sugars, etc. The seeds have a laxative, secretolytic, enveloping and anti-inflammatory effect. Swollen in water, the seeds increase the volume of feces, enhance its passage, and have a cleansing effect in case of colon atony and obesity. Water infusion of mucilage has a protective, soothing and anti-inflammatory effect in case of esophageal inflammation, gastric and duodenal ulcers, enteritis and colitis (in enemas). Outwardly, the mucus is used in the

form of compresses for trophic ulcers, burns and radiation damage to the skin.

MARSHMALLOW ROOTS – RADICES ALTHAEAE

MARSHMALLOW HERB – HERBA ALTHAEAE OFFICINALIS

Medicinal marshmallow *Althaea officinalis* L., Armenian marshmallow *Althaea armeniaca* Ten., family Malvaceae. Both types of marshmallow are perennial herbs with short, thick rhizomes. The roots contain polysaccharides (up to 35%) – mucilage (glucan and arabinogalactan), pectin (acidic galacturonorhamnan) and starch (about 37%). The herb contains carbohydrates (up to 10%), including mucilage (neutral polysaccharides consisting of glucan and arabinogalactan) and pectin substances. Flavonoids (glycosides of kaempferol, quercetin and diosmetin), coumarin scopoletin, phenolic carboxylic acids, traces of essential oil, carotene, ascorbic acid have also been found. Althea preparations have an enveloping, expectorant, mucolytic, anti-inflammatory and analgesic effect. Dry root powder, breast milk, infusion, syrup, liquid and dry extracts, and cough mixture are used. They are prescribed for respiratory tract diseases (bronchitis, tracheitis), diseases of the digestive tract (gastric and duodenal ulcers, gastritis, colitis). Pharmaceutical companies produce the drug mucaltin from the herb, which is used as an expectorant for colds and other acute and chronic diseases of the throat and upper respiratory tract.

LEAVES OF PLANTAIN MAJOR – FOLIA PLANTAGINIS MAJOR

PLANTAIN HERB – HERBA PLANTAGINIS MAJORIS RECENS

Plantago major L. (from Latin *planta* – sole and *ago* – to drive), plantain family Plantaginaceae, is a perennial herb with a shortened rhizome and numerous adventitious filamentous roots. It contains polysaccharides (20%), represented by pectin substances and neutral glycans. It also contains mannitol, sorbitol, allantoin, iridoids (aucubin and catalpol), steroids, flavonoids (derivatives of luteolin, quercetin, apigenin), and tannins. The leaves and herb contain carotenoids, vitamins C and K. The preparations have anti-inflammatory, expectorant, wound healing effects, and stimulate regenerative processes. Plantain tincture is used internally for bronchitis, whooping cough, asthma, and externally for treatment of boils and fistulas. Plantain juice is used for anacid gastritis, ulcers and chronic colitis. Plantaglucid, which is the sum of polysaccharides from the leaves, is used to treat gastritis, gastric ulcer and duodenal ulcer in cases of

normal and low acidity. In homeopathy, the whole fresh flowering plant is used for ear and toothache, hemorrhoids, diarrhea; externally – for trigeminal neuralgia, tinea capitis.

FLEA PLANTAIN SEEDS – SEMINA PSYLLII

FRESH FLEA PLANTAIN HERB – HERBA PLANTAGINIS PSYLLII RECENS

Flea plantain *Plantago psyllium* L. (from the Greek *psylla* – flea), Plantaginaceae family, is an annual herb. The seeds contain mucilage (10-15%), proteins, and fatty oil. The mucus consists of neutral and acidic fractions. The hydrolysis products include D-xylose, L-arabinose, L-rhamnose, D-galactose, and galacturonic acid. The herb contains polysaccharides, triterpene saponins, monoterpene alkaloids, as well as carotenoids, flavonoids, tannins, and the iridoid glycoside aucubin. The seed acts as an anti-inflammatory, emollient, and slightly laxative. In case of chronic constipation, it is consumed whole with plenty of warm water. It starts to act due to the increase in its volume by three to five times and irritation of the colon receptors. In the form of mucus, it is used internally as an enveloping agent for colitis and externally as an emollient and analgesic poultice.

LEAVES OF COMMON COLTSFOOT – FOLIA FARFARAE

Common cough drop, or common coltsfoot *Tussilago farfara* L. (from Latin. *tussis* – cough, *agere* – to expel, to drive out; *far* from *farina* – flour; *ferre* – to carry), family Asteraceae, is a perennial herb with a long branched rhizome. The leaves contain about 8 % mucilage (in hydrolyzate: glucose, galactose, pentoses, uronic acids), carotenoids, ascorbic and organic acids (gallic, malic, tartaric), essential oil, sitosterol, saponins, bitter glycoside tussilagin, flavonoids (rutin, hyperoside), tannins, pyrrolizidine alkaloids. The softening, expectorant, anti-inflammatory effect of the raw material is used for diseases of the upper respiratory tract. The leaves are a part of breast and diaphoretic teas.

Theme 3 MEDICINAL PLANTS AND PLANT RAW MATERIALS CONTAINING PROTEINS AND LIPIDS

1. Medicinal plants and raw materials containing proteins
   1.1 Structure and classification of peptides and proteins
   1.2 Biological functions of proteins in plants and animals
   1.3 Toxins of peptide and protein nature

1.4 Lectins. Medicinal plants and raw materials containing lectins
1.5 Enzymes. Medicinal plants and raw materials containing enzymes
2. Medicinal plants and raw materials containing Lipids
2.1 Physicochemical properties, biological action and use of fatty acids
2.2 Physicochemical properties, biological action and use of fats (actually lipids)
2.3 Medicinal plants and raw materials containing fats
2.4 Physicochemical properties, biological action and use of lipoids (fat-like substances)

Literature and Internet resources:

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. 96–155 p. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

1. Peptides, polypeptides, peptones – substances whose molecules consist of residues of α-amino acids connected by peptide bonds - C(O) –NH–.

Proteins are high-molecular-weight natural organic substances that also consist of amino acids and form the basis of the structure and function of living organisms.

1.1 Structure and classification of peptides and proteins

The peptide bond is formed through the attachment of the carboxyl group (–COOH) of one amino acid to the amino group (–NH2) of another amino acid by dehydration. Depending on the number of amino acid residues constituting the peptide, distinctions are made between dipeptides, tripeptides, and so forth. Polypeptides, containing 2 to 10 amino acid residues, are referred to as oligopeptides, while those with more than 10 are classified as polypeptides. Peptides are conventionally considered to contain up to 100 amino acid residues, while proteins have more than 100. This corresponds to the molecular mass of peptides, which is up to 10,000; proteins have a molecular mass ranging from 10,000 to 1 million and even higher.

High-molecular-weight peptides and proteins exhibit four levels of structural organization. The nature of amino acid residues and their arrangement constitute the primary structure, which, in turn, determines the formation of more highly organized structures. The

secondary structure involves the configuration of the polypeptide chain, often forming α-helices or β-structures. The secondary structure is stabilized by hydrogen bonds between peptide groups located closely in the amino acid residue chain. The tertiary structure is the spatial orientation of the secondary structure, stabilized not only by hydrogen bonds but also by other types of interactions, such as ionic, hydrophobic, and disulfide bonds. The first three levels of structural organization are characteristic of all protein molecules. The quaternary structure belongs to macromolecules consisting of several polypeptide chains (subunits) that are not covalently linked. The fourth level characterizes the combination and arrangement of these subunits in space.

Peptides are present in all organisms. Oligopeptides, in their pure form, are typically crystalline substances that decompose upon heating to 200–300°C. They are readily soluble in water, diluted acids, and alkalis, but practically insoluble in organic solvents, except those constructed from hydrophobic amino acid residues. Oligopeptides share properties more closely with amino acids, while polypeptides are more similar to proteins.

In living organisms, peptides may exist in a free state, such as glutathione and carnosine. Many of them exhibit specific biological activity. Peptides include hormones, antibiotics, vitamins, toxins, enzyme inhibitors, activators, and their derivatives. In laboratory conditions, peptides are obtained through incomplete hydrolysis of proteins, and physiologically active ones are synthesized from amino acids.

Most proteins have the following elemental composition: 50.6–54.5% carbon, 6.5–7.3% hydrogen, 21.5–23.5% oxygen, 15–17.6% nitrogen, and 0.3–2.5% sulfur. Additionally, some proteins contain phosphorus, iron, and zinc. Practically all proteins consist of amino acids, which, except for glycine, belong to the L-series. Unlike proteins, peptides have a more diverse amino acid composition and often include residues of D-series amino acids, as well as cyclic fragments and branched chains in their structure. Protein molecules do not pass through semi-permeable membranes, as they have a weak diffusion capacity. Proteins are amphoteric electrolytes, possessing free carboxyl (acidic) and amide (basic) groups. The solubility of proteins varies greatly. Protein solutions in water are

hydrophilic colloids, exhibiting significant viscosity and low osmotic pressure. Many proteins have the ability to crystallize.

The detailed chemical structure of proteins has not yet been fully explored, so they are classified based on their chemical composition into simple and complex proteins. Simple proteins, or proteids (albumins, globulins, histones, glutelins, prolamins, protamines, proteoids), consist solely of amino acids. Complex proteins (proteides) include a non-protein component, known as the prosthetic group, in addition to the protein portion. Complex proteins encompass glycoproteins containing carbohydrates, lipoproteins containing lipids, chromoproteins containing pigments, phosphoproteins containing phosphoric acid, nucleoproteins containing nucleic acids, and metalloproteins containing metals.

Based on spatial form, proteins are divided into globular and fibrous. Globular proteins are more characteristic of plants, having an α-helical structure and a spherical shape. Albumin (egg white protein) is an example of a globular protein. Almost all enzymes belong to globular proteins. Fibrous proteins are prevalent in animal organisms. They are characterized by a β-structure and fibrous composition. Examples include β-keratin (a component of hair and horn tissue) and collagen (connective tissue). Globular proteins are soluble in water and saline solutions, forming colloids, while fibrous proteins are insoluble in water.

1.2. Biological functions of proteins in plants and animals

Proteins play a crucial role as active agents in vital life processes, serving as the biological form of material movement. The diversity in structure and precision of unique organization, combined with the flexibility of proteins, creates significant functional possibilities. Based on their biological functions, proteins are classified into:

1. Enzymes: Highly specific catalysts for biochemical reactions.
2. Structural Proteins: Form the basis of bone and connective tissues, wool, etc. (e.g., collagen).
3. Regulatory Proteins: Control the biosynthesis of proteins and nucleic acids, as well as hormones.
4. Receptor Proteins: Located on the external surface of plasma membranes, they receive information about the surrounding environment.

5. Transport Proteins: Participate in the active transport of ions, lipids, sugars, and amino acids across biological membranes; examples include hemoglobin and myoglobin, which transport oxygen.

6. Bioenergetic Proteins: Convert and utilize energy from food and solar radiation (e.g., rhodopsin, cytochromes).

7. Nutritive and Reserve Proteins: Play a crucial role in the development and functioning of the organism.

8. Defensive Proteins: Serve as defense systems in higher organisms, including immunoglobulins (responsible for immunity), complement proteins (responsible for lysing foreign cells and activating immune functions), and blood clotting proteins (thrombin, fibrin), as well as antiviral interferon.

1.3. Toxins of Peptide and Protein Nature

Toxins (from the Greek "toxikon" – poison) are substances that cause disruptions in biochemical processes, resulting in symptoms of intoxication and, in severe cases, the death of an organism.

Toxins can have a polypeptide, protein, or non-protein nature. Based on their origin, toxins are divided into three groups: microbial toxins, plant toxins (phytotoxins), and animal toxins (zootoxins).

Bacterial toxins are classified into exotoxins and endotoxins. For example, toxins causing botulism, diphtheria, and tetanus are simple proteins released into the environment by bacteria during growth. These belong to the group of gram-positive microflora toxins. Endotoxins are complex proteins located in the surface layers of the cell membrane of pathogenic gram-negative bacteria. These toxins are released after the death of bacteria. Bacterial toxins are the most toxic, primarily due to their high similarity to biomolecules. Their key property is high physiological activity, capable of causing disturbances in molecular mechanisms at low concentrations.

Toxins act specifically on various organs and tissues. Therefore, toxins are classified into selectively acting toxins and cytotoxic substances. Examples of selectively acting toxins include the myotropic crotoxin from the rattlesnake Crotalus atrox. Toxins classified as cytotoxic disrupt biochemical processes in all cells. For instance, ricin, a protein from castor bean seeds (Ricinus communis), interferes with the synthesis of ribosomal proteins in various cells. Some cytotoxic toxins can act quite specifically on the cells of individual tissues.

Extremely toxic peptides are found in certain species of the Amanita genus, such as Amanita virosa and Amanita verna. The molecules of these compounds are bicyclic polypeptides. The most toxic mushroom causing fatal poisonings is the death cap mushroom, Amanita phalloides. Its toxins have a cyclic structure and belong to two groups: amatoxins and phallotoxins. The human body lacks enzymes for the proteolytic breakdown of amatoxin, and it remains stable even when heated. The content of the peptide in the fruiting body of the death cap mushroom is 17 mg/100 g of fresh weight. Consuming only 50 g of fresh mushrooms can cause irreversible damage to liver cells. Phallotoxins are also highly toxic, but their absorption from the digestive tract occurs slowly. Among the peptides of this group, phalloidin predominates—a heptapeptide with a thioether bond between cysteine and tryptophan.

Many phytotoxins have been isolated from the genera of the mistletoe family (Dendroptora, Phoradendron). Toxins such as croton I from *Croton tiglium* and momordin from the Indian cucumber, *Momordica charantia* are polypeptides with molecular masses of 72,000 and 23,000, respectively. Modecin from *Modeca digitata* and volkenzin from *Adenia volkensii*, both belonging to the Passifloraceae family, are glycoproteins with a molecular mass of approximately 63,000. All four mentioned toxins are protein synthesis inhibitors.

1.4 Lectins. Medicinal plants and raw materials containing lectins

Lectins (from Latin *legere* – to choose) are proteins or glycoproteins capable of binding sugar and thus facilitating cell agglutination and precipitation of glycoconjugates.

Lectins contain at least two regions that interact with free mono- and oligosaccharides, as well as with sugar residues in polysaccharides, glycoproteins, and glycolipids. In its simplest form, the interaction of lectins with carbohydrates results in the agglutination of particles and cells, such as erythrocytes, or the precipitation of polysaccharides and glycoproteins.

The discovery of lectins was influenced by the toxicity of castor oil *(Oleum Ricini*), which intrigued many pharmacologists and toxicologists in the late 19th century. The study of lectins was initiated by the works of P. G. Shtilmark, who found that the toxic substance in castor seed – ricin lectin – induces agglutination and hemolysis of

erythrocytes. This event is considered the birth of a new field – lectinology.

The modern stage of lectin research began after 1945 when U. Boyd discovered agglutinins specific to blood groups. In our country, Ukrainian scientists M. D. Lutsyk and Ye. M. Panasyuk made significant contributions to lectin research. Currently, the center for lectin research is located at the Institute of Molecular Biology and Genetics of the National Academy of Sciences of Ukraine. Lectin research involves obtaining pure preparations and determining their carbohydrate specificity. By 1965, only three crystalline lectins were known (phytohemagglutinin, concanavalin A, and ricin). Now their number exceeds 100.

One of the first classifications of lectins that has survived to the present day was proposed by O. Myokela. According to it, the specificity of lectin-carbohydrate interaction is determined by the position of the hydroxyl group at C_3 and C_4 and the D- or L-forms of sugar. Based on this, all lectins are divided into four groups specific to such sugars: 3,4-OH cis, L-form (L-fucose, L-galactose); 3,4-OH cis, D-form (D-galactose); 3,4-OH trans, D-form (D-glucose, D-mannose); 3,4-OH trans, L-form (L-glucose, L-gulose).

A more comprehensive classification is one of combined nature, dividing lectins into three groups based on carbohydrate specificity: lectins reacting with acidic sugars; lectins reacting with neutral sugars. Based on structural-chemical recognition of carbohydrates: lectins reactive only to terminal residues; lectins reactive to terminal di-, tri-, and tetrasaccharides; lectins reactive to oligosaccharides of internal portions of chains. According to functional activity: simple lectins that agglutinate or do not agglutinate; mitogenic lectins; toxic lectins.

There is still no unified classification of lectins, so researchers use all available classifications depending on the purpose of the study.

Lectins are characteristic of organisms at any level of organization – from viruses and bacteria to mammals. The first purified lectins from microorganisms were obtained in the late 1970s – toxins of Pseudomonas aeruginosa bacteria and Streptomyces spp. fungi. The structure of the influenza virus agglutinin has been thoroughly studied. Lectins have been found in lichens. Information about lectins in ferns and conifers is absent. The largest number of lectins has been found in flowering plants, among which several thousand species have been studied. Lectins have been identified in many representatives of

invertebrates and vertebrates. Lectin-like proteins are found on the surface of platelets, in the tissues of the liver, lungs, heart, placenta, and spleen in humans.

The presence of lectins in living objects of different evolutionary levels indicates their important biological significance, but the universal function of these proteins has not yet been fully revealed. The most reasonable positions are the roles of lectins: as "recognition" factors of molecules and cells in intercellular interactions; in the removal of damaged glycoproteins and cells from the bloodstream in mammals; in the aggregation of cells in lower plants and animals. The interesting hypothesis about the involvement of lectins in the transport, accumulation, and immobilization of carbohydrates deserves attention. In plants, the protective function of lectins manifests itself in preventing consumption by animals and inhibiting the growth of infectious bacteria and fungi.

Studies show that lectins may provide specificity in the interaction of pollen and stigma during plant fertilization. It is suggested that seed lectins stimulate the growth and development of embryos due to their mitogenic action.

The specificity of lectin-carbohydrate interactions forms the basis for their practical use as reagents: in the study of the structure and function of cell membranes in both normal and pathological conditions (e.g., malignant transformed cells); in the study of the effect of lectin-cell membrane interaction on cellular metabolism, including the mitogenic and antimitogenic effects of lectins on T- and B-lymphocytes; for the rapid determination of blood groups; for the purification of glycoproteins using affinity chromatography on immobilized lectins; for the identification of bacteria and viruses. In addition, lectins have found application in forensic medicine for the identification of objects and material evidence.

The antitumor activity of some toxic lectins, capable of blocking protein synthesis, especially in tumor cells, which are more sensitive to their action than normal cells, has been established. These lectins include ricin, abrin, diphtheria toxin, pokeweed lectin, mistletoe lectin, and others.

Some lectins, such as concanavalin A, exhibit immunosuppressive effects, which have been used in organ transplantation. A lectin from the hemolymph of the beetle Allomyria dichotoma has been proposed as a chemotherapeutic agent. It exerts a mitogenic effect on T-

lymphocytes, stimulates the production of interleukin-2, and activates natural killers. The use of lectins for diagnostics in living organisms, as well as as medicinal agents, is limited by their high toxicity, accumulation in the body, narrow therapeutic range, and the difficulty of determining their concentration in the blood.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING LECTINS

MISTLETOE SHOOTS – CORMUS VISCUS

White Mistletoe *Viscum album* L. – from Latin "*viscum*" meaning birdlime, belongs to the Loranthaceae family. It is a perennial dioecious semi-parasitic evergreen shrub with a spherical shape. It parasitizes on deciduous trees (poplar, maple, willow, lime, elm, pear, apple), attaching itself to them with suckers through which it extracts water and mineral substances from the host tree. It contains 0.03–0.10% glycoprotein viscotoxin, galactose-specific lectins (ML-1, ML-2), α- and β-viscol, viscerozin, oleanolic and ursolic acids, choline and its derivatives (acetylcholine, propionylcholine), amines (viscalin, viscalbin, tyramine), alcohols (pinet, quercetin), flavonoids (quercetin, rhamnetin, isorhamnetin, rhamnazin-3-glucoside, chalcones), fatty oil, ascorbic acid, carotene, resinous substances, mineral salts (over 20 microelements). Mistletoe shoots are used as a hypotensive, sedative, astringent, hemostatic, anthelmintic, diuretic, and hypouricemic agent. In folk medicine, the infusion is consumed for stage I–II hypertension, atony of the intestines, pulmonary, nasal, and prolonged uterine bleeding, especially in individuals with arterial hypertension during menopause. Mistletoe extract is part of the preparations Cardiofit, Energotonik Doppelherz. Purified mistletoe extracts Iscador and Helixor-M are proposed as cytolytic agents for inoperable forms of cancer. Prolonged use of mistletoe preparations can lead to poisoning. In homeopathy, fresh leaves and berries are used for hypertension and hypotension, spasmodic cough, bronchial asthma, and climacteric disorders.

1.5 Enzymes. Medicinal plants and raw materials containing enzymes

Enzymes are biological catalysts of protein nature present in all living cells, participating in biochemical transformations, directing and regulating metabolic processes in the organism.

The term "*enzyme*" comes from the Latin "*fermentum*," meaning ferment, associated with the nature of fermentation processes. Initially, the term "*enzyme*" was used to define living microorganisms

involved in fermentation, while the term "*enzyma*" (from the Greek "*enzym*" – in ferment) referred to substances like pepsin and emulsin. However, later on, an enzyme preparation was isolated from yeast cells, demonstrating that enzymatic catalysis can occur outside a living organism. Consequently, the need for using two terms, "enzyme" and "enzyma," to describe the same concept was eliminated, and both names are now considered synonymous.

Enzymes find applications in various sectors of the economy, but the proportion used in medicine is small. They are characterized by a high degree of purification, complex and costly production technology. Out of approximately 3000 known enzymes, about 40 are used in the medical and microbiological industries in the Commonwealth of Independent States (CIS) countries for drug manufacturing. Of these, 62% are of animal origin, 33% are from microbial cultures, and only 5% are derived from plant raw materials. It is worth noting that the current level of development and implementation of medicinal enzyme preparations in CIS countries cannot satisfy the existing demand.

The protein nature of enzymes is confirmed by X-ray structural analysis. Enzymes do not differ in amino acid composition from proteins; they exhibit four levels of structural organization in their molecules. Typically, enzymes are constructed from two or more peptides linked non-covalently. However, the presence of all four levels of macromolecule structure is not always obligatory. Simpler enzymes, such as lysozyme, trypsin, ribonuclease, lack quaternary structure.

Enzymes can be simple or complex. Simple enzymes consist entirely of polypeptides and hydrolyze exclusively into amino acids during hydrolysis (examples include pepsin, trypsin, papain, urease, lysozyme). Most enzymes belong to the class of complex proteins containing a non-protein component, a cofactor, essential for enzymatic activity. The polypeptide part of a complex enzyme is called apoenzyme. Complex enzymes with low dissociation constants, which do not split into apoenzyme and cofactor during purification, are called holoenzymes, and the cofactor is termed a prosthetic group. Coenzymes often refer to cofactors that easily separate from the apoenzyme upon dissociation. Vitamins are typical examples of coenzymes. Some divalent metals (Ca^{2+}, Mg^{2+}, Mn^{2+}) serve as cofactors. The cofactor function has been established for biologically

active substances like HS-glutathione, ATP, lipoic acid, nucleoside derivatives, and porphyrins.

It has been observed that substrate molecules are generally smaller than enzyme molecules, leading to the hypothesis that a limited number of amino acids in the polypeptide form the active site, also known as the active center, upon formation of the enzyme-substrate complex. The active center comprises a unique combination of amino acid residues that directly interact with the substrate and participate in catalysis. Prosthetic groups are part of the active center. The active center is conventionally divided into the catalytic center, which chemically interacts with the substrate, and the binding center, or anchoring site, providing specific affinity to the substrate and the formation of the enzyme-substrate complex. The active center determines the catalytic activity and specificity of the enzyme, with the configuration of the entire molecule being crucial. Structural disruptions (such as denaturation) can partially or completely destroy the active center, resulting in the loss of catalytic properties by the enzyme.

All enzymes, according to the classification accepted by the Commission on Enzymes of the International Biochemical Society, are divided into six classes based on the type of reaction they catalyze: **oxidoreductases** – enzymes that catalyze oxidation-reduction reactions and transfer electrons; **transferases** – enzymes that catalyze the transfer of various functional groups from one substrate (donor) to another (acceptor); **hydrolases** – enzymes that catalyze the cleavage of intramolecular bonds in substrates with the addition of water; **lyases** – enzymes that catalyze the cleavage of bonds, including double bonds, without the addition of water; **isomerases** – enzymes that catalyze isomerization reactions; **ligases** (synthetases) – enzymes that catalyze biosynthetic processes by joining molecules using ATP. Each of the six classes of enzymes is further divided into subclasses, and subclasses, in turn, into sub-subclasses. According to modern classification, each enzyme has a name and a code. In the code, the first digit represents the class, the second – the subclass, the third – the sub-subclass, and the fourth – the specific enzyme.

Among esterases, lipases should be noted, which catalyze the hydrolysis and synthesis of fats. In the human and animal body, the most active lipase is found in the pancreatic juice. The ability to hydrolyze fats is present in many plants. Lipase is found in the seeds

of cereals, oilseeds such as soybean, sunflower, cotton, and flax. However, the seeds of dioecious nettle are poor in lipase; it is mainly found in the vegetative organs of the plant. The influence of lipase should be considered in the storage of plant raw materials containing a significant amount of oil. Increased humidity and temperature activate lipase, leading to the breakdown of fats into glycerol and free fatty acids.

Tannase, an enzyme that catalyzes the hydrolysis of tannin, belongs to the group of esterases. It has unique action specificity – it hydrolyzes only those complex esters in which the acid component has at least two phenolic hydroxyls.

Carbohydrases (code 3.2) are enzymes that catalyze the hydrolysis and synthesis of homo- and heteroglycosides. Amylases, both alpha and beta, belong to carbohydrases. Amylases break down starch into dextrins and maltose, which is the end product of complete starch hydrolysis by these enzymes. The most active amylases are found in human and animal saliva and pancreatic juice. Interestingly, plant seeds differ in the content of alpha- and beta-amylases. For example, in the ungerminated grains of wheat, rye, and barley, only beta-amylase is present; alpha-amylase is formed in them only after germination. In soybeans, both alpha- and beta-amylases are present in both germinated and ungerminated seeds.

Beta-fructofuranosidase (invertase or sucrase) catalyzes the hydrolysis of sucrose into glucose and fructose. This enzyme hydrolyzes the bond located at the beta-glucosidic carbon atom of the fructose residue, while alpha-glucosidase hydrolyzes the bond in sucrose at the alpha-glucosidic carbon atom of the glucose residue. Beta-fructofuranosidase is found in higher plants, yeast, microorganisms, animal and human digestive juices, and pollen.

Proteases (code 3.4), or peptidohydrolases, are enzymes that catalyze the hydrolysis of the peptide bond in proteins and polypeptides. Proteases are divided into two groups: proteinases (endopeptidases) and peptidases (exopeptidases). Proteinases hydrolyze proteins into polypeptides, and polypeptides are further broken down by peptidases into amino acids. Among proteinases, digestive enzymes such as pepsin, trypsin, and chymotrypsin are noteworthy. Proteinases are found in some plants, with papain being a typical representative obtained from the milk sap of the papaya tree *Carica papaya*. The optimal pH for the enzyme's action is in weakly

acidic, neutral, and weakly alkaline environments (depending on the nature of the protein substrate). The action of papain and other proteolytic enzymes of plant origin is enhanced by citric acid and sulfhydryl compounds containing an SH group, primarily cysteine and reduced glutathione.

Proteinases similar to papain are found in the fruits and stems of pineapple *Ananas comosus* – bromelain, as well as in the latex of plants belonging to the genus Ficus – an enzyme called ficin.

Amidases (code 3.5). Urease belongs to this group of hydrolytic enzymes, which hydrolyzes urea into ammonia and carbon dioxide. Urease is present in plants, mold fungi, and certain bacteria. Large amounts of urease are found in soybean seeds *Glycine max* and lily of the valley *Convallaria majalis*. Watermelon seeds *Citrullus lanatus* are a promising source of this enzyme.

Disruptions in metabolic processes in the human body, caused by the absence or alteration of the activity of any enzyme, can be genetically determined (enzyme deficiencies) or result from inflammatory processes, injuries, tumors, or surgical interventions. Treatment of enzyme-related disorders of various etiologies involves enzyme replacement therapy and the use of enzymes in pathological processes.

From the experience of domestic and foreign enzyme therapy, six main directions of using medicinal enzyme preparations are conventionally identified.

Replacement therapy for diseases of the gastrointestinal tract. The use of enzymes in case of their deficiency in the gastrointestinal tract promotes the assimilation of nutrients and normalizes secretory activity. For example, tritikaza is a preparation based on a newly developed original plant substance from germinated wheat seeds *Triticum vulgare*. It contains amylolytic enzymes (β- and α-amylase), as well as β-galactosidase, invertase, amino acids, and trace elements. Granules are applied as a means of replacement therapy with amylolytic and anti-inflammatory effects for the treatment of digestive disorders resulting from insufficient enzyme function, particularly in chronic pancreatitis of various origins.

Treatment of acute and chronic inflammatory processes and wounds. Proteolytic enzymes hydrolyze residues of inflamed tissues, purulent exudates, exhibiting anti-inflammatory, fibrinolytic, and wound-healing effects. Additionally, enzymes can potentiate the

action of antibiotics and increase their concentration in blood and damaged tissues. The enzymatic preparation lysozyme directly exhibits bactericidal action by destroying the cell walls of microorganisms. Hyaluronidase preparations (lydase and ronidase) contribute to the resorption of scars and adhesions of various origins.

Enzyme therapy for cardiovascular diseases. Medicinal products based on proteolytic enzymes improve the capillary permeability of blood vessels, provide hypotensive and thrombolytic effects. In the treatment of thrombosis, trypsin, chymotrypsin, terrilytin, fibrinolysin, streptokinase, streptodecase, and chelias are used. In case of disturbances in tissue respiration processes, the drug cytochrome C is used.

Comprehensive therapy for oncological diseases. Proteolytic enzymes have been used since the late 19th century for the treatment of malignant tumors. Under the action of enzymes, the matrix connecting tumor cells with each other and with the endothelium is destroyed, leading to the reduction and necrosis of the tumor. In enzyme therapy for malignant tumors, in addition to proteases and nucleases, the enzyme L-asparaginase is used. It catalyzes the hydrolysis of the essential amino acid asparagine, necessary for the growth of cancer cells, into aspartic acid and ammonia. In the absence of asparagine, the growth of tumor cells and the formation of metastases are inhibited. L-asparaginase is used in the treatment of acute lymphoblastic leukemia with asparagine deficiency.

Treatment of allergic conditions. The use of antibiotics from the penicillin series is accompanied by the risk of allergic reactions and, sometimes, shock states. In these cases, the use of the enzyme penicillinase is indicated. This inactivator of penicillin antibiotics hydrolyzes their β-lactam ring.

Use of enzymes as biochemical reagents. Immobilized urease enzyme is used in the dialysis regeneration system in the "artificial kidney" apparatus. By catalyzing the hydrolysis of urea, urease actively contributes to the purification of blood from toxic substances.

Plants of the Fabaceae, Poaceae, and Solanaceae families are rich in trypsin and chymotrypsin inhibitors. Most often, protein inhibitors are found in seeds and are localized in aleurone grains, nuclei, chloroplasts, and mitochondria of cells. In some plants, they are found in leaves, stems, flowers, bulbs, etc. Scientists at the Institute of

Biochemistry have isolated a protease inhibitor from soybeans *Glycine max*. The possibility of its use as a medicinal product is being studied. As a result of research at the Institute of Biochemistry, a technology has also been developed for obtaining a protease inhibitor – **inamil**, from wheat seeds. The preparation can be used for clinical diagnosis of gastrointestinal diseases and as a hypoglycemic agent for the treatment of carbohydrate metabolism disorders.

Amylase inhibitors are found in storage organs of plants, as well as in leaves, fruits, and sprouts. They are represented by proteins or phenolic compounds, including tannins. Species of the legume, nightshade, and tea families are rich in amylase inhibitors.

Natural lipase inhibitors, isolated from plants, belong to the class of proteins or lipids and have high activity against pancreatic lipases. Lipase inhibitors are found only in seeds. The drug braguzol, undergoing clinical trials, contains a lipase inhibitor from the seeds of spring rapeseed *Brassica napus* var. *oleifera*. The drug is intended for the treatment of upper respiratory tract infections. The anti-inflammatory property of braguzol is provided by the lipase inhibitor, which can suppress the activity of lipolytic enzymes in the area of the inflammatory process.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING ENZYMES

BLACK CUMIN SEEDS – SEMINA NIGELLAE

Black cumin, *Nigella damascena* L. (from Latin *nigellus*, -a, -um – black, *damascenus* – Damascene), family Ranunculaceae – an annual herbaceous plant reaching a height of 40–60 cm. The seeds contain the enzyme lipase, fatty oil (35%), essential oil, alkaloids damascenin and damascenine, sterins, vitamin E, and melanin. The enzyme nigedase, obtained from the seeds, hydrolyzes plant and animal fats. Nigedase is used in the form of coated tablets, ensuring the complete preservation of enzyme activity under normal and increased acidity of gastric juice and partial preservation under reduced acidity. Nigedase, in combination with the enzyme orase, is part of the drug ornizyme-D, prescribed to children with diseases associated with insufficient digestive enzymes.

WATERMELON SEEDS – SEMINA CITRULLI

Common watermelon, *Citrullus vulgaris* Schrad (from Latin *citrus* – citrus tree), family Cucurbitaceae – an annual liana with tendrils, reaching a length of 2–5 m. The seeds contain the enzyme urease, fatty oil, and the watermelon pulp contains sugars (8–9%, mainly

fructose), pectin substances, cellulose, organic acids (malic, citric), folic acid, and small amounts of other vitamins (C, B1, B2, B6, PP, and β-carotene), iron and potassium salts. Urease is used in the "artificial kidney" apparatus, catalyzing the hydrolysis of urea and contributing to blood purification from toxins. Watermelon pulp is used in the dietary nutrition of patients with urolithiasis, atherosclerosis, diabetes, gallstone disease, gastritis, circulatory insufficiency, gout, and more.

PAPAIN – PAPAINUM

Papaya tree, *Carica papaya* L. (*carica* – Latinized name for fig), family Caricaceae – a tree reaching a height of 6 m, resembling a palm tree. Green fruits are poisonous due to alkaloids, while ripe fruits are edible. The latex contains proteolytic enzymes – papain, chymopapain, and lysozyme, as well as resins and malic acid. The peel of the fruits contains carotenoids, fatty oil, micro- and macroelements. The drug lysozyme contains a mixture of three proteases – papain, chymopapain, and lysozyme, exhibiting proteolytic, anticoagulant, and anti-inflammatory activity. It is used in orthopedics, neurosurgery, and ophthalmology to dissolve exudates and pathologically altered connective tissue. Bromelain is another proteolytic enzyme similar in action to papain, obtained from pineapple *Ananas comosus*. Papain and bromelain are part of complex natural origin drugs: wobenzym, wobemugos, and mulsal, used orally as agents for systemic enzyme therapy with anti-inflammatory, immunomodulatory, and angioprotective effects. In the nomenclature of foreign enzyme preparations, there are also medicinal products that improve digestive processes and contain papain and bromelain alongside animal-derived enzymes. Examples include luizim, elzim, kombizim, digenzim, mexasa, merkenzim, and pancreal Kirchner.

2 Medicinal plants and raw materials containing Lipids

The definitios "lipid" is difficult to define because it does not belong to any specific group of compounds that have common structural features. **Lipids** are a group of organic compounds – fats and fat-like substances that are heterogeneous in chemical state and have common physical and chemical properties. Lipids are insoluble in water and highly soluble in organic solvents (ether, chloroform, acetone, hexane, benzene, etc.).

There are three main classifications of lipids: chemical (structural), biological, and physicochemical. According to the biological

classification, lipids are divided into reserve and structural. According to the physicochemical classification, there are non-polar (neutral) and polar lipids; saponifiable (fats, waxes, complex lipids) and non-saponifiable (isoprenoids, carotenoids, prostaglandins, etc.).

According to their solubility and ability to be saponified, lipids include terpenoids, steroids, carotenoids, and chlorophyll. The group of lipids with fatty acid residues in their structure includes fatty acids, fats (lipids) and fat-like substances (lipoids).

2.1 Physicochemical properties, biological action and use of fatty acids

More than 200 fatty acids have been identified in the plant kingdom. According to the number of carbon atoms, they are divided into higher (containing from 16 to 24 atoms) and lower (with fewer carbon atoms) fatty acids. Saturated acids: butanoic (trivial name - butyric), octanoic (caprylic), decanoic (capric), dodecanoic (lauric), tetradecanoic (myristic), hexadecanoic (palmitic), octadecanoic (stearic), eicosanoic (arachinic), docosanoic (behenic), tetracosanoic (lignoceric); unsaturated acids: oleic, petroselinic, erucic, linoleic, ricinoleic, chaulmugic, arachidonic.

Some plant species contain acids with specific structures, for example, hydroxy acid in castor oil; an epoxy group is found in fatty acids of the genus Camelia, cyclic chaulmic acid in chaulmic oil. Chloroplasts contain acids with a trans configuration of double bonds.

A special group is made up of eicosapolyenoic acids and unbranched C20 acids with two or more double bonds between which methylene groups are contained. They form a widespread group of biologically active substances called eicosanoids. They include prostaglandins, related substances (prostanoids, thromboxanes, etc.) and leukotrienes. In recent years, the concept of "essential fatty acids" or vitamin F has emerged. Initially, only linoleic and α-linolenic acids were considered essential fatty acids that are not synthesized in animal organisms and whose absence in food causes symptoms of deficiency.

The biological role of essential fatty acids is not fully understood. Arachidonic, 8,11,14-eicosatrienoic and 5,8,11,14,17-eicosapentaenoic acids are precursors of prostaglandins and other lipoperoxides (prostacyclins, thromboxanes, leukotrienes) biosynthesis, and they are also an essential component of all biological membranes. The lack of essential fatty acids in food inhibits the

growth and reproductive function of young animals, causes dermatitis, reduces blood coagulation and affects blood pressure. Essential acids to some extent inhibit the development of atherosclerosis. Arachidonic acid is 10 times more active in normalizing these disorders than linoleic acid.

The human need for essential fatty acids, sometimes called vitamin F, in terms of linoleic acid is 10 g per day.

2.2 Physicochemical properties, biological action and use of fats (actually lipids)

Fats are high-molecular-weight organic compounds that consist exclusively of fatty acid triglycerides, i.e. they are esters of glycerol and higher monobasic fatty acids with the number of carbon atoms in the chain from 6 to 24 (R′, R′′, R′′′). Both saturated and unsaturated acids are involved in the formation of fats.

Fats are vegetable and animal by origin. By consistency, they are solid or fatty oils (with residues of saturated acids), and liquid or fatty oils, which are composed mainly of unsaturated acids. Fatty oils are classified into non-drying (oleic acid glycerides), semi-drying (linoleic acid glycerides) and drying (linolenic acid glycerides) based on the composition of unsaturated acids.

Fats always contain accompanying substances that affect their appearance, physical and chemical properties, and pharmacological effects. They make up the unsaponifiable fat residue (2-3%). The accompanying substances include: sterols, fat-soluble vitamins, pigments (chlorophyll, xanthophyll, carotenoids).

Sterols are monoatomic secondary alcohols derived from cyclopentaneperhydrophenanthrene (sterane). They are the most common steroids in nature and are divided into animal (zoosterols) and plant (phytosterols) by origin. In tissues, sterols are found in the free state and in the form of esters with fatty acids – sterols.

The most common phytosterol is sitosterol (β-sitosterol). Its structure is similar to zosterol, or cholesterol. Yeast, moldy fungi, wheat grains, and purple ergosterol contain ergosterol, which is a provitamin. After ultraviolet irradiation, it is converted into calciferol (vitamin D_2). Phytosterols and phytosterols are the main part of the unsaponifiable residue in fats. K vitamins are found in small amounts in both vegetable and animal fats.

Chlorophylls (from the Greek *chloros* – green and *phyllon* – leaf) are natural macroheterocyclic pigments involved in the process of

photosynthesis and belong to the metal porphyrins. The green color of plants is due to the presence of chlorophylls, which are localized in the chloroplasts of higher plants or chromatophores of lower plants in the form of peptide complexes.

More than 50 different chlorophylls have been isolated and structurally characterized from higher plants, algae, and photosynthetic bacteria. The main pigments of higher plants and algae are chlorophylls α and β. These chlorophylls are based on a dihydroporphyrin cycle with a central magnesium atom. Porphyrins are connected by an ester bond to the residues of the diterpene alcohol phytol

The chemical structure of chlorophyll is similar to that of heme, the blood pigment. Shade-tolerant plants contain more chlorophyll than light-loving plants. It is contained in plant materials from 0.2 to 2%. Chlorophylls α and β are extracted mainly from eucalyptus leaves (chlorophylliptus), nettle and spinach, and chlorophyll α is extracted from blue-green algae, which do not contain chlorophyll β. Studies have proven the bactericidal properties of chlorophyll, its stimulating effect on metabolism, and increased cardiovascular tone.

Some vegetable oils contain a significant amount of complex lipids - phosphatides (phospholipids), the structure of which will be discussed in the section "Lipoids".

The content of accompanying substances, the degree of saturation of fatty acids and the properties of specific acids significantly affect the physical properties of fats.

Fats are one of the main groups of substances that make up the body of a human, animal or plant. Vegetable fats are stored in fruits and seeds as a reserve material. Fatty oils are found in the parenchyma cells in the form of droplets. The richest in fat are the fruits of plants from the cabbage, poppy, flax, and olive families. The amount of fatty oil in the seeds of some plants can be tens of percent. For example, sunflower seeds contain 25-30% fat, bean seeds – 17-27%, flax seeds – 29-44%, castor oil seeds – 50-55%.

Plants growing in the north have more unsaturated acids than those growing closer to the equator (for example, cocoa butter is richer in saturated acid triglycerides). Oilseeds from temperate and northern climates contain semi-drying fatty oil. Those that grow further north contain more double bonds in their fatty acids.

In the animal body, fat is stored mainly in the abdominal cavity in the form of adipose tissue. It is also found in other tissues of the body. There is a lot of it in milk. A significant amount of fat is found in the liver, especially in fish and marine animals.

Fats in the body are the main source of energy. The oxidation of fats produces twice as much energy as the oxidation of carbohydrates and proteins. Fats, which are part of cell membranes, perform important structural functions. Due to its low thermal conductivity, fat deposited in the subcutaneous layer is a thermal insulator that protects the body from cooling and gives the skin elasticity. Fats from food and feed supply the body with vitamins A, D, E, F (fish oil, oils).

In pharmaceutical production, fats are used as a base for ointments, patches, liniments, suppositories, and emulsions. Olive, almond, and peach oils are used as a solvent for camphor, sex hormones, and other fat-soluble substances. The pharmacological effect of fats depends on the content of essential fatty acids and related substances. Fatty oils, which contain unsaturated fatty acids, have hypocholesterolemic activity (vitamin F). They are used as food additives to prevent atherosclerosis. Fats are widely used in the perfumery and cosmetics industry and for the production of soap, glycerin, stearin, plastics, micromers, lubricants, etc.

2.3 Medicinal plants and raw materials containing fats

NON-DRYING OILS

OLIVE OIL – OLEUM OLIVARUM

The European olive *Olea europaea* L. (olea Greek. *elaia* – name of the olive tree; Latin. *europaeus*, -a – European), family Oleaceae, is an evergreen tree. The main product is fatty oil (about 7%), which contains glycerides of oleic (up to 80%), palmitic (up to 10%), stearic (5-8%), linoleic and other acids. Some varieties of olive oil contain 13-25% of solid triglycerides, up to 5 μg of tocopherols, and carotenoids. Medical, edible, and technical oils are produced from olive fruits. In medicine, olive oil is used as a laxative, choleretic, and reparative agent; it is also used as a solvent for injectable drugs, in ointment bases and cosmetics. Domestic substitutes for olive oil are almond and peach oils.

ALMOND OIL – OLEUM AMYGDALARUM

Common almond *Amygdalus communis* L. (from Latinized Greek *amygdalos* – name of almond, possibly from Syriac *almugdala* – beautiful tree; Latin. *communis* – common), family Rosaceae, is a

short tree with a branched crown. The fatty oil of sweet and bitter almonds consists mainly of oleic acid triglyceride (almost 85%); other acids include linoleic acid (12%) and saturated fatty acids (3%). A substitute for olive oil. Refined almond oil, which is obtained by hot pressing, is used as a food product and in the perfumery industry.

PEACH OIL – OLEUM PERSICORUM

Common peach *Persica vulgaris* Mull. (Latin. *persicum* – peach, *vulgaris* – common), family Rosaceae, is a 3-5 m tall tree or bush. *Fatty oil, commonly known as peach oil, is obtained by cold pressing from the seeds of the peach *Persica vulgaris*, as well as apricot *Armeniaca vulgaris*, cherry plum *Prunus divaricata*, and plum *Prunus domestica*. The fruits of these trees are used in the food industry, while the seeds are a waste product and a cheap raw material for oil production. Colorless or yellowish liquid, odorless, with a pleasant oily taste. The acid number of medical oil is not more than 2.5, iodine number – 96-103. The chemical composition of peach oil is similar to that of almond oil. It contains a single-acid triglyceride of oleic acid, which is accompanied by linoleic acid glycerides. It is a substitute for olive oil.

CASTOR OIL – OLEUM RICINI

Castor oil *Ricinus communis* L. (from the Latinized Greek *rikinos* – or from the ancient European *rikar* – spherical, Latin. *communis* – common), family Euphorbiaceae – a tree, and in temperate countries, in particular in Ukraine – an annual herb. Castor oil (castor oil) consists of a monoacid glyceride of ricinoleic acid (85%) and glycerides of oleic (9%), linoleic (3%), stearic and dioctyric acids. A classic laxative.

When it enters the duodenum, castor oil is partially hydrolyzed into glycerin and ricinoleic acid, whose salts increase intestinal motility. It is a component of Urolessan, essence, Vishnevsky's liniment, allorom ointment, etc. As an external remedy, it is used to treat diaper rash, trophic ulcers, radiodermatitis, seborrhea, and diffuse hair loss. In homeopathy, mature seeds are used for gastroenteritis, cholera and as a lactation enhancer.

SEMI-DRYING OILS

SUNFLOWER OIL – OLEUM HELIANTHI

Annual sunflower *Helianthus annuus* L. (from the Greek *helios* – sun and *anthos* – flower, Latin *annuus* – annual), family Asteraceae, is an annual herbaceous plant with a hard pubescent surface. The seeds contain semi-drying fatty oil (35%), which consists of glycerides

of oleic (39%), linoleic (47%) and saturated acids (9%), including palmitic, stearic, arachinic and lignoceric acids; sterols, carotenoids and tocopherols (60 mg%). Sunflower oil is used as a base for ointments, patches and rubs, and is consumed as a choleretic agent for chronic diseases of the liver and biliary tract. It is a component of livian aerosol (for treatment of burn wounds), a solvent for medicinal substances (camphor, concentrates of rosehip, rowan, sea buckthorn carotenoids, etc.).

CORN OIL – OLEUM MAYDIS

Common corn *Zea mays* L. (from the Greek *zeia* – the name of fodder cereal; *mays* – from the Mexican folk name maiz, the Russian word "*corn*" – from the Spanish. *cucurucho*), Poaceae family, an annual herb. Corn germ contains fatty oil (57%), protein (18%), phytin (about 5%), and tocopherols. Corn oil contains triglycerides of oleic (43%), linoleic and hypogeic (46%) acids and unsaturated acids (up to 11%). Saturated acids include palmitic, stearic, arachinic, caproic, caprylic, and capric acids. Corn oil contains tocopherols (100 mg%) and many phytosterols. The oil is obtained from corn kernel germs (Embryonis Maydis), which are a waste product of flour milling. Cold-pressed oil has a golden yellow color and a pleasant taste. Iodine number is 111-131 (Iodine number is an indicator that characterizes the degree of unsaturation of organic substances. The iodine number is expressed in the number of grams of iodine that can be attached to the test substance weighing 100 g by unsaturated bonds. The higher the iodine number, the greater the degree of unsaturation of the compounds in the substance). Corn oil is used to prevent and treat atherosclerosis and hypertension.

PUMPKIN SEEDS – SEMINA CUCURBITAE

PUMPKIN SEED OIL – CUCURBITAE OLEUM

Common pumpkin *Cucurbita pepo* L. (*cucurbita* is the Latin name for pumpkin), family Cucurbitaceae, is an annual herb with a climbing stem, branched from the base, up to 10 m long, with antennae in the leaf axils. The seeds contain a fatty oil (35-50%), which consists mainly of glycerides of palmitic (13.5%), stearic (6.3%), oleic (25%) and linoleic acids (55.2%). The oil is a semi-drying oil (iodine number 110-115); when the temperature drops, a precipitate of saturated acid glycerides precipitates from it. The part of the oil that is not saponified (2.5-4.5%) contains sterols (campesterol, stigmasterol, stigmasterol, cucurbitol), phosphatides, B-vitamins, carotenoids, tocopherols,

phytin. The water-soluble fraction (cucurbitol) consists of amino acids and low molecular weight peptides. Amino acids are common (histidine, lysine, arginine, etc.) and specific (cucurbitine). Cucurbitin is considered to be the active ingredient in pumpkin seeds; its content is 3-7%, but some varieties, such as almond, Ukrainian perennial, contain more than 11% cucurbitin. The seeds also contain ascorbic and salicylic acids. anti-ulcer, antiseptic, antisclerotic, reparative, and to reduce prostate proliferation.

The fruits contain pectin substances, sugars (glucose, fructose, sucrose), ascorbic acid, vitamins B_1, B2, B_3, B_6, B_9, PP, tocopherols, a significant amount of carotene and minerals. Cucurbitin has an anthelmintic effect, which is why the seeds are used to get rid of tapeworms and roundworms. The seeds are eaten peeled or prepared as a decoction or emulsion. Pumpkin seed oil is used to make the dietary supplement tikveol, which is used as a hepatoprotective, choleretic, anti-ulcer, antiseptic, anti-sclerotic, reparative agent, and to reduce prostate proliferation. A similar drug, peponene, is used for prostate diseases and atherosclerosis. Pumpkin pulp is a source of carotene. In preventive nutrition and folk medicine, it is used as a diuretic, choleretic, laxative, as well as for gout, diabetes mellitus, pyelonephritis, colitis, enterocolitis, and cholecystitis. Externally, the pulp is used for burns, to treat eczema, skin inflammation, and in cosmetics.

DRYING FATTY OILS

FLAX SEEDS – SEMINA LINI,

FLAXSEED OIL – OLEUM LINI

Common flax *Linum usitatissimum* L. (from Latinized Greek *linon* – thread; Latin. *usitatissimus*, *-um* – the superlative of *usitatus* – used, common), Linaceae family, is an annual herb with a bare, cylindrical stem. The oil is obtained by pressing crushed flaxseeds. It is an oily liquid of light-yellow color with a brownish tinge; its odor is characteristic, taste is pleasant. Acid value is not more than 5, iodine value is 169-192. The seeds contain a drying fatty oil (30-48%), which consists of glycerides of linolenic (35-40%), linoleic (25-35%), isooleic (15-20%), palmitic and stearic acids, the enzyme linamarase, cyanoglycoside linamarin (about 1.5%), proteins (20-25%), carbohydrates, etc. Linetol contains ethyl esters of unsaturated fatty acids from flaxseed oil. It lowers blood cholesterol levels and is used to treat atherosclerosis. Linetol is a component of the aerosol

preparations vinizol, levovinizol, livian. Green soap and soap alcohol are made from flaxseed oil, which are used for skin diseases.

FATTY OILS CONTAINING PHOSPHOLIPIDS

SOYBEAN SEEDS – SEMINA SOJAE,

SOYBEAN OIL – OLEUM SOJAE

Bristlecone soybean *Glycine hispida* (Moench). Maxim., syn. *Glycyne soja* Sieb. et. al. Zucc. (Latinized name comes from the Greek glykys – sweet; hispidus - bristly; soja – Japanese name of the plant), Fabaceae family, is an annual herb with an erect, pubescent, branched stem from 30-50 cm to 2 m tall. Depending on the variety and growing conditions, soybean seeds contain 30-45% protein, 17-25% semi-drying fatty oil, vitamins A, B_1, B_2, B_6, D, E, C, choline, biotin (vitamin H), folacin (vitamin B). The fatty oil contains palmitic, leic, linoleic (about 50%) and linolenic (10.3%) acids. A characteristic feature of the seeds is a high content of phosphatides – lecithin (1-2%) and kefalin, as well as isoflavone glycosides. The oil is yellow or orange in color, a transparent liquid with a faint odor and a pleasant taste. The iodine number is 114-140. Soybean phospholipids, together with a complex of vitamins and flaccumin, are an integral part of the drug lipofen, which is used to treat gastrointestinal diseases. It is a component of hepatoprotective (essentiale, esel) and venotonic drugs (esgefol, esavengel). Fatty oil from unripe seeds contains a large amount of carotenoids, so it helps to heal wounds and ulcers caused by radiation exposure. Soybean seed protein is similar in chemical composition to animal protein and replaces it in the diet. Amino acids and some fatty acids are essential. After extraction of fatty oil, soybean meal is used to produce the drug glisabol. It contains isoflavones, pectins, sugars, and proteins. Soybeans are an important source of vegetable protein and oil. More than 100 food products are made from the seeds. Soybean "meat" is used in medical and vegetarian nutrition.

SOLID VEGETABLE FATS

COCOA BUTTER (COCOA BUTTER) – BUTYRUM CACAO (OLEUM CACAO)

Chocolate tree *Theobroma cacao* L. (Latinized name derived from the Greek *theos* – god; *broma* – food), Sterculiaceae family, is an evergreen tree usually 5 m high. The seeds are toasted, removed from the hard shell, heated to a homogeneous liquid mass, which is then pressed hot on hydraulic presses. The resulting oil is filtered and

poured into molds where it is cooled. The remaining cake is ground to make cocoa. The solid mass of cocoa butter is yellowish in color, oily to the touch, has a pleasant smell and taste; it is brittle at room temperature, melts at 30-35°C and turns into a clear liquid. It is soluble in 10 parts of alcohol.

Genuine cocoa butter, which is free of impurities, is completely soluble in three parts of ether and its solution remains transparent at 15 °C for a day. The oil contains two- and three-acid glycerides of stearic (up to 34%), lauric and palmitic (up to 25%), oleic (40%) and linoleic (2%) acids. The melting point is within the range of human body temperature, so it is used as a base for the manufacture of suppositories, balls and sticks or (in melted form) mixed with the corresponding medicinal substances and poured into molds.

2.4 Physicochemical properties, biological action and use of lipoids (fat-like substances)

Lipoids are a group of fat-like substances that include waxes and complex lipids. The latter are divided into phospholipids (phosphatides) and glycolipids. Lipoids are insoluble in water, soluble in organic solvents, and saponify when heated with alkali. Complex lipids are part of cell membranes.

Phospholipids are esters of polyhydric alcohols, fatty acids (or their aldehydes), and phosphoric acid. The molecules also include the nitrogenous bases choline and collamine, the amino acid serine, or the cyclic alcohol inositol. A significant amount of phosphatides is found in blood plasma as part of lipoproteins. Phosphatides are found in all cells and tissues of living organisms; nervous tissue is the richest in phosphatides. Some phospholipids are a transport form of fats in the body. Plant phospholipids are used to make hepatoprotective drugs, such as essence and lecithin.

Lecithins are fat-like substances that contain glycerol, fatty acids, phosphoric acid residues, and choline. They are waxy, white, and highly hygroscopic. They are found in tissues both in the free state and in the form of compounds with proteins and carbohydrates. The richest in lecithins are egg yolk, caviar, soy and sunflower seeds. Lecithins play an important role in the transport of fats in the blood, cell permeability, and in cellular fat metabolism.

Natural waxes are mainly esters of high molecular weight aliphatic monobasic acids (C_{24} - C_{36}) and higher alcohols (number of carbon atoms C_{16} - C_{36}); by consistency – solid and liquid. By origin, waxes

are divided into vegetable, animal, fossil, and synthetic. Vegetable waxes are secreted by plant tissues. Animal waxes include: beeswax (secreted by the bee's wax glands), wool wax – lanolin (obtained by washing sheep's wool), spermaceti (extracted from whales). Fossil waxes: ceresin – rock wax (obtained from ozokerite), montane wax (extracted from lignite or peat). Synthetic waxes are obtained by hydrogenation of carbon monoxide or from low molecular weight polyphenols.

Esters are the main part of waxes and determine their characteristic properties. The fatty acids that make up waxes are usually saturated; sometimes other acids are also found. Waxes also contain free alcohols, acids, and hydrocarbons. At normal temperature, waxes are solid, sometimes ointment-like substances of white or yellow color, with a pleasant odor or odorless and tasteless. They are soluble in ether, chloroform, and difficult to dissolve in cold alcohol, and insoluble in water. Similar to fats, they leave a greasy trace on paper when melted. Unlike oils, waxes are very slowly washed with aqueous alkaline solutions. They are washed with alcoholic alkali solutions at a temperature of 300°C with decomposition, but without the release of acrolein. Waxes are waterproof because they do not get wet (beeswax, lanolin, water bird wax).

Theme 4 MEDICINAL PLANTS AND PLANT RAW MATERIALS CONTAINING PHENOLS

1 Simple phenols

2 Phenolic derivatives: phenolic alcohols, phenolic acids, phenolic glycosides

3 Medicinal plants and raw materials containing simple phenols

4 Coumarini

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 169-205. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Phenolic compounds are those that contain an aromatic ring with one or more hydroxyl groups, and their derivatives. If there are two or more hydroxyl groups in a molecule, the substance is called

a **polyphenol**. In a broad sense, phenols can include all substances that have an aromatic nucleus to which the OH group or its functional derivative is directly bound. Along with simple phenols, phenolcarboxylic acids and their derivatives belong to this class a large group of natural compounds: coumarins, chromones, flavonoids, lignans, xanthones, quinones and tannins. Phenolic structures also occur in other classes of chemical compounds. Phenolic alkaloids (morphine), phenolic steroids (estradiol), protoalkaloids (capsaicinoids) and others are known, which will be discussed in the relevant sections.

The biogenesis of phenolic compounds has been proven using radioactive isotopes (C^{14}). It has been established that phenolic compounds are active metabolites, and not end products of cellular metabolism, as previously thought. These data suggest an important biological role for phenolic compounds. They occur in all organs of plants, but more of them are found in actively functioning organs – leaves, flowers, unripe fruits.

According to their chemical structure, phenolic compounds are divided into four main groups: with one aromatic core, with two aromatic nuclei, with a quinone structure and polymeric.

1 Simple phenols

Phenolic compounds with one aromatic nucleus are a large and diverse group of phenolic compounds consisting of simple phenols (C_6) and phenol with one (C_6–C_1), two (C_6–C_2) or three (C_6–C_3) carbon atoms attached to it.

Simple phenols are relatively rare in plants in their free state, but many of their derivatives are in the form of glycosides or constituents of plant products such as essential oils, resins, tannins, etc.

In plants, phenol occurs in minimal quantities in the leaves of *Nicotiana tabacum*, the bark of the willow *Salix* sp., the needles and cones of the pine *Pinus sylvestris*, the leaves of the black currant *Ribes nigrum*. Less commonly, phenol derivatives are the main constituents of essential oils, such as thymol (2-isopropyl-5-methylphenol) and its isomer carvacrol, which are found in thyme essential oils *Thymus* sp. and oregano *Origanum vulgare*. Pyrocatechin is found in the tea leaves *Thea sinensis*, onion husks of *Allium cepa*. Hydroquinone and methylhydroquinone in plants occur in a free state and in the form of glycosides – arbutin, methylarbutin. Common in members of the families Ericaceae, Rosaceae, Saxifragaceae, Asteraceae, Tiliaceae.

Pyrogallol, found in small quantities in redwood cones, is a fragment of tannins. Strong reducing agent. It is used in dermatology for the treatment of psoriasis, eczema.

Phloroglucin occurs in redwood cones, onion husks, and in the form of glycosides in citrus peels. Phloroglucin derivatives (aspidinol) are found in the rhizomes of the male shield fern *Dryopteris filix-mas*, are precursors of hop acids in the inflorescences of *Humulus lupulus* hops.

2 Phenolic derivatives: phenolic alcohols, phenolic acids, phenolic glycosides

Phenolic alcohols (structure C_6–C_1) have an alcohol group in their structure and differ in the number of phenolic hydroxyls, which can be free or methylated. These compounds are rarely found in higher plants, of which the most common are salicylic, gentisin, coniferyl and synapic alcohols. Salicylic alcohol (saligenin) is an aglycone of the glycoside salicinin, which is found in the bark of the willow *Salix* sp. It has anti-inflammatory and local anesthetic effects. Gentisin alcohol is an aglycone of the glycoside salireposide, isolated from the leaves of the aspen *Populus tremula*. Coniferyl alcohol plays an important role as a biochemical precursor of lignin. It also occurs in the form of the glycoside coniferin. Synapic alcohol (syringenin) is one of the main components in the biosynthesis of lignin in gymnosperms. It is also an aglycone of the glycoside siringin, which is found in the bark, leaves, and fruits of the lilac *Syringa vulgaris*.

Phenolic aldehydes such as vanillin, piperonal, salicylic and anise aldehydes, etc., are better known. Vanillin in the form of a glycoside is found in the fruit of the flat-leaved vanilla *Vanilla planifolia*; semi-synthetically, it is extracted from eugenol. Vanillin is used to improve the smell of medicines. Salicylic aldehyde is found in the essential oil of the elm-leaved viper *Filipendula ulmaria*. Piperonal is found in the essential oil from the flowers of the white acacia *Robinia pseudoacacia* or violets *Viola* sp. It has a pleasant smell, is used in perfumery and cosmetics.

Phenolic acids are compounds that have phenolic hydroxyl groups and a carboxyl group bonded to an aromatic core. The most important are derivatives of benzoic and cinnamic acids. In plants, they occur in free form, as well as in the form of depsids and glycosides. The ester bond formed between the phenolic hydroxil of one phenolcarboxylic acid molecule and the carboxyl group of another molecule is called a depsid bond, and compounds containing such a

bond are called depsids. Of this group, protocatechuc, hydroxycatechoic, gentisic and free gallic acids are most often found in plants. Vanillic, lilac and n-hydroxybenzoic acids are part of lignin. Salicylic and pyrocatechuic acids are relatively uncommon.

Salicylic acid is more commonly found in the form of methyl ester in some essential oils or bound in glycosides. Salicylic acid methyl ester is a biologically active substance in some types of raw materials, for example, the herb of the tricolor violet *Herba Violae tricoloris*, the roots of the senega *Radices Senegae*, the flowers of the elm-leaved viper *Flores Ulmariae*.

Gallic acid is found in plants both in its free state and as a depsid. Gallic acid and its depsids are part of hydrolyzable tannins and often occur in a free state. It has anti-inflammatory, antimicrobial, antiviral properties, etc. Phenolcarboxylic acids with a side chain, especially derivatives of cinnamic acid, are of practical interest. In the biogenesis of hydroxycinnamic acid, the main precursor is the amino acid phenylalanine, from which, through deamination with the participation of the enzyme phenylalanine deaminase, cinnamic acid is synthesized in the plant, and through hydroxylation and methylation, some hydroxy- and methyl derivatives are formed. Two stereoisomers of o-hydroxycinnamic acid are known: one has a trans configuration and is called coumaric acid, the other has a cis configuration and is called coumaric acid. Only coumaric acid can exist in a free state, for example in various types of aloe. Coumaric acid is cyclized into coumarin lactone, found in many plants.

Caffeic acid is very common in nature. It often forms dimers (pseudodepsids). For example, chlorogenic acid is a pseudodepside of caffeic and quinic acids. Of the tridepsids of caffeic acid, isochlorogenic acid and cynarin should be noted. Caffeic acid has weak bacteriostatic properties, has anti-inflammatory, hepatoprotective, and immunotropic effects. The methyl esters of caffeic acid – ferulic and synapic acids – are found in higher plants. Ferulic acid occurs in plants in a free state and as part of esters. It has choleretic, antimicrobial, antimycotic, hepatoprotective effects, inhibits the aggregation of erythrocytes. It is distributed in the Apiaceae family.

Of the **alicyclic acids** in plants, quinic and shikimic acids sometimes accumulate in significant quantities. For example, the bark of the *Cortex Chinae* tree contains up to 9% quinic acid. Quinic acid is an important metabolic intermediate in plants, often as part of

depsids. Thus, the Asteraceae family is characterized by the presence of depsid, chicory acid. Some scientists associate it with the biological activity of preparations of echinacea, chicory, etc. The chicory acid content in the raw material of echinacea is in the range of 0.6–2.1%. In the Russian pharmacopoeia, the quality of the herb *Echinaceae purpureae* is assessed by the content of hydroxycinnamic acids in terms of chicory acid. There are references in the literature to the antimicrobial and immunostimulating effects of chicory acid.

Shikimic acid was first isolated from the fruit of the real star anise *Illicium verum* (also known as star anise, Indian anise, Chinese anise, Siberian anise, ship anise). It plays an important role in the biosynthesis of aromatic amino acids, cinnamic acids, flavonoids and other phenolic compounds. When introduced into plant tissues, quinic and shikimic acids are easily converted into phenolic compounds.

Phenolic glycosides. Simple phenols, phenolic alcohols, aldehydes and their derivatives occur in plants mainly in the form of glycosides with glucose, but also with xylose and arabinose. **Arbutin** was first isolated from the leaves of the bearberry *Arctostaphylos uva-ursi*. Its content in plants varies widely – from 0.5 to 20 %: bearberry *Arctostaphylos uva-ursi* – 5–12 %, lingonberry *Vaccinium vitis-idaea* – 4–8 %, blueberry *Vaccinium myrtillus* – 0.5–15 %, thick-leaved *Bergenia crassifolia* – 15–20 %. Arbutin has an antiseptic effect on the urinary tract. The hydrolytic breakdown of arbutin to hydroquinone occurs only in the alkaline environment of urine. Gallic acid derivatives, such as hydrolyzable tannins, inhibit the activity of arbutin.

The glycoside **methylarbutin** is often a companion of arbutin in plants. It is more difficult to hydrolyze, so the leaves containing methylarbutin do not turn black when dried. The glycoside content depends on the geographical areas and place of origin, for example, in the southern regions, the ratio of arbutin and methylarbutin in the raw material is 1:1; In the north, arbutin predominates in plants.

Salidroside, or rhodioloside, is isolated from the rhizomes of *Rhodiola rosea*. It is a biologically active substance of the raw material of *Rhodiola rosea* and has an adaptogenic effect.

Echinacoside contains rhamnose and two glucose residues, one of which is combined with caffeic acid. Contained in Echinacea *Ehinacea* spp., acts on one of the links of the immune system, activates phenocytosis.

3 Medicinal Plants and Raw Materials Containing Simple Phenols

BEARBERRY LEAVES – FOLIA UVAE URSI, BEARBERRY SHOOTS – CORMI UVAE URSI

Common bearberry, also known as bear's ear *Arctostaphylos uva-ursi* (L.) Spreng., from Greek "*arktos*" – bear and "*staphyle*" – grape cluster; "*ursi*" – genitive of "*ursus*" – bear, meaning bear-like, belongs to the heather Ericaceae family – a low shrub reaching a height of 30–50 cm. The main active substances are phenolglycosides: arbutin (8–12%), methylarbutin, free hydroquinone, and sometimes arbutin forms an ether with gallic acid. A new glycoside, piceoside, has recently been identified in bearberry leaves. The decoction is used as an antiseptic, diuretic, and anti-inflammatory agent for pyelitis, cystitis, and urethritis. It is part of diuretic herbal blends. The pharmacological effect of the raw material is manifested only under alkaline urine conditions, as hydrolysis of arbutin and methylarbutin to hydroquinone occurs in an alkaline environment, which causes antibacterial and irritant effects, leading to increased diuresis. Tannins and their hydrolysis products enhance anti-inflammatory activity. Prolonged and excessive use of bearberry preparations may irritate the kidneys and cause miscarriages in pregnant women. In homeopathy, bearberry leaves collected during the flowering period are used for urinary tract diseases and hives without itching.

CRANBERRY LEAVES – FOLIA VITIS IDAEAE, CRANBERRY SHOOTS – CORMI VITIS IDAEAE

Cranberry *Vaccinium vitis-idaea* L., from Latin "*vaccinium*" – berry bush; "*vitis idaea*" – Idaean grape (*Ida* – mountain on the island of Crete), Ericaceae family – an evergreen shrub with a long creeping rhizome. The main active substances are phenolglycosides: arbutin (5–7%), methylarbutin (3%), pyroside, cavoarbutin. In addition, the raw material contains phenolcarboxylic and oxychoric acids – caffeic, ferulic, chlorogenic, and isochlorogenic acids; flavonoids – (+)-catechin, (+)-gallocatechin, kaempferol, myricetin, hyperoside; tannins (20%), iridoids; triterpenoids – ursolic acid; vitamin C (up to 32 mg%). The decoction is used as a diuretic and antiseptic for urolithiasis, pyelitis, and cystitis. It is a substitute for bearberry leaves.

RHODIOLA ROSEA RHIZOMES AND ROOTS – RHIZOMATA ET RADICES RHODIOLAE ROSEAE

Rhodiola rosea L. from Greek "*rhodos*" – rose; Latin "*roseus*" – pink, stonecrop Crassulaceae family – a perennial, succulent, dioecious plant with a gray-green color, a woody, thick, multi-headed tuberous rhizome covered with brown triangular scales. The main active substances are phenolic alcohols and their glycosides (up to 1%), dominated by tyrosol and its glucoside – salidroside. The raw material also contains glycosides of cinnamyl alcohol – rosin, rosavin, rosarin; flavonoids – derivatives of herbacetin, tricin, kaempferol; flavolignan rhodiolin; monoterpenes – rosiridol and rosiridin. Hydrolysable tannins make up 20%; there is essential oil (0.8–0.9%). Rhodiola is a manganese accumulator. Liquid rhodiola extract, containing at least 0.5% salidroside, is used as a tonic and adaptogenic agent. The raw material is also used in the composition of biologically active food additives.

VIOLET HERB – HERBA VIOLAE

Tricolor violet *Viola tricolo*r L., and field violet, *Viola arvensis* Murr., family Violaceae – annual or biennial herbaceous plants reaching a height of 10–45 cm. The herb contains salicylic acid (0.1%), flavonoids, essential oil containing methyl salicylate, saponins (14%), including ursolic acid, carotenoids, and vitamin C. Infusion is used as an expectorant, diuretic, diaphoretic, and anti-inflammatory agent. It is part of chest and diuretic herbal blends. In homeopathy, the entire fresh flowering plant of tricolor violet is used for diathesis in infants, as well as for skin diseases and nocturnal enuresis.

UNUSUAL PEONY HERB – HERBA PAEONIAE ANOMALAE

Peony anomala, Mariin root *Paeonia anomala* L. (named after *Paean*, the Greek god of healing; Latin "*anomalus*, -a" – irregular from Greek "-*an*" – not and "*nomalos*" – regular), family Paeoniaceae – a perennial herbaceous plant reaching a height of 60–100 cm. The rhizomes and roots of peony contain salicin glycoside, methyl salicylate, salicylic and benzoic acids, flavonoids, tannins (8%), and sugars (10%). The essential oil (1.6%) contains monoterpenoids: peonol, peonoside, peonolide, and others. The leaves contain up to 0.3% ascorbic acid. Peony infusion is used as a sedative. It is applied for neurasthenia with increased excitability, insomnia, and hypochondria. Peony preparations cause a slight increase in gastric juice acidity.

WILLOW BARK – CORTEX SALICIS

Sharp-leaf willow *Salix acutifolia* Willd., family Salicaceae – dioecious tree or shrub reaching up to 5 m. It contains phenolic compounds: pyrocatechin, salicylic alcohol; n-coumaric, ferulic, salicylic, and other acids; phenolglycosides – salicin (0.6%), populin, salicortin, picein; flavonoids, catechins, condensed tannins (up to 12.5%). Willow bark decoction is used for gargling in stomatitis, gingivitis, periodontitis, and inflammatory processes in the oral cavity and throat as an anti-inflammatory, analgesic, antiseptic, and astringent. From the bark, the standard luteolin and cynaroside (glycoside of luteolin) are obtained, used in pharmaceutical analysis. Willow bark is a component of biologically active food supplements.

RASPBERRY FRUITS – FRUCTUS RUBI IDAEI

Raspberry *Rubus idaeus* L. (from Latin "*rubus*" – raspberry, Greek "*idaeos*" – from Mount Ida in Crete), family Rosaceae – a semi-shrub with annual vegetative shoots and woody biennial stems forming shortened flowering branches. The fruits contain carbohydrates: fructose, glucose, sucrose (4–8%), pectin substances, and fiber; organic acids – malic, salicylic, sorbic, formic, acetic, and others (over 2% in total); vitamins C, B_1, B_2, carotene, PP; salts of potassium, iron, copper; ether oil, benzaldehyde, triterpene acids, flavonoids (1.4%): quercetin glycosides, anthocyanins; coumarins, tannins. Infusion of dried fruits is used as a diaphoretic and febrifuge for colds. It is part of diaphoretic herbal blends. Fresh fruits have anti-sclerotic properties; syrup (*Sirupus Rubi idaei*) improves the taste and odor of medicines. They are widely used in the food industry and in biologically active food supplements.

Artichoke Leaves and Basket – FOLIA ET ANTHODIA CYNARAE

Globe artichoke *Cynara scolymus* L., family Asteraceae – a perennial herbaceous thistle with an upright stem, branching, grayish-green, reaching a height of 0.5–2 m. The leaves contain phenolic carboxylic acids: caffeic, chlorogenic, neochlorogenic, cynarin, tannins. Flavonoids are represented by derivatives of luteolin. The baskets contain protein (3%), carbohydrates (10–15%), ascorbic acid, vitamins B_1 and B_2, carotene, isolated sesquiterpene lactones of the guaianolide group (cynaropicrin and grosheimin). The complex of cynarin, phenolic acids, and flavonoids determines the anti-sclerotic, choleretic, hepatoprotective, and diuretic activity of the raw material and the drug "Hofitol". Infusions of artichoke heads are used as food.

MALE FERN RHIZOMES – RHIZOMATA FILICIS MARIS

Male fern *Dryopteris filix-mas* (L.) Schott. (from the transliteration of the Greek name of this plant; Greek "*drys*" – oak, "*pteris*" – fern; Latin "*filix*" – fern, "*mas*" – male), family Dryopteridaceae (Aspidiaceae) – a perennial plant with a short, thick, horizontal or oblique cylindrical rhizome densely covered with remnants of petioles arranged like tiles; petioles are thick, elastic, densely covered with large lanceolate brown scales. The main active substances are phenolic compounds, which are monomeric, dimeric, and trimeric derivatives of various complexity of phloroglucinol: aspidinol, albaspidin, filixic acid, and others. The sum of phloroglucides is called "raw filicin H_7C_3." In addition to this, the raw material contains tannins (7–8%), triterpenoids, vitamins B, higher aliphatic alcohols, higher fatty acids and their esters. A dense extract is made from fresh or dried rhizomes, which is used as an anthelmintic for tapeworms.

4 Coumarini

Coumarins are found in plants of various families. They are most typical for the Apiaceae, Rutaceae, and Fabaceae families. In plants of other families (Asteraceae, Hippocastanaceae, Solanaceae), they are relatively rare. The most common derivatives of coumarin and furanocoumarin are prevalent. The majority of compounds in this class are found in a free state, less commonly in the form of glycosides.

Coumarins are unevenly distributed in plants, ranging from 0.2 to 10%. They mainly accumulate in fruits, seeds, roots, bark, flowers, and less so in grass and leaves. In the celery family, coumarin compounds are localized in the essential oil channels. It is common to find 5–10 coumarins of different chemical structures in a single plant. The qualitative and quantitative composition varies among different species, even within the same genus. Variations are also possible within a single species (subspecies, chemotype). The composition of coumarins changes during the ontogenesis of plants. In small concentrations, coumarins enhance plant growth, while in large concentrations, they have the opposite effect, slowing it down.

Natural coumarins exhibit diverse activities. Some of them (psoralen, bergapten, xanthotoxin) show photodynamic activity, increasing the skin's sensitivity to UV rays and finding applications in the therapy of vitiligo, focal melanosis, and leukoderma. Others (e.g., pyranocoumarins from the roots of hogweed, adamanthine from the roots and fruits of mountain lovage, pterixin from the flower heads of yarrow, pastinacin from the fruits of parsley) act as spasmolytics.

Esculetin, fraxetin, and their glycosides esculin and fraxin, found in horse chestnut fruits, exhibit vitamin P activity. Umbelliferone has antimicrobial properties, osthol has anti-tumor effects, and dicoumarin has anticoagulant properties. There is evidence of successful use of methyl, methoxy, and hydroxy derivatives of coumarin as anthelmintics, in the treatment of parasitic skin diseases, and trichomonadal colpitis.

Therefore, coumarins are characterized by a wide range of biological effects on the human body, but they have not gained widespread use due to the lack of optimal pharmaceutical forms, which is complicated by their low solubility in water.

CHESTNUT SEEDS – SEMINA HIPPOCASTANI

CHESTNUT LEAVES – FOLIA HIPPOCASTANI

Common horse chestnut *Aesculus hippocastanum* L. (from *aesculus* – Latin name for a tree; Greek *hippos* – horse; Latin *castanea* – edible chestnut), family Hippocastanaceae – a tree up to 30 m tall, with a large dense crown and white or pink flowers in upright pyramid-shaped panicles up to 20–30 cm long. The seeds contain coumarin glycosides – esculin, which breaks down into esculetin (6,7-dioxycoumarin) and D-glucose, as well as fraxin, which releases D-glucose and fraxetin upon breakdown. Horse chestnut seeds also contain triterpenoid saponins, flavonoids, starch (up to 50%), fatty oil, amino acids, proteins, tannins, bitter substances, and enzymes. In the leaves, along with coumarins and saponins, flavonoids are synthesized. Extracts such as escusan and escin, derived from the seeds, are used independently and in combination with other venotonic agents. Preparations like escin, escingel (based on saponins), esflazid (escin combined with flavonoids from the leaves), and escuvazin strengthen capillary walls, tone venous vessels, increase their resistance, and reduce inflammatory and allergic swelling. In homeopathy, fresh mature seeds without the outer skin are used to treat stasis in various organs: dilated vessels of the eye fundus, follicular pharyngitis, and proctitis.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING FUROCOUMARINS

PSORALEA FRUITS – FRUCTUS PSORALEAE

Psoralea corylifolia L. (from the Greek "*psoraleos*" – covered with scurf; Latin "*corylifolia*" – hazel-like leaves), family Fabaceae – a perennial herb with roots reaching a depth of 2–4 m. The fruits contain

furocoumarins (1%): psoralen and angelicin, accompanied by umbelliferone. The fruits also contain a significant amount of fatty oil. A preparation called psoralen is obtained from the fruits, consisting of psoralen and angelicin. It is used as a photosensitizing agent in the treatment of total and focal melanosis and vitiligo.

FRUITS OF GREATER AMMI – FRUCTUS AMMI MAJORIS

Greater ammi (Bishop's weed) *Ammi majus* L. (from the Greek "*ammi*" – the name of the plant, and Latin "*majus*" – larger), family Apiaceae – an annual herb up to 50–100 cm tall. The raw material contains methoxyl derivatives of psoralen (2.0%): bergapten, xanthotoxin, isopimpinellin, marmesin. A preparation called amifurin, a mixture of furocoumarins, is produced and used as a photosensitizing agent.

FRUITS OF COMMON PARSNIP – FRUCTUS PASTINACAE SATIVAE

Common parsnip *Pastinaca sativa* L. (from *pastinaca* – Latin name for a celery plant; Latin *sativus*, *-a* – cultivated), family Apiaceae – a biennial herbaceous plant with a fleshy, juicy, conical root and a straight, branching stem up to 1–1.7 m tall. The raw material contains furocoumarins (1%): imperatorin, bergapten, xanthotoxin, isopimpinellin. Flavonoids and essential oil are also found. Preparations such as beroksan, a mixture of bergapten and xanthotoxin (accompanied by flavonoids), and pastinacin are manufactured. Beroksan is used as a photosensitizing agent, while pastinacin acts as a spasmolytic, affecting coronary vessels and preventing angina attacks.

FIG LEAVES – FOLIA FICUSI CARICAE

FIG FRUITS – FRUCTUS FICUSI CARICAE

Common fig (fig tree) *Ficus carica* L. (from *ficus* – ancient Roman name for the plant; *carica* – reminiscent of the plant's homeland – Caria in Asia Minor), family Moraceae – a deciduous tree or shrub up to 5 m tall. The leaves contain furocoumarins psoralen, angelicin, and bergapten, tannins, rutin (0.1%), ascorbic acid, and essential oil. Fig fruits contain sugars (up to 75%), proteins (4–6%), fats (1–3%), pectin substances (5%), organic acids (up to 1%), anthocyanin glycosides, mucilage, vitamins A, B_1, B_2, B_6, C, and PP. A preparation called psoberan is made from the leaves, which consists of psoralen and bergapten and is used as a photosensitizing agent. Fig fruits are included in combined preparations such as cafiol and regulax, which have a laxative effect.

RHIZOMES AND ROOTS OF ANGELICA – RHIZOMATA ET RADICES ANGELICAE

Garden angelica (wild celery) *Angelica archangelica* L., syn. *Archangelica officinalis* (Moench.) Hoffm. (from *angelicus*, *-a* – angelic; Greek *archaios* – elder – named after the archangel Raphael, who provided people with knowledge of the medicinal properties of many plants), family Apiaceae – a herbaceous biennial or perennial plant up to 2 m tall with a short, thick rhizome. The raw material contains coumarins and furocoumarins: xanthotoxin, bergapten, angelicin, ostol, ostenol, imperatorin, angelic acid, apterin; essential oil (0.5%), sesquiterpenoid bitter compounds, organic and fatty acids, flavonoids (naringenin), tannins. The raw material belongs to aromatic bitters and is included in the pharmacopeias of various countries. The decoction exhibits spasmolytic, anti-inflammatory, and sedative effects, improves digestion. The infusion is used for rubbing in cases of myositis, radiculitis, and neuralgia. It is part of the complex preparation energotonic Doppelherz. In food supplements (dietary supplements), it is used as a flavoring agent. Xanthotoxin, in large doses, has mutagenic and carcinogenic effects.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING PYRANOCOUMARINS

RHIZOMES AND ROOTS OF SIBERIAN HOGWEED – RHIZOMATA ET RADICES PHLOJODICARPI SIBIRICI

Siberian hogweed *Phlojodicarpus sibiricus* (Fisch.) Koso-Pol. (from the Greek "*phloidad*" – to inflate, "*karpos*" – fruit; Latin "*sibiricus*" – Siberian, indicating the place of growth), family Apiaceae – a perennial herbaceous plant up to 70 cm tall. The roots contain pyranocoumarins (3%), the main ones being visnadin and dihydrosamidin. The preparation Floverin is used for spasms of peripheral vessels, spasmodic forms of endarteritis, Raynaud's disease, and mild forms of chronic coronary insufficiency.

Theme 5 MEDICINAL PLANTS AND RAW MATERIALS CONTAINING FLAVONOIDS

1 Flavonoids distribution and localization
2 Flavonoids biological functions in plants
3 Medicinal plants and raw materials containing flavonoids

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 213-255. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

1 Flavonoids distribution and localization

The flavonoids are biologically active substances based on a diphenylpropane fragment, with the general formula C_6–C_3–C_6. The name comes from the Latin word *flavus* – yellow, because the first isolated flavonoids had **a yellow color**.

The flavonoid molecule consists of two phenolic residues (rings A and B) connected by a propane unit, so they can be considered as derivatives of phenylpropanoids. Flavonoids have different positions of phenolic radicals in the propane moiety. On this basis, they are divided into three main groups: euflavonoids, isoflavonoids and neoflavonoids.

Flavonoids are found in almost all plants, microorganisms and insects. The richest in flavonoids are the families Fabaceae, Polygonaceae, Asteraceae, Rosaceae. They accumulate mostly in flowers, leaves, less in stems, rhizomes, roots. Their content varies from 0.1 to 20% (for example, in the buds of Sophora japonica) and varies depending on the vegetation phase of the plant. The maximum amount of flavonoids is observed during flowering, then they become less. External factors are of great importance: tropical and highland plants contain more flavonoids; Therefore, it is believed that their number depends on the intensity of sunlight and altitude above sea level. Glycosides are usually found in tissues of active growth (leaves, buds, flowers), glycones – in lignified tissues (bark, crust).

Flavonols make up 40% of all flavonoids. Rutin, for example, is found in more than 70 species belonging to 34 families, quercetin – in more than 400 species. Anthocyanidins affect the color of flowers, fruits, and leaves. There are 22 anthocyanidin aglicones in nature, but only three of them are very common: pelargonidin, delphinidin, cyanidin. For example, cyanidin stains apples, cherries, raspberries and onions; delphinidin – pomegranate, eggplant; pelargonidin – strawberries, passionflower fruits; cyanidin with delphinidin – black currants, oranges. Chalcones and aurons are easy to detect in the petals of flowers – under the influence of ammonia vapors, their color changes from yellow to red. Their distribution is limited to nine families.

Most flavonoids dissolve in plant cell sap and are found in chloroplasts. Chalcones and aurons of the tripartite string *Bidens tripartita* are localized in milk jugs; flavonols and flavones – in the epidermis; isoflavonoids – mainly in underground organs and seeds.

Flavonoids are typical plant dyes that play the role of filters and protect plant tissues from ultraviolet radiation, prevent the destruction of chlorophyll. The hypothesis about the participation of flavonoids in the processes of plant respiration was confirmed, because it became known that they, together with ascorbic acid, are consumed in the enzymatic processes of oxidation and reduction, performing an antioxidant function. It has also been proven that flavonoids affect the growth and development of plants, participate in the process of conception, but the mechanism of their action has not been clarified here. For example, rutin is able to inhibit fertility.

2 Flavonoids biological functions in plants

Flavonoids contain reactive phenolic radicals and a carbonyl group in the molecule. Due to this, they participate in various metabolic processes, which determines their biological activity. The most important types of pharmacological action include:

- P-vitamin, i.e. bioflavonoids have a positive effect on the condition of capillary vessels: their stability increases, elasticity and throughput increase;
- diuretic, which is inherent in both pure flavonoids and LRS; cardiotonic and hypotensive activity (e.g., Crataegus preparations);
- antispasmodic (primarily affect the smooth muscles of blood vessels);
- antioxidant, anti-radiation.

Flavonoids act on the digestive tract, liver, uterus, have anti-ulcer, wound healing, antitumor effects, etc. The pharmacological action of flavonoids depends on their class. Isoflavones are characterized by estrogenic, catechins – astringent and anti-inflammatory effects on mucous membranes; Flavones cause antispasmodic, hypotensive, bactericidal effects. Chalcones, flavanones (liquiritin), flavonols (quercetin, rutin), flavones (apigenin) also act as antispasmodics. Leukoanthocyanidins – pelargonidin, delphinidin, cyanidin – have a moderate antitumor effect.

Many flavonoids, such as miricetin, flavonoids of sand cumin, chicory, bidens, have a choleretic effect. Flavonoids form chelated

complexes with metals, have a radioprotective effect, bind and remove radionuclides. Recently, hypoglycemic and anabolizing effects of flavonoids have been established. All natural flavonoids are low-toxic, with a wide spectrum of biological action, which makes them attractive for the creation of new phytopreparations.

P-vitamin action. Phenolic compounds are combined under the name "vitamin P", which are able to reduce the permeability and fragility of capillaries, increase their resistance. These are flavones hesperidin, eriodictin; flavonols rutin, quercitrin, isoquercetin, quercetin, isorhamnetin; methylchalcone; L-epicatechin; oxycoumarins esculin, esculin. The mechanism of their action is explained by the fact that compounds with P-vitamin activity reduce the level of hyaluronidase, prevent the oxidation of ascorbic acid and adrenaline, which increases the strength of blood vessels. An excess of hyaluronidase increases the permeability of capillaries and causes hemorrhage under the skin, which is a sign of P-avitaminosis. Polyphenols and ascorbic acid complement and potentiate the mutual action on capillaries, so in medicinal forms they are often contained together (ascorutin). In addition, they are always combined in berries, fruits, vegetables.

Effect on the cardiovascular system. Derivatives of flavonols, catechins and anthocyanins (rutin, quercetin, quercitrin, leukoanthocyanidins, tea catechin complex, miricetin, pelargonidine) increase the amplitude of heart contractions, normalize the heart rhythm. Flavonoids increase heart contractions, accelerate blood microcirculation, as a result of which the nutrition of the heart muscle improves and a positive inotropic effect occurs. Some flavonoids (hyperoside, C-glycoside vitexin, quercetin, kaempferol, sum of polyphenols from hawthorn flowers *Crataegus*) dilate blood vessels, including coronary ones. Flavonoids also affect the rate of enzymatic processes and the activity of cyclooxygenase, lipooxygenase, adenosine deaminase, which affect lipid oxidation, neurotransmission, blood coagulation. But most of these interactions have not yet been clarified. Flavonoids can cause a short-term increase in blood pressure, but most publications are devoted to the study of the hypotensive activity of licorice *Glycyrrhiza glabra* flavonoids, sorrel *Rumex*, *Scrophularia* sp., tea *Thea sinensis* catechins and isolated aglycones and glycosides. Polyphenols stimulate (in large doses inhibit) the activity of the heart and reduce blood pressure for a short

time due to the dilation of the vessels of the abdominal cavity. But there is also evidence of a local, direct effect on the muscles of the heart and blood vessels.

Effects on renal function. A significant number of plants contain flavonoid compounds with diuretic activity – grass of various species of bitter grass *Polygonum* sp., herb of glabrous chill *Herniaria glabra*, steam *Agrimonia eupatoria*, licorice *Glycyrrhiza glabra*, St. John's wort *Hypericum perforatum*, creeping Tribulus *Tribulus terrestris*, rose hips *Rosa* sp. Flavone luteolin causes a long-term increase in diuresis; catechins, on the other hand, reduce urination. Noteworthy is the hypoazotemic activity of some flavonoids, for example, robinin, which contains robinia flowers *Robinia pseudoacacia* and astragalus species *Astragalus* sp. The same effect was found in other derivatives of kaempferol (biorobin, diorobin), in a hyperoside whose glycon is quercetin. The drug lespenephril, produced from the herb lespedeca, contains kaempferol glycosides. These compounds help to reduce the concentration of nitrogen in the urine.

Herbal remedies containing flavonoids are used for hemorrhagic diathesis (tendency to hemorrhages), capillarotoxicosis, vitamin C and P, against infectious and toxic pathogens, chronic hepatitis, hypertension, skin diseases, some inflammatory processes, etc. As a substance isolated from plant raw materials, rutin and quercetin are used. They are part of medicines, and most often they are prescribed for the prevention of sclerosis of blood vessels.

3 Medicinal plants and raw materials containing flavonoids

TEA LEAVES – FOLIA THEAE

Chinese tea *Thea sinensis* L., syn. *Camellia sinensis* (L.) Ltze. (from Chinese. *te* – tea bush; another generic name *Camellia* is in honor of the English botanist Camel (1661–1706), wild tea, a family Theaceae – a tree, and cultivated tea due to the constant cutting of young leaves and short shoots – a bush. Some botanists identify Camellia with tea. The only obvious difference between them is that the leaves of tea are almost sessile, and those of camellia are petiolate, in tea the sepals remain with fruits, and in camellia they fall off. Young shoots are plucked – flushes (three leaves), the fourth leaf with an axillary bud remains on the branch. As they grow, the leaves are harvested again. If the leaves are dried immediately after harvesting, green tea is obtained. To obtain black tea, the leaves are fermented, dried and sorted. The stems and tea dust are removed and

used to make pressed teas (tile tea) and to obtain caffeine. Polyphenolic compounds in green tea leaves make up 15–30% and are represented by catechin, its derivatives (vitamin P), flavonoids and tannins. It also contains alkaloids – caffeine, theophylline. Essential oil gives tea a strong aroma and specific taste. Vitamins C, B_1, B_2, PP, mineral salts were also found. The therapeutic properties of tea are due to a complex of biologically active substances; caffeine has a stimulant effect; polyphenolic compounds have P-vitamin, antioxidant and neutralizing effects. To provide first aid, tea is given in case of poisoning that causes depression of the central nervous system, weakening of cardiac activity and respiration, and alcohol poisoning.

CORNFLOWER FLOWERS – FLORES CENTAUREAE CYANI

Blue cornflower *Centaurea cyanus* L. (from the Greek name of the plant *kentaureion*, which is related to the name of the centaur Chiron and the Greek. *kyanos* – blue), family Asteraceae is an annual herbaceous plant with a thin branched stem up to 30 cm high. The flowers contain anthocyanins (0.6–1%) – cyanin, pelargonidin derivatives; flavones – apigenin diglucoside, luteolin; flavonols – quercetin-glucoside, quercetin-7-rutinoside, rutin, as well as saponins, coumarin chicorine, resinous and pectin substances, alkaloids. The infusion is a mild diuretic, used for kidney disease, urinary tract. It also has a choleretic, anti-inflammatory, disinfectant effect.

Fresh chokeberry fruits – FRUCTUS ARONIAE MELANOCARPAE RECENTES

Aronia (mountain ash) chokeberry *Aronia melanocarpa* (Michx.) Elliot (from the Greek. *aronia* is the name of a medlar-like fruit; From the Greek. *melas* – black and *karpos* – plid), family Rosaceae is a deciduous shrub from 0.5 to 2 m tall. Fruits contain cyanidin and its glycosides, phenolic acids (5-6%), flavonoids – rutin, quercetin, hesperidin, catechins; pectin substances (2.5%); ascorbic acid (110 mg%), a significant amount of iodine (5-6 μg/100 g), as well as nicotinic and folic acids, riboflavin, tocopherol, carotenoids, lipophilic substances (lipids, waxes, paraffins). Fresh fruits and juice are used to prevent P-vitamin deficiency. They are also useful for patients with hypertension. Lipophilic substances are included in the composition reparative aromalin.

Violet Herb –HERBA VIOLAE

Tricolor violet *Viola tricolor* L., field violet *Viola arvensis* Murr., family Violaceae, is an annual or biennial herb 10–45 cm tall. Violet herb contains flavonoids (0.5–1.5%): rutin, and other quercetin O-glycosides; C-glycosides: vitexin, saponaretin, orientin; The flowers are stained with anthocyanins violaxanthin, zeaxanthin, violanine, 3-glycoside delphinidin, 3-glycoside peonidin. Violet herb combines antiseptic, anti-inflammatory, bronchodilatory, expectorant, diuretic, diaphoretic, weak choleretic and antispasmodic properties. Mild dermatonic, hyposensitizing, anti-inflammatory, antimicrobial, antisclerotic and the analgesic effect justifies the widespread therapeutic use of violets.

Sand cumin flowers – FLORES HELICHRYSI ARENARII

Sand cumin *Helichrysum arenarium* (L.) Moench. (from the Greek. *helios* – sun and *chrysos* – gold and Latin. *arenarius*, *-um* – sandy), Asteraceae, is a perennial herb with white felt pubescence. Flavonoids (6.5%) are represented by flavanone naringenin and its glycosides – salipurposide, isosalipurposide and helichrysin; flavones are dominated by apigenin and its 5-glycoside; The flavonol group is made up of kaempferol derivatives. The inflorescences contain a number of phthalic anhydride derivatives. Tannins, essential oil, coumarins, sterols, resins, organic acids, mucilages, carotenoids were found in the raw materials. Choleretic. Enhances the secretion of the stomach and pancreas. Use infusion, dry extract, collections, flamin preparation.

Tansy flowers – FLORES TANACETI

Tansy *Tanacetum vulgare* L. (Latinized *tanaceta* or *tanazito* is the name of tansy in the Middle Ages; Latin. *vulgaris* – common), family Asteraceae, is a perennial herb. *Flavonoids (2.5%) are represented by derivatives of apigenin, acacetin, luteolin; there are also alkaloids, tannins, organic acids. The essential oil (2%) contains the terpenoids thujone, isotujone, borneol, α- and β-pinenes. The bitter taste is due to sesquiterpene lactones (tanacetin). Tansy chemotypes differ in the chemical composition of the essential oil (there are raw materials without the toxic α-thujone) and the content of triterpenoids. Tansy preparations increase the secretion of bile, tone the digestive organs, increase the amplitude of heart contractions, slow down the heart rate, and increase blood pressure. Flower powder is used as an anthelmintic; the drug tanacechol for hepatitis, enterocolitis, gastritis with low acidity. The drugs cause blood flow to the pelvic organs,

which can cause miscarriage in pregnant women. In homeopathy, a mixture of fresh leaves and inflorescences is used equally for weakness of the arms and legs, spasms and cramps of different parts of the body, for dysmenorrhea and metritis, as an anthelmintic.

Dried Rosemary Grass – HERBA GNAPHALII ULIGINOSI

Gnaphalium uliginosum L. (from the Greek. *gnaphalon* – felt, non-woven textiles made from wool fibers.; Latin. *uliginosum* – muddy from *uligo* – moisture), family Asteraceae is an annual herbaceous plant, grayish-green, gray or whitish in color from an unevenly patched woolly pubescence. Flavonoids are represented by flavonols (quercetin, kaempferol) and flavones. There are also tannins (4%), resins, carotenoids, phytosterol, ascorbic acid. The lipophilic fraction contains carotenoids, terpenoids. The infusion and decoction have a vasodilatory and hypotensive effect, slow down the heart rate, have an antibacterial and wound healing effect. Oil extracts are used to treat wounds, burns, fistulas, trophic ulcers; The action is due to carotenoids. In homeopathy, all A fresh plant for hypertension, sciatic neuralgia.

Hawthorn fruit – FRUCTUS CRATAEGI, Hawthorn flowers – FLORES CRATAEGI

Blood red hawthorn *Crataegus sanguinea* Pall. (from the Greek. *Krataios* – robust, due to its strong wood, as well as because of its hard spines) and other species (more than 30 species) common in Ukraine, family Rosaceae, are tall bushes, less often trees with straight axillary spines. The flowers contain flavonoids (0.5–2.5%). There are 25 known flavonoids, the most important being hyperoside (0.7%), C-glycoside vitexin and its O-glycosides. C-glycosides dominate the leaves. Biosides, di- and oligoglycosides of leukoanthocyanidins, other derivatives of flavan, oligomers of dehydrocatechin, and essential oil are synthesized in flowers. The fruits contain compounds similar to those localized in flowers, but notin addition to hyperoside, epicatechins, leukoanthocyanidin oligomers are important. Their composition depends on the degree of ripeness of the fruit. This also applies to anthocyanins, pectins, ascorbic acid. Common to both types of raw materials is the content of triterpenoid acids – ursolic, oleanolic, crategoic, acanthus, etc. Their average content in flowers is 0.1–0.3%, in fruits – 0.3–0.5%. Galenic drugs have cardiotonic, hypotensive, sedative, antispasmodic effects. Hawthorn preparations increase blood

circulation in the coronary vessels of the heart and brain vessels, eliminate tachycardia and arrhythmia. With vasospasms, flower tincture is much more effective than fruit extract, which is used most often for hypertension. Liquid extract of the fruit is part of cardiovalene. Cratheside is made from the fruits of the bent hawthorn. Liquid extract of flowers is part of the preparations Cardiofit, Biovital, Gerovital, which have hypotensive and sedative properties; Phytulvent – reparative, choleretic, antiseptic, sedative. In homeopathy, fresh ripe fruits are used for angina pectoris, weakening of cardiac activity after infectious diseases.

Roots of the Baikal skullcap – RADICES SCUTELLARIAE BAICALENSIS

Baikal skullcap *Scutellaria baicalensis* Georgi (from Latin. *scutellum* – *scutellum*, diminutive of *scutum* – shield, according to the shape of the calyx appendage; *baicalensis* – Baikal, family Lamiaceae is a perennial, herbaceous plant, 15–35 cm tall. Flavones and their glycosides (up to 10% in total): baicalin, scutellarin, vogonin, oroxylin. Skullcap preparations have sedative, hypotensive and anticonvulsant properties. The tincture is used for hypertension of I and II degrees. On the basis of baicalein, a semi-synthetic drug aspalinate of a similar action is made.

Japanese sophorae fruit – FRUCRUS SOPHORAE JAPONICAE

Buds of Japanese sophorae – ALABASTRAE SOPHORAE JAPONICAE

Japanese Sophora *Sophora japonica* L. (Latinized Arabic name of one of the types of acacia – sofera; Lat. japonicus – Japanese), Fabaceae family, – deciduous tree up to 30 m tall. *Sophora buds and young fruits contain up to 20% rutin. The fruits also contain kaempferol-3-sophoroside, quercetin-3-rutinoside, genistein-4-sophorabioside. The main active ingredient in Sophora preparations is rutin, which has the ability (especially in combination with ascorbic acid) to strengthen blood vessel walls and reduce their fragility. It is used for the prevention and treatment of hypovitaminosis P, in diseases accompanied by increased vessel permeability, and for the prevention of capillary damage when using anticoagulants, salicylates, and arsenic preparations. Sophora fruit infusion is an antiseptic agent. Quercetin and rutin preparations are obtained from buds and are used in the form of powders, tablets, and in the composition of preparations such as ascorutin, vicalin, and rutes. The aerial part of common

buckwheat (*Fagopyrum esculentum*, Polygonaceae), which contains up to 4% rutin, is also used for rutin production.

Motherwort Herb – HERBA LEONURI

Common motherwort *Leonurus cardiaca* L. (from the Greek *leon* – lion and *ura* – tail; Greek *cardia* – heart), five-lobed motherwort – *Leonurus quinquelobatus* Gilib., Lamiaceae family, – perennial herbaceous plant. The active substances are controversial, but a complex of flavonoids, iridoids, and alkaloids is likely to be responsible. The main flavonoids include quinquelozyde, rutin, quercitrin, cosmosin, isocquercitrin, hyperoside. The protoalkaloid stachydrine and two unidentified alkaloids are present in an amount of 0.05%. Motherwort iridoids belong to the aucubin type (harpagide, ayugol, ayugoside). Bitter taste is given to the raw material by diterpenes (marubin), triterpenoids (about 0.3% ursolic acid). Among other biologically active substances are tannins, a small amount of essential oil, and rutin of caffeic acid. The herb is used in the form of infusion and tincture as a sedative and hypotensive agent for cardiovascular neuroses, initial stages of hypertension, cardiosclerosis, and increased nervous excitability. The infusion is part of the Traskov mixture, and the tincture is part of cardiophyte, biovital, herovital, and energytonic Doppelgerts. In homeopathy, fresh herb is used during the climacteric period, with heart and nervous weakness, and flatulence.

Pepper Mustard Herb – HERBA POLYGONI HYDROPIPERIS

Water pepper *Polygonum hydropiper* L. (Latinized Greek name from *poly* – many and *gony* - knee, node, or *gonon* – offspring; Latin *hydropiper* – from Greek *hydor* – water and *piper* – pepper, i.e., a plant grows near water and has a pungent taste), Polygonaceae family, – annual herbaceous plant with an upright, reddish stem. Flavonoids (2.5-3%) are the main components, including rutin, quercitrin, hyperoside, kaempferol, methoxylated flavonoids – isorhamnetin, ramnetin, ramnosin in the form of complex esters with $KHSO_4$, these compounds are called persicarins. There are tannins (about 3-5%), free gallic and ellagic acids, vitamins K and C. The raw material contains colored substances of the phagopyrin type that cause photophobia (sensitivity to light). The bitter taste of fresh raw material is due to sesquiterpene aldehydes (polygodial, its isomer isothadeonal), lactones (conifertifolin, isodrimaninol). Infusion, liquid extract – hemostatic agents for uterine and hemorrhoidal bleeding,

mild laxative, also used for urolithiasis to facilitate the excretion of concrements.

Mustard Herb – HERBA POLYGONI PERSICARIAE

Spotted smartweed *Persicaria maculosa* Gray, syn. *Polygonum persicaria* L. (Polygonum comes from the Latinized Greek name *polygonon* – smartweed; from *poly* – many and *gony* – knee, node, or *gonon* – offspring; persicaria from Latin *persica* – peach, due to the similarity of smartweed leaves to peach tree leaves), Polygonaceae family, – annual herbaceous plant with a taproot and an erect, reddish stem. Flavonoids are represented by hyperoside, isokvertsetin, avicularin, persicarin, tetramethylquercetin. The herb contains vitamin K, tannin (1.5%), phlobaphens (oxidation products of condensed tannins), free gallic acid, essential oil (0.05%), a significant amount of phylloquinones, and pectin (more than 5%). Infusion and extracts of smartweed herb have a pronounced laxative, hemostatic effect. They are indicated for uterine bleeding caused by uterine atony, inflammatory processes, profuse menstruation, and hemorrhoidal bleeding.

Knotweed herb – HERBA POLYGONI AVICULARIS

Polygonum aviculare L. (common knotgrass) is an annual herbaceous plant in the buckwheat family Polygonaceae. Its stem is mostly prostrate, branched, reaching a length of 10–25 cm. The primary flavonoids (2–2.5%) include avicularin, quercetin, hyperoside, and catechins. It contains phenolic acids (caffeic, n-coumaric, chlorogenic, gallic), water-soluble silicon compounds (4.5%), mucilage, carotene, ascorbic acid, tannins (about 4%), and traces of anthraquinone glycosides like emodin. A new lignan glycoside, avicularin, has been isolated from the herb. Knotgrass preparations affect the kidneys and urinary tract, aiding in the dissolution and elimination of stones and sand. Infusions find application in obstetrics and gynecology as hemostatic agents; they tonify uterine muscles and increase diuresis. Knotgrass is also used in tuberculosis, believed to strengthen lung tissue due to the presence of silicon acid. It is a component of medications such as marelin and phytolith.

St. John's wort herb – HERBA HYPERICI

Common St. John's wort *Hypericum perforatum* L. and spotted St. John's wort *Hypericum maculatum* L. are perennial herbaceous plants in the St. John's wort Hypericaceae family. The herbs contain various bioactive compounds. Flavonoids (5–6%) are mainly represented by

flavonols: hyperoside (0.3–0.7%), rutin, quercetin, myricetin, leukoanthocyanidins, and anthocyanins. Biflavonoids, such as amentoflavone and biapigenin, have also been isolated. The fresh flowers of common St. John's wort contain the specific hyperforin, with bactericidal properties. Infusions and decoctions have astringent, antimicrobial, hemostatic, and anti-inflammatory effects. St. John's wort preparations (tinctures, novoimanin) exert antibacterial action. The plant is part of complex preparations like polyfitol, herbogastrin, phytolith, fitolvent, armon, and arfazetin.

Black Elderberry Flowers – FLORES SAMBUCI NIGRAE

Black elderberry *Sambucus nigra* L., Adoxaceae family, is a large, bushy shrub growing 3–6 meters high. The flowers contain flavonoids (up to 1.8%), including rutin (about 0.3%), derivatives of quercetin, kaempferol, astragalin, anthocyanidins, and the cyanoglycoside sambunigrin (about 0.1%). Various phenolic acid compounds (n-coumaric, chlorogenic, caffeic, and their glucosides), amines (ethylamine, isobutylamine, choline), tannins, mucilage, and ascorbic acid are present. Elderberry flowers have diaphoretic, anti-inflammatory, diuretic, and mild expectorant properties. Infusions are used for respiratory infections, chronic bronchitis, and in gynecology.

Linden Flowers – FLORES TILIAE

Linden species such as small-leaved linden *Tilia cordata* Mill. and large-leaved linden *Tilia platyphyllos* Scop. belong to the mallow Malvaceae family. The flowers contain a significant amount of flavonoid compounds (1%), including flavones, flavanones, and flavonols. Identified flavonoids include quercetin glycosides, kaempferol, and derivatives, such as tiliarin. The essential oil (0.05%) contains farnesol, hydrocarbons, 2-phenylethanol, and monoterpenoids. Mucilage makes up to 40%, and tannins and their precursors (leukoanthocyanins) make up to 2%. Linden infusions have diaphoretic, enveloping, anti-inflammatory, and diuretic properties, and they enhance blood clotting. Traditional medicine recommends them for gout, neurosis, and diabetes.

Ginkgo Leaves – FOLIA GINKGO

Ginkgo biloba L., also known as maidenhair tree, Ginkgoaceae family, is a deciduous gymnosperm, reaching up to 25 meters in height. It can live up to 1000 years. The main active compounds include flavonoids, sesquiterpenes, and diterpenes. Flavonoids in the leaves consist of flavones (luteolin, 2-hydroxyluteolin), flavonols

(quercetin and kaempferol glycosides), flavonoid ethers (with coumaric acid), catechins, and leukoanthocyanins. Biflavonoids like ginkgetin and bilobetin, as well as amentoflavone, are also present. A specific substance, the sesquiterpene trilactone bilobalide, is derived from biologically active ginkgolides. The overall content of these compounds in raw material is around 0.06%. Ginkgo leaf extracts have antispasmodic, vasodilating, and bacteriostatic effects. Ginkgolides prevent erythrocyte aggregation, normalize cerebral blood circulation and blood pressure. Extracts from fresh leaves are used in galenic preparations such as ginkgogink, tanakan, memoplant, ginkgo-proct, ginkgo-gel, and ginkgo-fort, prescribed for disorders of the peripheral and central nervous system and cerebral circulation. Decoctions of ginkgo leaves are recommended for the elderly with cerebral vessel sclerosis, venous insufficiency of the legs, varicose veins, and hemorrhoids.

Goldenrod herb – HERBA SOLIDAGINIS

Goldenrod – *Solidago virgaurea* L., Canadian Goldenrod – *Solidago canadensis* L., Goldenrod, derived from Latin "*solidus*" meaning strong, and "agere" meaning to make, belongs to the Asteraceae family. It is a perennial herbaceous plant. The herb contains flavonoids such as kaempferol, quercetin, and their glycosides (astragalin, rutin). Saponins (about 1.5%) with oleonolic and polygallic acids as aglycones also influence its activity. Standardization of the raw material is based on the content of the phenolic diglycoside leucocarposide. Tannins (10%), essential oil, diterpenes, nicotinic acid, and ascorbic acid are also present. Goldenrod preparations possess diuretic, cholagogue, astringent, antibacterial, and anti-inflammatory properties. They prevent excessive fragility of capillaries. Goldenrod extract is part of medications like marelin and phytolith, used in kidney stone disease. In homeopathy, fresh flowering tops of common goldenrod are used for albuminuria, phosphaturia, and mucus in urine, as well as for skin diseases.

Horsetail Herb – HERBA EQUSETI ARVENSIS

Field horsetail *Equisetum arvense* L., derived from Latin "*equus*" meaning horse and "*seta*" meaning bristle, belongs to the Equisetaceae family. It is a perennial herb with a branching rhizome. It has two types of stems: spring, spore-bearing, which wither after spores mature, and summer, sterile, which persist until autumn. Summer shoots are brightly green, reaching a height of 15–40 cm.

The main active substances are flavonoids: derivatives of apigenin, luteolin, kaempferol, and quercetin. The herb also contains phenolcarboxylic acids, tannins, and saponins of an unspecified composition. The silica content in the ash residue is 6–10%, sometimes reaching 20%. The plant concentrates molybdenum and selenium. The impact of pyridine alkaloids (nicotine, palustrine) – whether toxic or pharmacological – is not clear. It exhibits diverse therapeutic effects: diuretic, hemostatic, anti-inflammatory, litholytic, detoxifying in lead poisoning. The extract is part of complex preparations like marelin, phytolith, phytolysin, Traskova mixture, and arfazetin collection.

Zlinka herb – HERBA ERIGERONIS CANADENSIS

Erigeron canadensis L., Asteraceae family, is an annual herb, with a stiff-haired, erect, ribbed, 30–100 cm high, branched stem in the upper part. The herb contains flavonoids (apigenin, luteolin, quercetin, isorhamnetin), tannins, choline and essential oil, which includes limonene, dipentene, terpineol; phenolcarboxylic acids (caffeic, chlorogenic, neochlorogenic); coumarins (umbeliferon, scopoletin), sitosterol. The infusion of the herb is used as an anti-inflammatory, hemostatic, and the drug erican is used as an antidiarrheal.

Licorice Roots – RADICES GLYCYRRHIZAE

Licorice glabra *Glycyrrhiza glabra* L. (Greek: *glykys* – sweet and *rhiza* – root; Latin. *glabra* – naked), legume Fabaceae family, is a perennial herb. Along with triterpene saponins, licorice roots contain significant amounts of flavonoids. Liquiritin was isolated by Japanese chemists Shinoda and Ueda in 1933. The sum of flavonoids (3–4%) is represented by chalcones and flavanones, the main of which are liquirtigenin and its glycosides – liquiritin, neoliquiritin, uraloside. The main chalcone is isoliquirtigenin and its glycosides (isoliquiritin, licurazide). Licorice flavonoids have antispasmodic, anti-inflammatory and anti-ulcer effects. Drugs liquiriton, flacarbine are used for gastric ulcer and duodenal ulcer.

Beggars Grass – HERBA BIDENTIS

The tripartite string *Bidens tripartita* L. (Latin: *bi* – two- and *dens* – tooth, according to the structure of the fruit, which has two toothed points, tripartita – *tripartital* from tri – *tri-* and *pars, partis* – part, according to the shape of the leaf), Asteraceae family, is an annual herb. Beggars herb contains flavonoids: luteolin glucoside, chalcones

(butein and its glucoside), aurons (sulfuretin), condensed tannins (up to 6.5%), coumarins (umbeliferon and scopoletin), carotene, ascorbic acid, essential oil (traces), mucilage, amines, trace elements (including manganese). The infusion of the herb has diuretic, diaphoretic, choleretic and bactericidal effects, improves digestion, and normalizes impaired metabolism. The oil extract has anti-inflammatory and wound healing properties.

Lupus roots – RADICES ONONIDIS

Field lupus *Ononis arvensis* L. (Greek: *Onos* – donkey, because donkeys eat this plant well, Latin. *arvensis* – arable, field, from *arvum* – field, arable land), legume Fabaceae family, is a perennial herb. The roots contain isoflavonoids (1.5–2.5%): formononetin, ononin, onogenin, onogenin 7-glucoside (onoside), onospin, pterocarpans, easily resined essential oil, tannins, triterpene saponins. The decoction is used as a diuretic and hemostatic agent for hemorrhoids. The tincture, as well as the drug flavanobol, has an anabolizing effect. In homeopathy, fresh roots of *O. arvensis* are used as a diuretic for ascites, nephrolithiasis.

Theme 6 MEDICINAL PLANTS AND PLANT RAW MATERIALS CONTAINING TANNINS

1 Tannins structure and classification
2 Tannins distribution and localization
3 Biological action and application
4 Medicinal plants and raw materials containing tannins

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 296–316. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Tannins (tanids) are a complex of low- and high-molecular polyphenols, genetically linked to each other, which exhibit tanning properties, have an astringent taste, and precipitate proteins and alkaloids from diluted solutions.

In 1796, the French researcher F. Seguin gave the name "tanning substances" to the substances of plant extracts capable of tanning and turning raw animal hides into leather. Tanning is not an ordinary

physical process, but a complex chemical interaction of phenolic groups of tannins with skin collagen molecules. When tannin is placed flat on the protein molecule, stable hydrogen bonds occur between the OH groups of phenols and the carboxyl groups of amino acids.

Simple polyphenols (pseudotannin, food tannins, tea tannins) have a small mass, so they cannot form strong cross-links and do not exhibit a tanning effect, but they have an astringent taste and provide a therapeutic effect for a number of diseases. Compounds with a molecular weight higher than 20,000 are also ineffective in tanning hides, because they cannot pass between the collagen fibers in the skin of the animal.

1 Tannins structure and classification

Already the first studies of tannins showed that compounds similar in physical and chemical properties differ in structure. The first classification, proposed by Procter in 1894, divided tannins according to the products of their thermal decomposition into two groups: pyrogallol (which give pyrogallol during pyrolysis) and pyrocatechin (which form pyrocatechin). In 1920, K. Freudenberg proposed to divide tannins on the basis of their natural structure and chemical properties into hydrolyzable and condensed tannins.

Tannins hydrolyzed under the influence of acids, enzymes and alkalis are split into simple phenolic compounds and sugars. The latter can be glucose, galactose, arabinose, xylose, maltose, fructose, sucrose or a fragment that plays the role of sugar – quinic or oxycinnamic acid, flavan.

Hydrolyzable tannins are divided into three groups according to their structure: halotannins – esters of gallic acid and sugars; ellagotannins – esters of ellagic acid and sugars; non-saccharide esters of phenolic acids.

Halotannins are the most common in this group of tannins. The highest content of halotannins is recorded in formations called galls. In the works of E. Fischer and K. Freudenberg, it was proved that the ratio of glucose to gallic acid in Turkish galls is 1:5–6, and in Chinese – 1:9–10. Previously, these types of galls were imported for tannin production.

Elagotannins after hydrolysis form ellagic acid or acids biogenetically related to it, such as hexoxydiphenic, chebulic, dehydrodigalic, etc. The first of the group of elagotannins in crystalline form was corilagin obtained from tannin raw materials of devi-devi

and myrobalans. During hydrolysis, it forms one molecule of gallic and ellagic acids, as well as glucose. Later, alnitanin was isolated from the suppositories of sticky alder.

A non-saccharide ester of gallic acid is found in green tea. It is an ester of gallic and quinic acids and is called theogaline. From the black (fermented) tea *Thea sinensis*, three galloyl esters, which are related to catechin, such as catechyl gallate, have been isolated.

2 Tannins distribution and localization

Tannins occur mainly in higher plants. The largest number of plant species with a high content of tannins was noted in the families Fabaceae, Polygonaceae, Anacardiaceae, Myrtaceae, Rosaceae, Hamamelidaceae, Salicaceae, Geraniaceae, Plumbaginaceae, and Asteraceae. The pods of *Caesalpinia brevifolia* and *C.coriaria* and the bark of some species of *Eucalyptus* sp. are extremely rich in tannin (45% by dry weight). About 64% of the tannins that are hydrolyzed accumulate in pathological formations (gals) – on the leaves of the sumac hemi-winged *Rhus semialata* and the Lusitanian oak *Quercus lusitanica*.

The following sources of tannins are known around the world:

• catechu – dry extract from the wood of acacia catechu from India *Acacia catechu* and other species. Catechus are uneven pieces of dark brown color, astringent and bitter taste, which are completely soluble in water and alcohol. Contain tannins of the condensed group. It is used internally as an astringent; fruits of the black myrobalan *Terminalia chedula*, which contain about 40% of tanids, are used for gastrointestinal disorders and dysentery;

• gambir – dry extract from leaves and young shoots of *Uncaria gambir*, which is obtained by extracting raw materials with water. Contains tannins of the condensed group; used internally as an astringent;

• kino – dry juice of various tropical plants containing tannins and dyes. In the countries of South Asia, it is obtained from the bag-shaped pterocarpus *Pterocarpus marsupium*, in Australia – from the eucalyptus *Eucaluptus rostrata*, in Central America – from the one-seeded butea *Butea frondosa*. When cut, dark red juice flows from the bark, which is collected and dried in the sun. The juice dissolves in hot water and alcohol. Contains tannins of the condensed group. It is used internally and externally as an astringent;

• Krameria root from *Krameria lappacea*, which contains about 15% of condensed tannins. Used externally.

3 Biological action and application

Experimental and clinical data collected at this time indicate that there are actually at least three types of biological action of plant polyphenols on the body of mammals. First, direct action on cell membranes, smooth muscle cells, enzyme proteins and nucleic acids. Secondly, the effect on the exchange of biologically active substances - adrenaline, ascorbic acid, acetylcholine. Thirdly, the influence on the leading systems of neurohumoral and neuroendocrine regulation.

Constantly entering the human body with plant food, polyphenols have a long-term effect on all parts of the digestive tract, and after absorption into the blood – on the cardiovascular system, kidneys, other organs and systems. The main sources of polyphenols in our food are fruits and berries. Polyphenols are found in large quantities in tea, coffee, cocoa, as well as in infusions and decoctions of plant raw materials. Catechins and flavan-3,4-diols are the most active in influencing vascular permeability.

Tannins that enter the body affect the mucous membrane of the digestive tract, motility, secretory and digestive functions. They have an astringent taste and contribute to the formation of a thin layer of compacted protein. It reduces irritation of the mucous membrane and eliminates superficial erosions and ulcers. Plant polyphenols significantly reduce the toxic effect of chemical agents. The primary role in this is given to the mechanism of compaction of cell membranes, which prevents the flow of toxic substances to vital organs, helps to preserve endogenous ascorbic acid and glycogen.

The anti-inflammatory effect of polyphenols promotes the healing of small wounds. Under their influence, the exudative component of the inflammatory reaction is particularly effectively reduced and even eliminated, which is easy to explain considering the action of phenols that seal membranes. Polyphenolic compounds mobilize the living organism's own homeostasis mechanisms, stimulate the function of the adrenal cortex, glucocorticoid hormones, due to which they exhibit anti-inflammatory activity and related antimicrobial, antifungal and protistocidal activity. Polyphenols in plant and animal tissues perform a protective function, the most important element of which is the antioxidant effect. In the course of oxidative reactions in the body, free radicals are formed, which, when interacting with tissue lipids,

produce toxic lipid peroxides, oxides that slow down cell reproduction. The level of tissue antioxidants plays a significant role in the growth of malignant cells.

Tannins are widely used in medical practice. They have an astringent, anti-inflammatory and antimicrobial effect. Preparations containing tannins are used internally for acute and chronic colitis, enteritis, gastritis, sometimes as a hemostatic agent for uterine and hemorrhoidal bleeding. Tannins are widely used for inflammatory processes of the oral cavity, larynx, nose in the form of rinses, as well as for burns, bedsores, ulcers in the form of irrigations and lubrications. Although all polyphenols have the ability to strengthen capillaries, the antihemorrhagic effect of plant substances may be due not only to their effect on blood vessels, but also to the enhancement of blood coagulation.

Catechins are prescribed as P-vitamins. The radioprotective action of most tannins has been established, as well as their ability to remove radioactive isotopes of cesium and strontium from the body.

4 Medicinal plants and raw materials containing tannins

Sumac leaves – FOLIA RHOIS CORIARIAE

Tanning sumac *Rhus coriaria* L. (*rhus* is the ancient Greek name of a tree whose leaves and young branches were used for tanning leather; Latin. *coriarum*, *-a* – leathery, from *korium* – leather), Anacardiaceae family, – a bush or tree 2–3 m tall, the trunk is thin. *Contains tannins (13–25%), flavonoids (myricetin), essential oil (0.01%), ascorbic acid. Among the tannins found: halotannin, free gallic acid and its methyl esters. Sumac leaves are raw materials for obtaining tannin, which is included in galascorbin and Novikov's liquid.

Leaves of sumac – FOLIA COTINI COGGYGRIAE

Common scallion *Cotinus coggyigria* Scop. (Greek. *kotinos* – wild olive; *coggygria* – twisted name of the plant kokkygea), family Anacardiaceae – a branchy bush or tree 3–6 m tall, with a spherical crown. Halotannin, which is similar in composition to the tannin of *Chinese galls*; flavonoids (myricetin), essential oil. Industrial raw material for the production of tannin and its preparations (galascorbin with astringent and P-vitamin activity). Flacumin is produced from the leaves of sumpia, which contains a sum of flavonoids (up to 75%) and exhibits choleretic activity.

Badan rhizomes – RHIZOMATA VERGENIAE

Badan thick-leaved *Bergenia crassifolia* Fritsch. (*bergenia* – in honor of the German doctor and botanist von Bergen; Latin *crassifolius*, *-a* – thick-leaved), family Saxifragaceae, is a low perennial herb with a strong horizontal branched rhizome, 1.5-3 cm thick, which reaches a considerable length, outside (2 m or more) dark brown, inside – light brown. The raw material contains a mixture of halotannins and condensed tannins (21–25%), phenolglycoside arbutin (up to 5%), catechin, catechingalate, bergenin-2-glucosyl-4-0-methylgallic acid (up to 11%), gallic acid, traces of rutin and quercetin. Antimicrobial and anti-inflammatory activity is due to the presence of arbutin (leaves), and astringent properties are determined by the content of tannins. Badan is prescribed for infectious colitis and enterocolitis in the form of a decoction, externally - for rinsing with diseases of the oral cavity. In gynecology - for douching with erosion of the cervix.

Rhizomes and roots of the genus – RHIZOMATA ET RADICES SANGUISORBAE

Medicinal genus *Sanguisorba officinalis* L. (Latin. *sanguis* – blood and *sorbere* – to absorb, absorb; Latin. *officinalis* – pharmacy), family Rosaceae, is a perennial herb with a thick horizontal rhizome and long thin roots. Contains tannins (20%), tannins predominate, which are hydrolyzed; free gallic and ellagic acids, saponins, sterols. Liquid extract and decoctions are used for enterocolitis, diarrhea of various etiologies and as a hemostatic agent for uterine and hemorrhoidal bleeding.

Rhododendron rhizomes – RHIZOMATA BISTORTAE

Snake bitterwort, cancerous necks of *Bistorta officinalis* Delarbre (syn. *Polygonum bistorta* L.), (*polygonum* is the Latinized Greek name of the plant *polygonon* – bittersweet; from *poly* – many and *gony* – knee, node or *gonon* – descendants; Latin. *bis* – twice, *tortus* – twisted), family Polygonaceae, is a perennial herbaceous plant with a thick, slightly flattened snake-shaped rhizome, on which the remains of leaves and stems form numerous scars. A mixture of tannins (25%), in which halotannins prevail; there are free gallic and ellagic acids, catechins. The decoction and liquid extract are used for acute and chronic diarrhea, other inflammations of the intestines and stomach, for uterine and hemorrhoidal bleeding, as well as for stomatitis and gingivitis. They are part of astringent gastric collections.

Alder fruit – FRUCTUS ALNI

Gray alder *Alnus incana* (L.) Moench, glutinous alder *Alnus glutinosa* (L.) Gaertn (*alnus* – the name of alder in ancient Roman authors; comes from the Celtic *al* – near, *lan* – shore; given in connection with the place where the plant grows; Latin *incanus*, *-a* - gray, gray and *glutinosus*, *-a* – sticky), family Betulaceae – a tree 5–10 m tall with smooth gray bark. The raw material contains ellagotannins, halotannins, free gallic and ellagic acids, about 15% in total. The fruit is used as an astringent, anti-inflammatory and hemostatic agent; is a part of gastric collections, the combined drug Kamilal (suppositories). Altan drug is used in dyspeptic disorders as an anti-inflammatory and pain reliever.

Oak bark – CORTEX QUERCUS

Common oak (petiolate) *Quercus robur* L. (*Q. pedunculata*), rock oak *Q. petraea* L. ex Liebl. (Greek *kerkeen* – rough, Latin *robur* – oak wood; *pedunculus* – petiole), family Fagaceae is a large tree more than 40 m tall, with a very developed root system and a powerful spreading crown. The bark contains tannins mainly of the condensed group (12%), free gallic and ellagic acids, flavonoids, saponins, carbohydrates. The decoction is used externally as an astringent and anti-inflammatory agent for rinsing with gingivitis and stomatitis, burns and frostbite. Oak bark is part of anti-hemorrhoidal collections, complex preparations.

Foxglove rhizomes – RHIZOMATA TORMENTILLAE

Potentilla erecta (L.) Rausch. (syn. *Potentilla tormentilla*), (Latin. *potentia* – power; *erectus*, *-a* – upright, straight), family Rosaceae, is a perennial herbaceous plant 35 cm tall, four-membered flowers. The raw material contains condensed tannins (30%), ellagic acid, phlobafens, triterpene saponins, essential oil. Decoction is used internally for dyspepsia, enteritis, enterocolitis; externally – with stomatitis, gingivitis. It is a part of binders, Wundehil ointment and the complex preparation Polyphytol-1.

Blueberry fruits – FRUCTUS MYRTILLI, Blulberry leaves – FOLIA MYRTILLI

Common blueberry *Vaccinium myrtillus* L. (*vaccinium* is the Latinized name of the blueberry plant from *bacca* – berry, Latin. *myrtillus* – diminutive of *myrtus* – myrtle, myrtle bush, based on the similarity of the leaves), family Ericaceae – semi-shrub 15–40 cm tall. Berries contain tannins (12 %) of the condensed group; anthocyanins are glucosides and galactosides of delphinidin and malvinidin, the

mixture of which is known as myrtilin. In addition, berries contain organic acids – citric, malic, amber, henna, lactic, oxalic, ascorbic, as well as carotene, pectin substances. The leaves contain condensed tannins (7–20%), phenolic compounds (neomyrtilin, myrtilin (2%), arbutin (1%), flavonoids (quercetin, quercetin rhamnoside, avicularin, meratin, hyperoside). Blueberry fruits are used as a gentle astringent and dietary agent for acute and chronic disorders of the digestive tract, especially for diarrhea in children and acute enterocolitis in adults. The astringent properties of fruits are due to the presence of tannins in them. Myrtilin reduces blood sugar, which is why blueberry shoots are part of the antidiabetic collection Arfazetin.

Cherry fruits – FRUCTUS RADI

Black cherry *Prunus padus* L., family Rosaceae, subfamily Prunoideae – a tree or bush 2–10 m tall. The pulp of the fruit contains condensed tannins (15%), anthocyanins, sugar, organic acids (malic and citric). The seeds contain amygdalin (1.5%). The smell of flowers and leaves is pleasant and strong (persistent), due to pronasin, which differs from amygdalin in its monoglucosidic nature. They are used internally in the form of decoctions as an astringent for intestinal disorders, or whole fruits are brewed as tea. The bones must remain intact to avoid amygdalin extraction. Fresh fruits, flowers and leaves have phytoncide properties. It must be remembered that all parts of the plant, except for the pulp of the fruit, contain the glycoside amygdalin, which in the presence of enzymes breaks down into benzaldehyde, hydrocyanic acid and glucose, so all medicines from the bark, leaves and flowers of the cherry tree can cause poisoning.

Theme 7 MEDICINAL PLANTS AND PLANT RAW MATERIALS CONTAINING ESSENTIAL OILS

1 Essential oils, their classification, distribution and localization
2 Physical properties of essential oils
3 Biological effect and use of essential oils of medicinal plants
4 Medicinal plants and raw materials containing essential oils
  4.1 Medicinal plants and raw materials containing monoterpenoids
  4.2 Raw sources of camphor (medicinal plants and raw materials containing sesquiterpenoids, sequiterpene lactones, threecyclic sesquiterpenoids, phenylpropane derivatives, cymene derivatives)

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 335–385. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

1 Essential oils, their classification, distribution and localization

Essential oils are multicomponent mixtures of volatile organic compounds that are formed in plants and determine their smell.

Essential oils include hydrocarbons, alcohols, simple and complex ethers, aldehydes, ketones, aliphatic and cyclic acids. Cyclic compounds are divided into hydrocyclic, which include terpenes and their derivatives, and aromatic compound row Essential oils are dominated by hydrocarbons, but the most valuable component part are oxygen-containing compounds, especially alcohols and ethers, which have a pleasant scent.

Classification of essential oils and essential oil raw materials is based on structure the main valuable components (monoterpenoids, sesquiterpenoids and aromatic compounds).

Monoterpenes and their oxygen derivatives are widespread in the free state, are included in the composition essential oils.

They are formed from two C_5-units according to the isoprenoid rule "head to the tail." Monoterpenes are classified according to the number of cycles into acyclic, monocyclic and bicyclic. Acyclic monoterpenes belong to the type 2,6- dimethyloctane and can have three, two or one double bond. They represented by hydrocarbons (myrcene and its isomer ocimene), alcohols (geraniol, linalool, citranellol), aldehydes (citral, citronellal), etc. Monocyclic monoterpenes belong to the n-menthane type. From unsaturated hydrocarbons of the typ of menthane, limonene, α-, β- and γ-terpinene, α- and β-phellandrene are the most common.

Essential oils often contain oxygenated menthane derivatives: alcohols (menthol, terpineol), ketones (menthone, pulegone, carvone), oxides (cineole) and peroxides (askaridol). Bicyclic monoterpenes have two fused non-aromatic rings.

Depending on the hydrocarbon structure, they are divided into types: thujana, karana, pinan, kamphan, fenkhan.

Thujane-type compounds:

Thuian→Thujol→Thujone→Sabinene→Sabinone.

Thujan derivatives are found in plants of the thuja *Thuja*, tansy *Tanacetum*, and juniper *Juniperus* genera.

Carane derivatives are characterized by the main cyclohexane and three-membered side cycle that is formed from the isopropylene group of menthane. The compounds are contained in raw birch. Bicyclic monoterpenoids of the pinane type were found in juniper *Juniperus* fruits, tansy *Tanacetum* flowers, and pine *Pinus* needles. Camphane-type monoterpenoids are found in valerian *Valeriana* root rhizomes, wood of camphor laurel *Cinnamomum camphora*, fir *Abies* needles and oils.

Sesquiterpenes and their derivatives are the most common group among known terpenes both by the number of compounds (more than 2,000 representatives were studied) and by the variety of structural options and the number of types. Sesquiterpenes often occur together with monoterpenes in essential oils. In such cases, their found in special cellular structures. Sesquiterpenes are present in almost all of them higher plants. Like monoterpenes, sesquiterpenes exist in acyclic and cyclic (monocyclic, bicyclic and threecyclic) forms. More than 200 are known main types of sesquiterpene hydrocarbon skeleton. We cite only the main ones them, which are common in medicinal plants.

Acyclic sesquiterpenes are formed from three C_5-units after the isoprenoid by the "head to tail" rule. The acyclic sesquiterpenoid farnesol is found in linden *Tilia* flowers.

Monocyclic sesquiterpenes are compounds with a cyclohexane unit an open hydroaromatic ring and two to four double bonds. Common in nature are bisabolan type compounds (lemon *Citrus* × *limon*, chamomile *Matricaria recutita*~*Chamomilla recutita*, ginger *Zingiber*), species pines *Pinus*, humulana (hops *Humulus*), elemanu (ayre *Acorus*).

Bicyclic sesquiterpenes have two fused hydrocarbon rings with two-four double bonds. According to the structure of the rings and the type of condensation or connection sesquiterpenes are divided into types, the main ones being cadinane, eudesmane and guaiane. Compounds of the type cadinane and eudesman are found in the raw materials of ayre *Acorus*, valerian *Valeriana*, birch *Betula*, delusion *Inula*.

Guayan derivatives are guayol, azulene, hamazulene, guaiazulene, etc., which differ in the location of substituents and double bonds. Azulene in free states do not occur in nature, but are formed in the process of their transformations precursors – lactones of guaianolides (proazulenes) during the distillation of essential oil from steam or dehydrogenation of azulenogens contained in essential oils. For increasing the yield of azulenes, the raw materials are treated with alkali, and then distilled in acidic environment.

Azulenes are liquid, sometimes crystalline substances, colored in blue, purple, less often – green color. They slowly decompose in the air, changing their color to brown. Guiana derivatives are isolated from chamomile *Matricaria recutita~Chamomilla recutita*, wormwood *Artemisia absinthium*, yarrow *Achillea*, arnica *Arnica*, eucalyptus *Eucalyptus*.

A separate group of sesquiterpenoids consists of sesquiterpene lactones with high pharmacological activity. More than 1200 compounds are known (mono-, bi- and threecyclic), which are isolated mainly from plants of the Asteraceae family, but also occur in the families Amaranthaceae, Lamiaceae, Magnoliaceae, Lauraceae, Apiaceae and in some mushrooms. The type of elemanolides is widespread in tropical plants family Balsameaceae~Burseraceae, compounds occur sporadically in plants from genera of wormwood *Artemisia*, cornflower *Centaurea*, etc.

Well-known compounds of the eudesman type are alantolactone from *Inula helenium*. Tarragon cytvarny *Artemisia cina* contains a lactone with a keto group – santonin, known for its anthelmintic effect, which was previously widely used for ascariasis. Almost all types of wormwood *Artemisia* synthesize artemisinin, which is similar in chemical structure to santonin.

In sesquiterpene lactones of the guaianolide type, the lactone ring is attached to of the hydrocarbon skeleton in the C_6–C_7 or C_7–C_8 positions. The latter are found in flowers apothecary chamomile *Matricaria recutita~Chamomilla recutita*, bitter wormwood herb *Artemisia absinthium*, yarrow herb *Achillea*, arnica flowers *Arnica*. To this group belongs to many compounds (matricin, lactucopyrin, cinaropicrin, achilin, artabsin), which have a potential anti-inflammatory effect due to the formation of derivatives azulene. The bitter taste of lactones is caused by the use of dandelion *Taraxacum*

and wormwood *Artemisia absinthium* raw materials bitter, yarrow *Achillea* as bitters to stimulate appetite and improve digestion.

The aromatic sesquiterpene dimergosypol has an unusual chemical structure cotton. Non-volatile sesquiterpene acylglycerols (glycerides), ethers and alkaloids. Sesquiterpene lactones, which are part of essential oil raw materials, have a pronounced antimicrobial and antimycotic effect. Cytotoxic effect sesquiterpene lactones are linked to an unsaturated lactone ring, keto group or epoxy group. Complex ester radicals perform the role of a "carrier" that ensures the penetration of substances through cell membranes.

Some sesquiterpene lactones cause the death of insects as a result untimely metamorphosis. These substances are potential antifeedants and insect attractants. It is also believed that lactones are inhibitors of amylases and proteases, they have a regulatory effect on seed germination and plant growth.

Distribution and localization. Essential oils are very common in nature. More than 2.5 thousand higher plants are able to accumulate them. Lichens and ferns do not synthesize components of essential oils. Plants of the tropics are rich in essential oils. To the number of families, rich in essential oils, belonging to Lamiaceae, Apiaceae and Asteraceae (about 180 genera in each family), Rosaceae (58 genera).

The content of essential oils in different types of plants varies from 0.01 to 5%, and for of some species, for example buds of a clove tree (*Syzygium aromaticum)* and citrus (subfamily *Citreae*) fruits, reaches 20%. During the ontogenesis of plants, the percentage of oil, the ratio, changes components, and sometimes even the complete disappearance of some and the appearance of others is noted substances that were not detected before. Most of the essential oils are found in the leaves before and at the beginning of flowering; in flowers - during flowering; in the roots – after dying off of the ground part; in buds - during their drumming.

For the most part, all parts of plants contain oils of the same composition, but there are some cases where organs contain different oils that differ dramatically in composition. So, for example, Ceylon cinnamon *Cinnamomum verum* bark oil is dominated by cinnamic aldehyde, in the leaves – eugenol, in the roots – camphor. Essential oils are localized in different parts plants, are produced and accumulated in special exogenous and endogenous formations The first of them develop from epidermal tissue; they include glandular

"spots", glandular hairs and essential oil glands. The simplest of them, glandular "spots", are found on the petals of rose *Rosa*, violet *Viola*, lily of the valley *Convallaria*. To endogenous formations developing in parenchymal tissues, include secretory cells, receptacles (schizogenic and lysogenic), secretory tubules and ducts. The combined type of containers is more often observed – schizolisogenic, when cell division occurs, and then intercellular the space increases in volume due to the dissolution of cells under the influence of ether oil. They occur in the peel of fruits, in the parenchyma of roots and rhizomes, mesophyll leaf (for example, citrus *Citrus* sp.) fruits, roots and rhizomes of wild plants *Scrophularia*, leaves eucalyptus *Eucalyptus*. Essential oil tubules are typical for the fruits of plants from the Apiaceae family.

2 Physical properties of essential oils

Essential oils are clear, colorless or slightly yellowish liquids with a pleasant smell characteristic smell and spicy, bitter taste. Some of them are blue in color, caused by the presence of azulene (oils of chamomile *Matricaria recutita*~*Chamomilla recutita*, yarrow *Achillea*, wormwood *Artemisia absinthium*). They happen greenish (bergamot), red (cumin), red-brown (cinnamon) oils. The specific gravity of oils ranges from 0.700 to 1.060 g/cm^3. Their reaction, of courseneutral or acidic. Most of them are optically active.

Essential oils are distilled with steam. They do not have such complex mixtures defined boiling point. By distillation at different temperatures, they can be divided into similar factions in structure. Monoterpenoids make up the low-boiling fraction essential oils, and sesquiterpenoids – high-boiling. Many essential oils with after cooling, they solidify into a crystalline mass, for example, mint, anise, camphor.

Essential oils are well soluble in alcohol, mixed in all proportions with petroleum ether, chloroform, carbon disulfide, fats. Do not dissolve in water. On paper do not leave greasy stains, unlike fatty oils. Essential oil raw materials, essential oils, their separate fractions and components (menthol, camphor, thymol).

3 Biological effect and use of essential oils of medicinal plants

Essential oils show bacteriostatic, antiseptic, disinfectant and fungistatic effect. In addition, they are able to irritate more or less the skin. Turpentine, camphor, rosemary oils and others are part of many ointments prescribed for rheumatism, neuralgia and colds.

Essential oils dissolved in fats inhibit inflammation after application to the skin. They can enter the blood through the skin and spread throughout the body. They use they are also for inhalation, because they facilitate coughing.

As expectorants, essential oils are used, which are secreted by the lungs in unchanged form. They affect bronchial secretion, increase or reduce the amount of sputum. In small doses, they cause hyperemia of the mucous membrane membranes, increase the secretory function of the bronchi (when inhaled, taken inside) and cause an increase in the amount of secretion, its dilution and acceleration of evacuation. Essential oils stimulate the respiratory center. A number of essential oils with resorptive use, they have a weak analgesic and sedative effect activity.

Essential oil plants are also used as diuretics, which is related to them irritating effect on the kidneys. Some components of essential oils are irritating mucous membrane of the oral cavity and gastrointestinal tract. In small doses, they intensify salivation and gastric secretion, improve digestion. This is achieved the use of essential oil raw materials as food seasoning (cinnamon *Cinnamomum verum*, cloves *Caryophyllus aromaticus*, mint *Mentha*, cumin *Carum carvi*). A number of essential oils and essential oil raw materials (thyme *Thymus*, tansy *Tanacetum*, divina *Verbascum*, wormwood anthelmintic *Artemisia cina~Seriphidium cinum*) have an anthelmintic effect.

An important property of terpenoids, which are part of essential oils, is the ability to be oxidized by air oxygen at the site of the double bond with formation peroxide During decomposition, it turns into an oxide with the release of atomic oxygen, which forms ozone with air oxygen. The pleasant smell that can be felt in coniferous forests is determined not only essential oils, but also the presence of ozone. Volatile phytoncides of plants and ozone create a healing atmosphere for lung patients.

4 Medicinal plants and raw materials containing essential oils

4.1 Medicinal plants and raw materials containing monoterpenoids

Coriander fruits – FRUCTUS CORIANDRI

Coriander oil – OLEUM CORIANDRI

Coriander seed *Coriandrum sativum* L. (Greek: *koris* – bug, throughthe bug-like smell of unripe fruits, and aneron – dill; *sativus*, -um – seed), family celery Apiaceae is an annual herbaceous plant, 40–150 cm tall. Fruits coriander contain essential oil (0.7–1.5%), which includes linalool (60-70%), pinene, limonene, terpinene, myrcene, phellandrene, geraniol, cymol, borneol and in small amounts citronellol, geranyl acetate, bornyl acetate; fatty oil (20%) protein and tannins, coumarins, flavonoids, choline, resins. Infusion stimulates the secretion of the glands of the digestive tract, has antispasmodic and antibacterial properties properties, included in the composition of appetizing, choleretic, expectorant and anti-hemorrhoid fees; tincture is part of a complex anxiolytic means Flora; essential oil – in the composition of pain reliever, anti-inflammatory complex drug espol. Linalool is obtained from the oil, and citral is obtained from it,1% solution of which is used as an anti-inflammatory and antimicrobial agent.

Melissa leaves – FOLIA MELISSAE

Melissa herb – HERBA MELISSAE

Melissa officinalis L. (Greek: *melissa* – bee; Latin *officinalis* – pharmacy), family Lamiaceae – perennial herb with four-sided, up to 1 m tall, very branched stem. The herb contains essential oil (1%), which includes citral (60%), linalool, geraniol, citronellol, myrcene, aldehydes; is also tannins (5%), bitterness, mucilage, organic (amber, coffee, chlorogenic) and triterpenic (ursolic, oleanolic) acids. The infusion is used for general nervous excitement, insomnia, vascular-vegetative dystonia, heart rhythm disturbances; has a tonic effect on the digestive organs, has anti-inflammatory, bacteriostatic and antiviral properties.

Lavender flowers – FLORES LAVANDULAE

Lavender oil – OLEUM LAVANDULAE

Narrow-leaved lavender *Lavandula angustifolia* Mill. (~*L. vera*, *L. spica*), (*lavare* – wash and *angustifolius*, -a – narrow-leaved), family Lamiaceae – an evergreen semi-shrub with numerous branched stems, 20–60 cm tall. Inflorescences contain essential oil (1.2 %). The main component of the oil is linalool acetate (30–50%) and free linalool (25–45%), geraniol, nerol, 1,8-cineole, borneol, bornyl acetate, camphor. Found also coumarins, ursolic acid, tannins (12%), anthocyanins. Infusion has a calming and antispasmodic effect. Lavender oil is antiseptic properties The complex preparation Livian,

which includes essential oil, has an anti-inflammatory and analgesic effect, is used to treat burns.

Peppermint leaves – FOLIA MENTHAE PIPERITAE

Peppermint oil – OLEUM MENTHAE PIPERITAE

Peppermint *Mentha piperita* L. (from the Greek name of the nymph Minta, which is related to the myth of its transformation into a plant; *piperitus*, -a – burning, from *piper* – pepper), family Lamiaceae, is a perennial herbaceous plant a plant with a four-sided stem, elevated, branched, often reddish, 30–50 cm tall. Leaves contain essential oil, its content depends on the variety is from 1.5 to 2.7, sometimes up to 3.5%. The main component of the oil is menthol (50–80%), menthone ketones (10–30%), piperitone, jasmon, pulegone. It also contains other terpenes: menthofuran (5–10%), limonene, α-phellandrene, proazulenes, as well as menthol esters with acetic and isovaleric acids. On the aroma of the oil is influenced by the ratio of jasmon and menthofuran. Other biologically active substances groups – flavonoids (hesperidine, anthocyanidins), tannins (6–12%), triterpenoids (ursolic and oleanolic acids), betaine, carotenoids. Infusion increases the secretion of digestive glands, exhibits antispasmodic, sedative, antidiarrheal, choleretic, weak analgesic effect. Essential oil is included drugs ingalipt, corvaldin, corvalol, mint tablets, tooth drops, urolesan, foam salt. Menthol irritates nerve endings, reveals reflex-vasodilator, analgesic and antiseptic effect. Included in the composition drugs alorom, bom-benge, boromenthol, valokormid, hevkamen, cameton, Camphomen, Zelenin drops, Menovasin, Pectusin.

Sorrel leaves – FOLIA SALVIAE

Medicinal sage *Salvia officinalis* L. (salvus – healthy, officinalis – medicinal), family Lamiaceae – multi-stemmed semi-shrub, stems straight, branched, 20–70 cm tall, almost round, whitish-woolly from long skin. Sage leaves contain essential oil (1–2.5%), which is part of it include thujone (up to 50%), 1,8-cineole (up to 15%), camphor, camphene, as well as o-cymene, myrcene, cedrene, α-pinene, sabinene, limonene, borneol, bornyl acetate. Leaves accumulate bitter diterpene lactones: carnosol, carnosolic acid, rosmanol, sagenone; triterpenoids: oleanolic and ursolic acids (more than 2%); a certain role flavonoids (1.2%) – derivatives of apigenin and luteolin – play a role in biological action. Galen preparations and infusion of sage show anti-inflammatory, antimicrobial and astringent effect, reduce sweating, stimulate secretion of gastric juice.

Externally, it is used to rinse the mouth and throat in case of inflammation processes. Salvin (acetone extract of sage leaves) acts as a herbal antibiotic due to the content of diterpenes; it is used for gingivitis and stomatitis. In homeopathy fresh leaves are used as a means that regulates sweating. Appointed exhausted people, as well as in the climacteric period. Externally - in appearance rinsing with diseases of the throat and oral cavity.

Eucalyptus leaves – FOLIA EUCALYPTI

Eucalyptus leaves – FOLIA EUCALYPTI VIMINALIS

Eucalyptus oil – OLEUM EUCALYPTI

Globular eucalyptus *Eucalyptus globulus* Labill., ash eucalyptus *Eucalyptus cinerea* F. Muell. ex Benth., *Eucalyptus viminalis* Labill. (in Greek *eu* – good and *calypto* – to hide, due to the fact that the buds are hidden under the sepals), Myrtaceae family. Spherical eucalyptus is a tall winter-green tree 50–70 m, ash eucalyptus – an evergreen tree up to 20 m tall, eucalyptus rod-shaped – a winter-green tree 40–50 m tall. Accumulates in the leaves essential oil (1.3–4.5%), the main component of which is cineole (80%), in a smaller amount of α-pinene, pinocarvone, aliphatic aldehydes – isovaleric, caproic and caprylic. Among other biologically active substances, flavonoids, tannins, chlorophyll, ellagic acid, phenolic acids. Eucalyptus preparations show bactericidal, anti-inflammatory, astringent. A mixture of chlorophylls from eucalyptus leaves gives antistaphylococcal drug chlorophyllipt. Eucalyptus oil is included combined drugs Ingalipt, Kameton, Efkamon, Alorom, Hevkamen, Pinosol.

Rhizomes with valerian roots – RHIZOMATA CUM RADICIBUS VALERIANAE

Medicinal valerian *Valeriana officinalis* L. (*valere* – to be healthy, *officinalis* – pharmacy), family Valerianaceae, is a perennial herb 30–100 cm tall. Rhizomes and roots contain essential oil (2%), the main a constituent part of which is bornelysovalerianate – a complex ester of borneol and isovaleric acid, as well as free borneol, bornyl acetate, camphene, limonene, pinene, terpineol, etc. In addition to essential oil, underground organs contain valerian valerine and khatinine alkaloids; iridoids – valepotriates, which have a calming effect. Contents of valepotriates (the sum of native compounds and their components) in raw materials reaches 0.5–1%. When drying freshly dug rhizomes, valepotriates partially succumb enzymatic cleavage

with the formation of free isovaleric acid or its analogues and iridoid of baldrinal. At the same time, the raw material acquires a characteristic for valerian scent. Valerian preparations reduce excitability and improve functions of the central nervous system, regulate heart activity, reduce blood pressure, have an antispasmodic and weak choleretic effect, increase secretion of glands of the digestive tract. Valerian liquid extract is used, valerian extract in tablets. The raw material is included in the soothing and stomachic meetings Valerian tincture is used alone or as part of complex preparations drugs Valokormid, Cardiovalen, Cardiofit, Zelenin drops, gastric drops. In homeopathy, rhizomes with roots are used for mental disorders, depression, insomnia, headache.

Juniper fruits – FRUCTUS JUNIPERI

Common juniper *Juniperus communis* L. (Celt. *jeneprus* - prickly), family Cupressaceae – evergreen shrub or small (3–5 m tall) tree. Cone berries of a spherical-ovoid shape, black, with a bluish coating, 6–9 mm in diameter, often with three tubercles at the apex. Fruits contain ether oil (0.5–2%), which contains α-pinene, camphene, cadinene, dipentene, α-terpineol, borneol, isoborneol. Other groups of BARs are flavonoids, resins (9%), organic acids (apple, vinegar, formic, glycolic), sugars (30%), pectins, tannins substances, inositol, potassium salts. Juniper preparations increase diuresis and disinfect urinary tract, increase secretion of gastric juice and bile, excite peristalsis of the intestines, facilitate expectoration, act as an anti-inflammatory and and pain reliever.

Cumin fruits – FRUCTUS CARVI

Common caraway *Carum carvi* L. (Greek: *kara* – head and the Arabic name of caraway – karwia), family Apiaceae, is a biennial herb 30–80 cm tall. The fruits contain essential oil (3–7%), which includes carvone (38–60%), limonene (40–50%), carveol, dihydrocarvone and other terpenoids, as well as flavonoids (quercetin and kaempferol), fatty oil, polyacetylenes. Drugs caraway fruits are found to be antimicrobial, antispasmodic, and expectorant choleretic effect, increase lactation, sweating and diuresis. Used for improvement of digestion, with atonic constipation, flatulence, chronic pancreatitis. The fruits are carminative, stomachic and sedative of tea In homeopathy, dry old leaves are used for upper catarrh respiratory tract, which are accompanied by purulent secretions.

4.2 Raw sources of camphor

Camphor (2-bornanone) exists in two forms isomers (+) dextrorotatory, natural by origin, (–) levorotatory – semi-synthetic and (±) racemate – synthetic. (+)-Camphor is contained in ethers oils of camphor laurel *Cinnamomum camphora*, fir *Abies*, camphor basil *Ocimum menthifolium*, wormwood *Artemisia*, sage *Salvia*. In industrial volumes, it is obtained from the wood of camphor laurel, or camphor tree (*Cinnamomum camphora,* Lauraceae). (+)-Camphor Ukraine imports. Semi-synthetic (–)-camphor is obtained from shoots of Siberian fir *Abies sibirica*. Distillation with steam produces essential oil, which is 40% consists of borneol and bornyl acetate. Their mixture is separated from the oil by rectification.

Bornyl acetate is saponified to borneol, which is then dehydrogenated to (–)-camphor:

Bornyl acetate → Borneol → Camphor Production of (±)-camphor

In industry, (±)-camphor is synthesized from α-pinene (the main component of turpentine). The camphor content of the starting product is 87%. For use in medicine racemic camphor is purified to 98% of the main content substance in substance.

***Biological action and application*.** With parenteral use of oily of camphor solutions has an analeptic effect, when externally - antimicrobial, irritating and analgesic (camphocin, camphomen, camphor oil, camphor alcohol, camphor ointment). Bromocamphor is used internally as sedative and cardiac agent.

Medicinal plants and raw materials containing sesquiterpenoids

The fruit of hops – STROBILI LUPULI

Common hop *Humulus lupulus* L. (*humulus* – medieval Latinized hop name, Latin. *lupulus* comes from Italian. *lupullo* – name of hops), family Cannabaceae, is a perennial herbaceous liana. Female inflorescences, "cones", contain essential oil (1.0–3.0%), used which includes humulene (up to 50%), myrcene (up to 25%), farnesene, β-caryophyllene. The components of bitter resin (11–20%) are α- and β-hopic acids are derivatives of phloroglucin: humulone, cohumulone, allupulone, lupulon, colupulon. Among other phenolic compounds are coumarins, flavonoids, catechins, tannins. In addition, there are B vitamins, ascorbic acid, tocopherols and substances acting as estrogenic hormones. Raw materials include composition of sedation fees. The extract is a component of the complex preparation urolesan, which is used as an antispasmodic and diuretic in kidney stone

disease. Essential oil is part of sedative drugs valocordin, corvaldin. In homeopathy, hop inflorescences are used under the name Lupulinum as a sedative, especially in stomach ailments nervous nature. Often used in combination with other plants (for example, barley).

Birch buds – GEMMAE BETULAE

Birch leaves – FOLIA BETULAE

Hanging birch *Betula pendula* Roth. (syn. warty birch *Betula verrucosa* Ehrh.), downy birch *Betula pubescens* Ehrh. (Celt. *betu* – birch and Latin. *pendulus*, -a – hanging, *verrucosa* – warty), family Betulaceae – monoecious tree 10–20 m tall. Buds and leaves contain essential oil, saponins, tannins, resins, ascorbic and nicotinic acids. Of the essential oil includes betulene, caryophyllene, α- and β-betulenol, their esters with acetic acid Damaran type and pentacyclic triterpenoids were also found Lupan type – derivatives of betulinic acid; flavonoids, carotene. In birch juice contains sugar up to 2%, tannins and aromatic substances, malic acid, salts iron, calcium and magnesium. Birch preparations are diuretic, choleretic, antispasmodic, anti-inflammatory, wound-healing, antiviral, anthelmintic and antiparasitic properties. The raw material is used in the form of an infusion, tinctures, included in the complex drug propobesan.

Poplar buds – GEMMAE POPULI

Black poplar *Populus nigra L.* (*popularis* – popular, useful to the people; Latin. *niger*, -gra – black), family Salicaceae – deciduous dioecious tree up to 30 m tall, with a spreading crown. Essential oil (0.7%), which contains humulene, α-caryophyllene, cineol. Black poplar buds contain sesquiterpenoids, phenol glucosides (salicin and populin), 8% flavonoids (apigenin, galangin, genquanine, galangin 3-methyl ester, isalpinin, quercetin, kaempferol, rhamnetin, isorhamnetin), organic acids (benzoic, cinnamic, gallic, caffeic, ferulic and apple), vitamin C, resins, fatty oil. Poplar preparations have diuretic, antiseptic, diaphoretic properties. When used externally exhibit anti-inflammatory, antimicrobial, hemostatic and mild anesthetic effects. Preparations from poplar buds (ointment, oil infusion, less often – tincture) used to treat wounds, ulcers, burns, cuts, dermatitis, trichomonad colpitis. It is part of the complex drug propobesan.

Rhizomes of ryegrass – RHIZOMATA SALAMI

Acorus calamus L. (Greek: *akoros* – name plants with a fragrant root and *kalamos* – reed), family Araceae – a perennial herbaceous

plant. Rhizomes contain essential oil (up to 5%). Storage of essential oils is very variable and depends on the origin and chemotype of lepeha. To essential oil of yarrow harvested in Ukraine contains mono- and sesquiterpenoids: α- pinene, α-camphene, camphor, alcohols borneol, eugenol, methyleugenol, cyclic sesquiterpenes: elemol, β-elemene, α-camphene, acorone. They have a biological effect the effect of bitter glycoside acorin, phenolic compounds (azarone), ascorbic acid, tannins. Ayr reveals tonic, anti-inflammatory, pain-relieving, expectorant, choleretic, antibacterial and disinfectant properties.

Internally, its drugs are prescribed for non-specific digestive disorders tract as a tonic, externally – for stomatitis, for rinsing purulent wounds and ulcers, douching with colpitis, to enhance hair growth. Medicinal forms: infusion of dry rhizomes, tincture, olimetin, polyphytol – antispasmodic, choleretic, diuretic, anti-inflammatory action, vikalin, vicar, herbogastrin – drugs for the treatment of peptic ulcer disease.

Medicinal plants and raw materials containing sequiterpene lactones

Rhizomes and roots of delusion – *RHIZOMATA ET RADICES INULAE*

Oman tall *Inula helenium L.* (*inula* is the Latinized name of the plant, *helenium* is perhaps from Greek. *helos* – marshy meadow or *helios* – sun), family Asteraceae, is a perennial herbaceous plant. Rhizomes and roots contain ether oil (3%), which is called allantovy. At room temperature, it is oily crystalline mass, at a temperature of 35–45 °C it turns into brown liquid with a specific smell. The crystalline part of the oil is called gelenin. To its composition includes a mixture of bicyclic sesquiterpenes: alantolactone, isoalantolactone and dihydroalantolactone. In addition to the essential oil in the rhizomes and roots contain a lot of inulin (up to 40%). Galenic preparations relieve delusion expectoration, stimulate appetite and improve digestion, reduce secretion intestinal activity and regulate its motility, have a stimulating effect on the process of bile formation, normalizes metabolism in the body. Alanton used for the treatment of peptic ulcer disease of the stomach and duodenum, is a part of complex preparations. Essential oil reveals an antiseptic, anti-inflammatory and anthelmintic effect. Fresh ones are used in homeopathy rhizomes with

roots for the treatment of chronic bronchitis, in gynecology – with dysmenorrhea, metritis.

Chamomile flowers – FLORES CHAMOMILLAE

Medicinal chamomile *Chamomilla recutita* (L.) Rausch., syn. chamomila odhrana *Matricaria recutita* L. (*Matricaria chamomilla* L.), tongueless chamomile *Chamomilla suaveolens* (*Matricaria matricarioides* Porter.), (*metrix* – uterus, because in the ancient plant was used for women's diseases; Latin chamomilla from Greek chamai - low, small in stature and melon - apple, Latin. recutitus, -a - trimmed, edged), family Asteraceae – annual herb plant. Chamomile flowers contain blue essential oil (0.8%). Its main components are hamazulene, sesquiterpene hydrocarbons farnesene and cadinene, sesquiterpene alcohol bisabolol, aliphatic terpene myrcene. In flower flavonoids, coumarins, triterpene alcohols, phytosterol, choline, ascorbic acid, carotene. It was established that hamazulene is formed in flowering baskets made of guaianolide matricin (prochamazulen). In the inflorescences of daisies oleander contains essential oil (0.5%). The essential oil contains bisabolol, but no chamazulene. There are also flavonoids (apigenin, luteolin-7-glucoside), choline, coumarin, umbelliferone, polysaccharides, tannins, ascorbic acid acid. Medicinal chamomile preparations increase the secretory activity of the digestive tract glands, stimulate bile secretion and stimulate appetite, eliminate organ spasms of the abdominal cavity, exhibit pain-relieving, anti-inflammatory, anti-allergic, antimicrobial effect.

Chamomile drugs are detected when used externally anti-inflammatory, analgesic, epithelizing, antimicrobial and antifungal effect. An infusion of chamomile flowers is used for rinsing with inflammation of the mucous membranes oral cavity, for washing purulent wounds, ulcers, hemorrhoidal nodes, douching with colpitis, endocervicitis. Chamomile flowers are made drugs romazulan, rotokan, alor, herbogastrin, fiton, kamistad-gel, gastrolith, flowers are included in the collection of arfazetin, elekasol, anti-hemorrhoidal. Chamomile without tongue is used only externally in the same way, like a pharmacy. In folk medicine – from colds (anti-inflammatory and diaphoretic effect), with violation of the menstrual cycle, as an effective remedy for helminthiasis in children. In homeopathy, the whole flowering plant is used for reflex dry cough with worsening from 21 to 24 hours, flu, intestinal cramps, dyspepsia in children infancy Prescribed to people who do not tolerate any pain.

Leaves of bitter wormwood – FOLIA ABSINTHII

Wormwood herb – HERBA ABSINTHII

Wormwood *Artemisia absinthium* L. (the Latinized name is related to the name Artemisia, the female king of Mausolus, or from the Greek. *artemes* – healthy, unharmed, in connection with the medicinal properties of the plant, absinthium is a Latinized Greek the name of wormwood *absinthion*, from -a – no and *psenthos* – pleasure, satisfaction, i.e a plant from which you do not feel pleasure due to the bitter taste), family Asteraceae, is a perennial silver-gray herbaceous plant. Wormwood grass contains essential oil (2.0%), which includes cineole, thujone, sesquiterpenes alcohols (absynthine, anabsynthine and artabsynthine), sesquiterpene lactones (tauremisin), as well as alkaloids, carotene, ascorbic acid, B vitamins. Galen preparations of wormwood stimulate the appetite, stimulate reflexes the activity of the glands of the alimentary canal, increase the secretion of bile, pancreatic and gastric juice Wormwood is included in bitter tincture, wormwood tincture, appetizing and choleretic teas.

Yarrow grass – HERBA MILLEFOLII

Yarrow flowers – FLORES MILLEFOLII

Achillea millefolium L. (the name *Achillea* is given in honor of the Greek the mythical hero Achilles, who first applied the plant to a wound; *millefolium* – thousand-leaved, comes from *mille* – thousand and *folium* – leaf), family Asteraceae is a perennial herbaceous plant, sparsely pubescent. Grass and leaves contain essential oil (0.3 and 0.8%, respectively), which is a complex mixture of mono- and sesquiterpenes. The pharmacological activity is affected by the proazulenes of matricin, matricarin, azulene, 8-acetoxyartabsin (a stereoisomer of matricin), achilicin, humulene, sesquiterpene lactones – achiline, millefin, balquinolide, acetylbalquinolide. Among the monoterpenoids α- and β-pinene, sabinene, camphor, borneol, thujone etc. In addition to terpenes, the herb contains flavonoids (rutin, luteolin-7-glycoside, apigenin), tannins, alkaloids and other nitrogen-containing compounds (achilein, betaine, choline, trigonelline), vitamin K. Galenic preparations are effective hemostatic effect and are used for pulmonary, intestinal, hemorrhoidal and nosebleeds. They increase the secretory activity of the stomach, expand it bile ducts and increase bile secretion in the duodenum, increase diuresis, eliminate spastic pain in the intestines. Common tree is part of laxative, appetizing, gastric, hypotensive collections, drug

Rotokan, Wundehil. A fresh flowering plant is used in homeopathy with venous and arterial bleeding from the nose, throat, stomach, intestines, bladder, uterus, with internal bleeding after operations, bleeding from early and after childbirth.

Arnica flowers – FLORES ARNICAE

Arnica mountain *Arnica montana L.,* arnica Chamisso, subspecies Arnica leafy chamissonis Less. subsp. *foliosa* Nutt. (*arnica* is a name of unclear etymology, *montanus*, - *a* – mountain), family Asteraceae, – perennial herb, glandular-downy plant. Contains sesquiterpene lactones. Their content in baskets of mountain arnica is in the range of 0.2–0.8%, and in the flowers of Arnica Chamisso – from 0.5 to 1.5%. Lactones belong to the type of pseudoguanolides. The main lactones of mountain arnica are gelenaline, 11,13-dihydrogelenaline and their esters with organic acids. In 1970 year from the leaves and baskets of mountain arnica and chamisso arnica (subspecies of broadleaf). arnifolin was isolated and its tonic effect on the smooth muscles of the uterus was proven. The second group of biologically active substances, which affects the pharmacological activity, is flavonoids, composition which is very diverse. The main ones are aglycones of flavones (apigenin, luteolin, eupafolin), flavonols (kaempferol, quercetin, isorhamnetin) and their acetylglucosides or glucuronides. Flavonoids have chemotaxonomic value, because Chamisso arnica contains quercetin instead of 3-O-(6-acetyl)-glucoside Luteolin 7-O-glucoside and eupafolin 7-O-glucoside, which are not found in arnica flowers mountain Essential oil in arnica flowers accumulates in the range of 0.2 - 0.5%, it oily consistency, has a golden color. As part of its thymol derivatives, thymohydroquinone, sesquite- and monoterpenes, fatty acids, polyacetylenes. Raw also contains up to 4% triterpenoids (arnicine), carotenoids, tannins, inulin, choline, mucus, organic acids (lactic, fumaric, malic), ascorbic acid Arnicine is a mixture of two terpenoids of arnidiol and its isomer faradiol, which belong to the lupeol group. Arnica preparations have hemostatic, choleretic, antisclerotic, irritating and bacteriostatic properties.

In large doses, arnica drugs have a sedative effect. Externally (in the form of lotions and compresses) tincture or infusion is prescribed for the treatment of congestion places, hematomas, purulent skin diseases, trophic ulcers, burns, etc frostbite It is used in homeopathy for internal use rhizome with roots, for external use – a whole fresh

flowering plant. Main remedy for various types of injuries, including childbirth and postoperative ones: quickly relieves pain, stops bleeding, helps dissolve blood clots, prevents the development of sepsis.

Dandelion roots – RADICES TARAXACI

Dandelion *Taraxacum officinale* Wigg. (Greek *taraxis* – eye disease, *akeomai* – treat, heal; Latin. *officinalis*, *-e* – pharmacy, medicinal), family Asteraceae, is a perennial herbaceous plant with a fleshy vertical stem root and a shortened stem with a basal rosette of leaves. Bitterness, what belong to sesquiterpenoids and triterpenoids, including sesquiterpene lactones (eudesmanolides – tetrahydroridentin B, taraxacolide glycoside; germacranolides – glycosides of taraxin and 11,13-dihydrotaraxin). Among α-amyrin, taraxasterol, pseudotaraxasterol and their triterpenoids were identified octanes, saponin taraxacoside; there is also inulin (more than 40%), flavonoids, phenolic acids, many potassium salts (4.5%). Dandelion thick extractincreases secretion of digestive glands, increases appetite. The root is included in the composition appetizing, choleretic, diuretic, laxative teas. Can be used as a substitute for coffee. Inflorescences and leaves are used as food in the form of salads source of vitamins. Homeopathy uses a plant harvested before flowering, in diseases of the liver and digestive organs, "geographical tongue".

Medicinal plants and raw materials containing threecyclic sesquiterpenoids

Common swamp herb – HERBA LEDI PALUSTRIS

Common marsh *Ledum palustre* L. (Greek *ledoa* – the name of a resinous plant and from Latin *palustris*, *-e* - swamp), family Ericaceae – evergreen branched bush 50–120 cm tall. The herb contains up to 2.5% essential oil, which has a thick consistency, green color, sharp unpleasant smell. In the cold from her Stearoptene precipitates. The oil consists of 25% sesquiterpene alcohols, 60% % from the aliphatic terpene myrcene and a complex mixture of other terpenoids. Ledol and palustrol are saturated tricyclic alcohols compounds that have an azulene skeleton in their composition. In the leaves, in addition to the essential oil, found diterpenes (andromedotoxin), triterpenes (taraxasterol), phenolglycoside arbutin, flavonoids, tannins. Infusion reveals antispasmodic, expectorant, diaphoretic, diuretic, disinfectant and narcotic properties; dilates blood vessels and lowers blood

pressure. Produced from grass antitussive drug ledin. In homeopathy, the whole plant is used, collected during flowering, with prickly contaminated wounds for prevention sepsis, acute and chronic rheumatism, whooping cough, acute and chronic bronchitis, eczema and boils.

Medicinal plants and raw materials containing phenylpropane derivatives

Fruits of anis – FRUCTUS ANISI VULGARIS

Anise oil – OLEUM ANISI

Common anise (ganus) *Pimpinella anisum* L., syn. *Anisum vulgare* Gaertn. (*pimrinella* is the medieval name of a plant of unclear etymology; *anisum* from the Greek name of the plant anison), family Apiaceae, is an annual herbaceous, pubescent a plant with a grooved stem, branched at the top, 25–60 cm tall. Fruits anise contain essential oil (up to 6%), which includes anethole (80–90%), methylchavicol (10%), anisic aldehyde, anisic ketone and anisic acid, as well as fatty oil (28%), protein substances, furocoumarins. Anise preparations have expectorant, anti-inflammatory, antispasmodic, diuretic and bactericidal properties The fruits are part of breast tea and gastric collection, aniseed oil - in the composition of ammonia-anise drops, breast elixir, dry mixture from cough, anti-asthmatic mixture according to Traskov's prescription, anitos drugs, altalex, Strepsils-original.

Fennel fruits — FRUCTUS FOENICULI

Fennel oil — OLEUM FOENICULI

Common fennel *Foeniculum vulgare* Mill. (*foenum* – hay; *vulgaris*, *-e* – common), family Apiaceae, is a biennial or perennial herb with a branched stem, 1–2 m tall. Fruits contain essential oil (3–6.5%), in which includes anethole (up to 60%), fenchone (10–12%), methylchavicol, α-pinene, α- phellandrene, anisic aldehyde, anisic acid. In addition, the raw material contains fat oil, protein substances, coumarin umbelliferone, flavonoids, quercetin, quercetin- 3-arabinoside. Common fennel preparations have secretolytic, antispasmodic, carminative and weak diuretic properties. Fruits are included in the composition carminative, laxative and soothing teas; dill essential oil water, altalex drops, anti-asthmatic mixture according to Traskov's prescription.

Medicinal plants and raw materials containing cymene derivatives

Herba serpylli – HERBA SERPYLLI

Creeping thyme *Thymus serpyllum* L. (*thymos* – spirit, courage, strength – for stimulating and strengthening effect, another origin is also possible – from ancient Egyptian *tham* – the name of one fragrant plant; *serpyllum* – from the Greek name of this plant herpyllos, which is related to the verb herpo – to crawl), family Lamiaceae, – low (10–35 cm tall), fragrant creeping bush that forms small turfs. The herb contains thyme essential oil (1.5%), which includes thymol, carvacrol, cymol, α- and β-pinene, γ-terpinene, α-terpineol, borneol and other terpenoids. There is also in the raw materials flavonoids, tannins and bitter substances, gum, triterpene acids (ursolic and oleanol), mineral salts. Infusion of grass and liquid extract of thyme have an expectorant, antibacterial, antispasmodic and analgesic effect; have a calming effect on the central nervous system, stimulate secretions gastric juice Thyme is part of Pertusyn and Anitos preparations.

Herba of common thymi – HERBA THYMI VULGARIS

Essentiao oil of common thymi – OLEUM THYMI

Common thyme *Thymus vulgaris* L., family Lamiaceae, is a small (up to 50 cm tall) subshrub. Thyme herb ordinary contains essential oil (1–2%), which includes thymol (20–60%), carvacrol, n-cymol, monoterpenoids, sesquiterpene caryophyllene. Important BAR groups are flavonoids (luteolin, luteolin-7-glucoside, luteolin-7- diglucoside), triterpene compounds (ursolic, oleanolic acids), phenolic acids (coffee, chlorogenic, henna). From the essential oil of common thyme receive thymol - a strong antiseptic, which is used for disinfection oral cavity, treatment of fungal skin lesions, in stomatology practice It is part of Kamistad gel. Inside thymol is prescribed as antiseptic agent for diarrhea and flatulence to reduce fermentation in intestines and as an anthelmintic. The herb extract is included in the composition of pertussis, efcamon, pinosol.

MOTHER'S HERBS – HERBA ORIGANI

Origanum vulgare L. (*origanum* is the Latinized Greek name plants, *oreiganon* from oros – mountain, *ganos* – shine; Latin *vulgaris*, *-e* – ordinary), family Lamiaceae, is a perennial herbaceous plant. The grass contains essential oil (1.2%), the main components of which are carvacrol and thymol (their total content reaches 44%). Also revealed monoterpene alcohols, geranyl acetate, sesquiterpenes. Phenolics are present in the raw materials compounds such as flavonoids (apigenin, luteolin glycosides), tannins, ascorbic acid. The infusion of the herb

has a calming effect on the central nervous system, strengthens the secretion of digestive, bronchial and sweat glands, strengthens stimulates peristalsis, intestinal tone, uterine smooth muscles bile secretion, increases diuresis, regulates the menstrual cycle; reveals anti-inflammatory, pain-relieving and antimicrobial effect. Motherwort extract is part of urolesan, which is used as a litholytic agent. In homeopathy a fresh flowering plant is used as a sedative; increases secretion digestive, bronchial and sweat glands, intestinal tone, uterine muscles, gall bladder.

Theme 8 MEDICINAL PLANTS AND PLANT RAW MATERIALS CONTAINING CARDIAC GLYCOSIDES

1 Cardiac glycosides structure and classification

2 Cardiac glycosides distribution, localization and physico-chemical properties

3 Biological action and application

4 Medicinal plants and raw materials containing cardiac glycosides

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 423-444. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/Фармакогнозія-з-основами-біохімії-рослин.pdf (in Ukrainian)

1 Cardiac glycosides structure and classification

Cardiac glycosides are a large group of glycosides, derivatives of cyclopentanoperhydrophenanthrene, which selectively act on the heart muscle.

Among natural glycosides, cardiac glycosides occupy a special place because they **have no synthetic analogues**. Plants that contain cardiac glycosides, as well as drugs derived from them, are the main means in the treatment of cardiovascular insufficiency.

A characteristic feature of cardiac glycosides is a specific effect on the heart muscle: in small doses, they increase its contraction and improve heart function, in large doses, on the contrary, they suppress the work of the myocardium and eventually cause cardiac arrest. Cardiac glycosides have a calming effect on the central nervous system in small doses.

Since ancient times, plants containing cardiac glycosides have been used to treat heart diseases. Onion was used as a heart and diuretic in ancient Egypt and Rome. In ancient times, the peoples of Africa used the root of kharg *Gomphocarpus* sp., which is called "Uzaru root", for heart diseases. Foxglove as a medicinal remedy was known in England from the 11th century.

The first experiments on the structure of cardiac glycosides were started in the 19th century. In 1913, the work of the German scientist Vanraus was published, which contained information on the structural features of cardiac glycosides. Later, the works of the American Jacobs, the Swiss Cheche, and the German Stoll appeared, which expanded knowledge about cardiac glycosides.

D. G. Kolesnikov, Y. I. Khodzhai, M. A. Angarska, V. T. Chornobai, I. Kh. Makarevych, M. F. Komisarenko participated in the creation of medicinal products from cardiac glycosides (State Scientific Center of Medicinal means, Kharkiv), N. K. Abubakirov (Institute of Chemistry of Natural Substances of the Academy of Sciences of Uzbekistan, Tashkent), I. T. Kutateladze, E. P. Kemertelidze (Institute of Pharmacochemistry of Georgia, Tbilisi).

Aglycones of cardiac glycosides are steroids, but unlike other compounds of this class, they have a specific spatial orientation of the molecule. The A/B and C/D rings in cardiosteroids are in the cis position, and the B/C rings are in the trans position.

This ring arrangement distinguishes cardiac glycosides from other natural steroids in which the C/D rings are in the trans position.

Cardiosteroids have a chemical structure of butenolide five-membered unsaturated lactone ring, or coumaline – doubly unsaturated six-membered lactone ring. It is the presence of the lactone ring that determines the cardiac action. Absence, rupture or isomerization of the lactone ring leads to loss of physiological activity. Cardiac glycosides are divided into two groups by the nature of the side chain at C-17: cardenolides (group of digitalis, strophant) have an unsaturated five-membered lactone ring at C-17; bufadienolides (the hellebore group, bulbs) have a six-membered unsaturated ring with two double bonds at C-17. Cardenolides, which occur only in plants, are more common.

2 Cardiac glycosides distribution, localization and physico-chemical properties

In the world flora of 434 families of flowering plants, cardiotonic glycosides are found in 14 families and 34 genera, which include about 300 species. Most of them synthesize glycosides, contain cardenolides. Bufadienolides have been identified only in plants of the families Alliaceae, Hyacinthaceae, Liliaceae, Iridaceae and Meliaceae. In addition to plants, bufadienolides of the cis-A/B series (Latin. *bufo* - frog) are found in the poisonous secretions of the skin glands of frogs.

In 1978, E. Reichstein and his colleagues found cardenolides of the cis-A/B series in some insects that parasitize African species of cottontail (*Asclepias*). These insects themselves do not produce poisonous substances, but, eating plants that contain cardiac glycosides, they accumulate them to protect themselves from enemies.

The presence of cardiac glycosides was found in the following families and genera: Scrophulariaceae (*Digitalis*), Convallariaceae, Hyacianthaceae (*Ornithogalum*, *Scilla*, *Bowiea*), Apocynaceae (*Strophanthus*, *Nerium*), Ranunculaceae (*Adonis*, *Helleborus*), Brassicaceae (*Erysimum*), Fabaceae (*Coronilla*), Asclepiadaceae (*Asclepias*, *Periploca*), Moraceae, etc.

They are localized in various plant organs – seeds, leaves, stems, rhizomes, roots, bark, etc. Their content changes according to ecological and geographical conditions, the growing season, the state of the plant (fresh or dried), etc.

Physico-chemical properties. Cardiac glycosides are colorless or white crystalline, less often amorphous, odorless substances, bitter in taste, have a certain melting point (100–270 °C), optically active, many of them fluoresce in UV light. The majority is sparingly soluble in water, it dissolves well in aqueous solutions of methyl and ethyl alcohols. Glycosides with a long carbohydrate chain dissolve better in water and aqueous solutions of alcohols, and aglycones – in organic solvents.

Cardiac glycosides are susceptible to hydrolysis. It can be acidic and fermentative. In an alkaline environment, the aglycon part of the molecule is destroyed (opening of the lactone group), which leads to the loss of cardiotonic action.

The sugars of cardenolide glycosides are specific: they do not cleave the glycoside, the only exception is grape snail enzymes. D-Glucofuranosides are resistant to enzymatic cleavage, unlike D-

glucopyranosides; the rate of hydrolysis depends on the structure of the aglycone.

3 Biological action and application

It was found that the nature and mechanism of action of various cardiac glycosides on the cardiovascular system is generally the same, but each of them has some features: strength, duration and speed of action, accumulation, etc.

The cardiotonic effect develops as a result of direct action on the myocardium. Cardiosteroids change all **its functions**: increase heart contraction (positive inotropic effect); increase the tone of the myocardium (positive tonotropic effect); reduce heart rate (negative chronotropic effect); impair myocardial conduction (negative dromotropic effect); increase the excitability of the myocardium (positive bathmotropic effect).

In the range of therapeutic doses, only the first three effects occur. They determine the clinical value of cardiac glycosides. At the same time, the last two effects contain signs of overdose, indicating the toxic effect of glycosides on the myocardium. In addition to the cardiotonic effect, cardiac glycosides have a cytostatic effect and have a beneficial effect on the central nervous system.

Cardiac glycosides are prescribed to patients with chronic heart failure with impaired blood circulation. The relationship between the chemical structure and pharmacological action of cardiac glycosides. The diversity of action (therapeutic and toxic) of steroid lactones is due to several features of their structure. First. the nature of the lactone ring in C-17 is important, followed by the presence of substituents, double bonds, the nature of the carbohydrate component, and stereochemical features of the molecule.

Cardiac glycosides of 12 aglycones have been used in medicine. Six of them (hitoxigenin, digitoxigenin, digoxigenin, diginatigenin, oleandrogenin and periplogenin) contain a methyl radical in C-10, which causes a cumulative effect. Two aglycones – strophantidol and ouabagenin at C-10 have a methoxyl group; four aglycons – an aldehyde group (adonitoxigenin, strophanthidin, cannogenin, and hellebrigenin). Glycosides with a carboxyl group in the C-10 position lose their cardiotonic effect.

Changing the orientation of the lactone ring from 17β- to 17α-configuration, restoration of its double bond or formation of isocardenolides leads to a sharp decrease in cardiotonic activity.

4 Medicinal plants and raw materials containing cardiac glycosides

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING CARDENOLIDES

DIGITAL LEAVES – FOLIA DIGITALIS

Purple foxglove *Digitalis purpurea* L., Plantaginaceae family. The Latinized name comes from *digitalis* – digital, due to the thimble-like shape of the flowers; *purpureus* – purple, red. The plant is a biennial herb, up to 120 cm tall. Poisonous plants! It has been established that in all parts of the plant there are more than 50 cardiotonic glycosides and their aglycones, the activity of which is equal to 50-70 IU. The most studied genuine glycosides of digitalis purpurea are purpureaglycoside A, purpureaglycoside B, and glucohytaloxine, which have different radicals at C-16. In addition to cardenolides, steroid saponins (digitonin, gitonin, tigonin), flavonoids (glycosides of apigenin and luteolin), aromatic acids (oxybenzoic, vanillic, n-coumaric, caffeic, ferulic, etc.) were found. Digitoxin, gitoxin, cordigite are used for chronic (rarely acute) heart failure of the II and III degrees, which is accompanied by impaired blood circulation. The action of these drugs occurs 30–60 minutes after use, the therapeutic effect lasts from 8 to 24 hours. Regarding the duration of action, other preparations of cardiac glycosides cannot compare with digitalis preparations. However, digitalis preparations tend to accumulate, that is, accumulate in the body, so they should be alternated with preparations of other plants (lily of water, yarrow, yarrow), which do not show cumulative properties. In homeopathy, fresh leaves collected before flowering are used for rheumatism, weak pulse, cataracts, urethritis, and edema.

LEAVES OF WOOLLY DIGGULUM – FOLIA DIGITALIS LANATAE

Woolly foxglove *Digitalis lanata* Ehrh., Plantaginaceae family. The Latinized name comes from *digitalis* – digital, due to the thimble-like shape of the flowers; *lana* – wool. The plant is perennial or biennial with a small rhizome and tap roots. Stems are single (rarely several) upright. Poisonous plants! The leaves contain about 30 cardenolides. The main ones are primary glycosides – lanatosides A, B, C, D and E. Similar in structure to purpureaglycosides, they differ in the presence of an acetyl group in the digitoxose molecule. The biological activity of the raw material is at least 100 IU. Among other classes of natural compounds, the leaves contain flavonoids (luteolin, scutellarin) and

steroid saponins. Preparations of digitalis wool have a number of advantages over preparations of digitalis purpura: they act more quickly on the heart; have less cumulative properties and are better tolerated by patients. In medical practice, digoxin, celanide, isolanide, lanikor, lanatoside, lanatoside C, which includes digoxin, as well as a new galenic drug containing the sum of cardiac glycosides of digitalis wool are used in medical practice.

STROPHANT SEEDS – SEMINA STROPHANTHI

Combe strophanthus *Strophanthus kombe* Oliv., bristly strophanthus *Strophanthus hispidus* DC, attractive strophanthus *Strophanthus gratus* (Hook.) Franch, Apocynaceae family. The Latinized name comes from the Greek. *strophos* – twisted and *anthos* – flower, indicating spirally twisted flower petals; *kombe* is the African name for the species. Perennial vines with opposite hairy, oval-shaped leaves with a pointed tip. The plant is poisonous. In the seeds of strophanthus kombe, the content of the sum of cardiac glycosides is 8–10, in strophanthus bristly and attractive – 4–8%. The main cardioglycosides of strophanthus kombe and bristly: K-strophanthoside (2–3%), K-strophantin-β, cymarin, strophantidol, cymarol. The main glycoside of attractive strophant is G-strophantin or ouabain (makes up to 90% of the sum of all glycosides). In addition to cardiac glycosides, the seeds contain saponins, trigonelline, choline, enzymes and up to 30% fatty oil. Strophanthin-K (solution in ampoules) is mainly used for treatment. Strophantin-G is used as a standard in the biological evaluation of raw materials and preparations. The following injectable drugs are used as "emergency aid": strophantin-K, which is a mixture of strophantin kombe glycosides (mainly K-strophantin-β and K-strophanthoside), strophantin-G and acetylstrophantin. In homeopathy, ripe seeds are used for a sharp drop in blood pressure in hypertensive patients, tachycardia in those affected by Bazed disease, a weak, uneven pulse.

HERBA ADONIDIS VERNALIS

Spring gorse *Adonis vernalis* L., Ranunculaceae family, the Latinized name comes from the Greek: *Adonis* is the name of the son of Cypriot king Kinirus; Latin *vernalis*, *-e* – spring. The plant is a perennial herb, with a yellow short rhizome and several erect stems that are densely covered with leaves, with pressed twigs. The leaves are broadly ovate in outline, finger-dissected, the segments are narrow, linear, entire. The flowers are single, bright yellow, with 10–

20 petals. The fruit is a multicorn. Among other species of gorse, we can name Turkestan gorse – *Adonis turkestanicum* (equal to the official species), Amur gorse – *Adonis amurensis* (more active), golden gorse – *Adonis chrysocyanthus* (raw material – rhizome with roots); K-strophantin-β is produced from it. The herb contains cardiac glycosides (0.7%): adonitoxin, cymarin, K-strophanthin-β (formed during slow drying from cymarin), etc. Flavonoids, saponins, and coumarins (vernadin, etc.) were also found in the roots. Along with the cardiotonic effect, which is weaker than that of strophanthus and digitalis, preparations of St. John's wort calm the central nervous system. The infusion of the goritsvit grass is part of Bekhterev's mixture, which also contains sodium bromide, codeine (or codeine phosphate). Dry St. John's wort extract (produced 1:1 and 2:1) is used to make tablets and infusion. Adonis-brom coated tablets contain: dry extract of St. John's wort (1:1) – 0.25 or (2:1) – 0.125 g. It is used as a sedative. Adoniside is a new galenic drug that contains the sum of the glycosides of St. John's wort, which is part of the Cardiovalen drug; adoniside dry, cardiophyte. In homeopathy, the whole fresh plant is used in heart failure with arrhythmia, palpitations, edema, and albuminuria.

HERBA CONVALLARIAE, LILY OF LILY LEAVES – FOLIA CONVALLARIAE

LILY OF LILY FLOWERS – FLORES CONVALLARIAE

Common lily of the valley *Convallaria majalis* L., Transcaucasian lily of the valley – *Convallaria transcaucasia* Utkin ex Grossh., Keiske's lily of the valley (Japanese) – *Convallaria keiskei* Miq., Asparagaceae family; the name comes from lat. *convallis* – valley, Greek. *leirion* – lily, i.e. "lily of the valleys", *majalis* – tequal. The plant is a perennial herb, up to 20 cm tall, with a creeping rhizome. All parts of the plant contain about 20 compounds of cardenolide nature, flavonoids (derivatives of quercetin, kaempferol and luteolin), coumarins, terpenoids, steroidal saponins. The main cardiac glycosides are convalotoxin, convalotoxol, convaloside. Tincture of lily of the valley 1:10 on 70% alcohol (prepared from grass); corglycon (sum of glycosides from lily of the valley leaves); Zelenin drops, konvaflavin (contains the amount of flavonoids of Keiske's lily of the valley) are used as a choleretic agent and as part of the litholytic drug Marelin.

HERBA ERYSIMI CANESCENTIS RECENS

Erysimum canescens Roth, syn. *Erysimum diffusum* Ehrh., family Brassicaceae; the Latinized name comes from the Greek. *eryomai* – to save, to heal; Latin *canescens* – graying, *diffusus* – sprawling. The genus of the yellow-bellied tree unites more than 130 species, of which about 60 occur in our country. Cardenolides were found in half of them. Of practical importance is the grayish (sprawling) sedum, which is cultivated for medical purposes. A biennial plant, the stems are branched, single or several, 30–90 cm tall. Cardiac glycosides are contained in all plant organs: seeds and flowers (2–6%), leaves (1.0–1.5%), stems (0.5–0.7%) and roots (up to 0.2%). Erysimin, erysimoside, glucoerysimoside, neurotoxin and others whose aglycone is strophanthidin were isolated from grass and seeds. The seeds contain a lot of fatty oil (up to 40%). Herbs and flowers contain flavonoids. St. John's wort preparations (erysymin) have cardiotonic, sedative and diuretic effects. Dandelion juice is included in the complex drug Cardiovalen, 1 ml of which contains 45–50 IOD. Ecdysteroids, ecdysones, or insect molting hormones, are C-27 steroids based on the cholestane skeleton. These are natural compounds that have the activity of insect molting and arthropod metamorphosis hormones. They were first found in insects and crustaceans. Insect metamorphosis is controlled by several hormones (α-ecdysone, β-ecdysone, or ecdysterone) produced in special glands. Ecdysones are divided into zooecdysones (isolated from animals) and phytoecdysones (isolated from plants). Now more than 60 compounds of this group are known. Ecdysones are solid crystalline compounds that dissolve well in ethanol, acetone, methanol, ethyl acetate and poorly in chloroform, petroleum ether; are optically active compounds. Ecdysones accumulate in 90 species of plants belonging to 41 genera and 20 families. Their content ranges from 0.01 to 2%. For the extraction of ecdysteroids, it is best to use acetone or methanol. Purification is carried out using chromatography on aluminum oxide or silica gel. The quantitative determination of these compounds is carried out by the spectrophotometric method after their preliminary separation in a thin layer of silica gel. One such method is the method based on the Chugaev reaction (zinc chloride in acetic acid and acetyl chloride), which produces colored products. A direct spectrophotometric test at a wavelength of 242 nm is also used. The pharmacological properties of ecdysones have not been studied enough. They have a psychostimulating and adaptogenic effect. In

addition, ecdysones enhance the processes of protein synthesis in the body, so they can be used as anabolic compounds.

MEDICINAL PLANTS AND RAW MATERIALS CONTAINING ECDYSTEROIDS

RHIZOMATA ET RADICES LEUZEAE

Leuzea carthamoides (Willd.) DC, syn. *Rhaponticum carthamoides* (Willd.) Iljin, Asteraceae family; the name "*maral grass, maral root*" is related to the fact that *deer* - marals are treated with the roots of the plant. The Latinized name comes from the Greek. *rha* – names of fragrant plants; *pontikus* – Pontic, Black Sea; *carthamoides* – safflower-like; *Leuzea* – on behalf of the French scientist J. Deleuze. The plant is a perennial herb, 40–100 cm tall. Rhizomes with numerous woody, thin, branched adventitious roots. The main active substances are phytoecdysteroids (0.03–0.08%) – ecdysterone, inocosterone, integristerones A and B, 24 (28)-dihydromarkisterone A. In addition, organic acids, ascorbic acid, carotenoids, tannins, essential oil, flavonoids, gums, resins, inulin. Liquid extract of leuzea stimulates the central nervous system, is an antagonist of hypnotics, and increases blood pressure. It is prescribed for nervous and physical fatigue, functional disorders of the nervous system. Lewzea extract is part of biologically active food additives. The drug ecdysten belongs to the group of anabolic agents.

Theme 9 PRACTICAL USE OF MEDICINAL PLANTS

1 Biologically active food additives
2 Food supplements from medicinal plant raw materials
3 Safety and efficacy of food additives
4 Main directions of development of BAD and SHP in Ukraine

Literature and Internet resources:

Kovalev, V. M., Pavliy, O. I., Isakova, T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P. 593-606. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

1 Biologically active food additives

Biologically active food additives are products that are used for the purpose of providing the diet with curative or curative-

prophylactic properties. Most of them are produced from medicinal plant raw materials.

Food additives (FA) are substances or substances that are introduced into the composition of food products in order to improve the technological process of their production, structure, physico-chemical and organoleptic properties, extend the shelf life, and increase the biological or nutritional value. These include preservatives, antioxidants, oxidizers, leavening agents, emulsifiers, stabilizers, substances that regulate pH, dyes, flavors and aromas, taste and smell intensifiers, vitamins, trace elements, amino acids, as well as natural spices.

Preservatives are used to prevent damage to products by microorganisms. These include SO_2, sulfites, hydrosulfites, benzoic, sorbic acids and their salts, H_2O_2, food gelatin, urotropin. Hydroxybenzoic acid esters, other phenol derivatives, propionic acid, and some antibiotics are also used abroad.

Antioxidants prevent oxidation and rancidity of fats. Among natural antioxidants, ascorbic acid and its salts, gallic acid esters, and tocopherols are widely used.

Thickeners and **gelatinizers** include vegetable polysaccharides – starch, pectin, agar, sodium alginate, carrageenans, gums, modified starch, cellulose and its esters.

Emulsifiers and **foaming agents** are mono- and diglycerides – products of esterification of glycerol with citric, lactic, tartaric, ricinoleic, palmitic acids, tweens (sorbitals), stearoyllactic acid and its salts. In the Soviet Union, tweens were banned due to their ability to increase the permeability of cell membranes. Natural dyes used in food products include β-carotene; extract from the rhizomes of the tropical turmeric plant, crocin from saffron (yellow color); anthocyanins of dark grape varieties, black elderberries, currants, chokeberry, sorghum, as well as betalains from red beets (gives a red color); chlorophyll derivatives: abroad – chlorophyll copper complex, in Ukraine – nettle chlorophylls (green color). Vodka, confectionery, sauces are colored with "burnt sugar".

Flavorings are a large group: individual substances and compositions (essences, smoking liquids). Natural flavorings are obtained from vegetable, fruits, plants in the form of alcohol infusions or use alcohol solutions of essential oils. Synthetic flavors that have natural analogues include citral (citrus *Citrus*), linalool and geraniol

(apples *Malus domestica*, grapes *Vitis vinifera*, apricots *Prunus armeniaca~Armeniaca vulgaris*, coriander *Coriandrum sativum*, etc.), dimethyl sulfide (garlic *Allium sativum*, mustard *Sinapis alba*), cinnamic aldehyde (cinnamon *Cinnamomum verum*, cocoa *Theobroma cacao*, coffee *Coffea s*pp., tea *Camellia sinensis*, tomatoes *Lycopersicon esculentum~Solanum lycopersicum*), pyridine, which imitates the smell of asparagus *Asparagus officinalis*, onions *Allium cepa*, garlic *Allium sativum*, and tomatoes *Lycopersicon esculentum~Solanum lycopersicum*.

Sugar substitutes are synthetic and plant-based. The latter include steviol (*Stevia rebaudiana*) and thaumatin, or talin, from the African plant *Thaumatococcus daniellii*.

Substances allowed as food additives have passed hygienic and toxicological tests. Their industrial use is regulated by technological instructions, sanitary rules and acceptable standards, which are approved by state bodies (the Ministry of Health of Ukraine). At the international level, medico-biological recommendations for food additives are developed by a joint committee of EU and WHO experts, which establishes the level of "favorable daily intake" – the amount of a substance that does not cause harm to human health with constant intake with food.

In recent years, many foreign companies, followed by Ukrainian producers, offer the population "food supplements" mainly from medicinal plant raw materials. Food additives have found their place in the global consumer market, and companies engaged in the production and distribution of this category of goods are ahead of others in terms of capital turnover. "Food supplements", as they are called in the West, have been used for a long time. It is known that half of the US population and 80% of Japanese people add these substances to their food. New terms appeared: nutrients, nutraceuticals, parapharmaceuticals, etc. Thus, essential (indispensable) nutrients are called **nutraceuticals** – vitamins or their precursors, for example beta-carotene, omega-3 polyunsaturated fatty acids, minerals and trace elements – iron, calcium, selenium, zinc, iodine, fluorine, some amino acids, mono - and disaccharides, dietary fibers (cellulose, pectin).

In Ukraine, this category of food products is called biologically active supplements (BAD) and special food products (SHP). The appearance of dietary supplements and nutritional supplements is

natural, because the inhabitants of industrialized countries eat refined, refined, preserved, chemically processed products, which are poor in nutritious biologically active substances and additionally contain not only the above-mentioned, but also synthetic food additives.

2 Food supplements from medicinal plant raw materials

History shows that the implementation of medicinal plant raw materials in the form of food additives first appeared in the USA, and then a theoretical basis was created for their use.

Legal relations in the field of food products are regulated by the Federal Act on Food, Drug and Cosmetic Products (1938). In October 1962, the Keefover - Harris Amendment was passed, requiring that by 1983 all drugs be tested for safety and efficacy. This marked the beginning of a new era in pharmacy. To implement the amendment, the US Food and Drug Administration (FDA) contracted with the Research Council of the National Academy of Sciences to test the effectiveness of drugs that had been approved for use since 1938 only on the basis of their safety. Manufacturers were required to provide the FDA with reports of side effects from the use of the drugs. Since 1972, ready-made medicinal products began to pass the examination procedure according to the specified criteria.

"Obsolete" drugs that did not need to prove their safety and were used to treat painful conditions, not pathologies, were withdrawn from the trade. This applied mainly to medicines from plant raw materials, because clinical indicators rarely contributed to their approval. The pharmaceutical industry made no effort to finance additional research on the in-depth study of the effectiveness of herbal remedies, which led to a situation where almost all herbal remedies disappeared from pharmacies. The demand for products was met by stores and parcel firms trading in "food supplements" in the guise of teas, herbs, healthy food, food products, etc. The label stated only the name of the product without indicating its effectiveness. The seller, of course, did not give recommendations for its use, so as not to be accused of unlicensed medical activity. The answer to the question of why medicines of natural origin in the countries of the world are not distributed in the usual way lies in the economic mechanisms of the introduction of medicines. A potential manufacturer or entrepreneur must invest a significant amount of money (sometimes hundreds of millions of dollars) to conduct all the necessary tests and research. And since

patent protection of drugs of natural origin is difficult or impossible, companies do not invest money in their development. This is very unfortunate, because by researching "old" medicines with the help of modern methods, it is possible to determine new useful properties of active substances.

Even sadder, from the point of view of economics, science and professionalism, is the quackery that accompanies the recommendations of inexperienced persons on the use of nutritional supplements by people with serious diseases who are not helped by known drugs and have resorted to self-medication. Therefore, a qualified pharmacist or pharmacist must be knowledgeable about food additives for special purposes, especially biologically active ones, which are allowed to be sold in pharmacies. The specialist is obliged to inform and warn the population, patients and their families that unknown foreign food additives that are not approved by the Ministry of Health of Ukraine cannot be used out of desperation or ignorance. At the same time, he should closely monitor the appearance of new registered biologically active food additives, be professionally knowledgeable in order to inspire confidence in buyers, and avoid categorical judgments such as "it's outdated", "it's worthless", treat the patient with care and unobtrusively direct him to the path of traditional treatment.

In the countries of the European Commonwealth, the legislative acts on the control of food products, cosmetics and medicines are the EU Directives. But there are situations when it is impossible to determine to which category the product belongs. The same product can be considered a medicine in Germany and have the status of a food supplement in the Netherlands. Now the term " nutraceutical " is widely used to denote products that have the properties of *both* food products and medicinal products, but there are still no legislative documents in the EU that would regulate the properties of such products. According to the norms of European legislation, products can belong to the sphere of either the food industry or the medical industry, but not both together.

The beginning of the harmonization of the legislation of the EU states on medicinal products was laid by Directive 65/65/EU of January 26, 1965. Article 1 defines "**medicinal product**": "any substance or combination of substances intended for the treatment or prevention of diseases human or animal. Any substance or

combination of substances that can be administered to humans or animals for the purpose of diagnosis or restoration, correction or modification of physiological functions is also considered a medicinal product. Despite the accuracy of the wording, companies find it possible to advertise a dietary supplement as, for example, a "heart-healthy" product, or a "carefully selected combination of lipotropic ingredients that oxidize (burn) fat," or "hormone precursor pills," or "to stabilize the level of sugar in the blood", or those that "contribute to the maintenance of normal water balance in the body".

There are often difficulties in establishing the product category when the food product is manufactured in the form of a medicinal product (tablets, capsules, granules). Some products that contain vitamins and minerals are considered medicinal products and must be licensed for sale because the instructions state that they are used to treat conditions caused by vitamin deficiency in the body and contain these substances in large doses. If there is no such statement, the product can be sold as a food additive (if there is a permit for this).

In August 1999, the Ministry of Health of Ukraine approved the Regulations on State Control of the Quality and Safety of Special Food Products, Biologically Active Food Additives, and Food Additives. In the Regulation, for the first time, the terminology is given, according to which biologically active additives are recognized as substances or their mixtures, which are used to provide the diet with special curative or curative-prophylactic properties.

Special food products are therapeutic, dietary, therapeutic and preventive and biologically active food supplements, baby food and nutrition for athletes.

Now the import into the territory of Ukraine, the sale and use of food additives, BAD and SHP is allowed only after state examination of the products, regulatory documentation for it and subsequent registration in the State registers of HD, BAD and SHP.

3 Safety and efficacy of food additives

Drugs of natural origin, which during testing did not show any or showed little therapeutic value, went to the category of "food additives" abroad. In addition, there are some drugs left on the market that are harmful with long-term use. During the study of their chemical composition, it was found that they contain substances with carcinogenic, mutagenic, and allergenic properties.

Despite this, people pay crazy money for them and continue to use them. This is explained by the fact that, firstly, in many cases, the positive effect occurs as a result of the so-called placebo effect, and the therapeutic effect depends little or does not depend at all on the active substances of the drug. The placebo effect has a psychological mechanism of action. The experiments of Western scientists proved that, depending on the condition of the patient, the placebo effect occurs in those who were prescribed a placebo. It is believed that the positive effect from it appears at the end of treatment and is caused by changes in behavior, subjective feelings or is a response of the endocrine system or internal control. Most herbal preparations and biologically active supplements are used by patients with the hope of improving their well-being and, apparently, sometimes they achieve it. Confidence is also the reason for good results of therapy or treatment procedures. The choice of plant raw materials, phytopreparations, special food additives is often based on family or folk traditions, advice from friends or annoying distributors. The latter is very dangerous – let's recall the harmful consequences of uncontrolled use of "famous" herbalife or vitamins.

Secondly, plant raw materials, phytopreparations and plant food products contain a very complex complex of substances. We need some of them to meet vital needs, others have physiological activity. Small doses of active substances cause positive changes in the biochemical processes of the macroorganism slowly, therefore only long-term use, cumulative effects, polyvalence of influence, the use of technological methods of manufacturing drugs that prolong the action of active substances, implementation of recommendations on changing lifestyle and nutrition can contribute to improving human well-being in pre-disease condition or recovery.

And finally, the excess profits received by manufacturers and distributors of food supplements of various kinds encourage them to invest crazy money in product advertising or in the training of distributors for network marketing. Consumers artificially form an opinion about the extraordinary benefits of food additives. Network marketing measures are aimed at trusting the distributor, his personal authority, influence on family, friends, acquaintances, as a result of which public opinion is artificially formed. These methods of distribution of goods are recognized as the most effective in the world, but the road to success is slow.

4 Main directions of development of BAD and SHP in Ukraine

In Ukraine, a new branch of knowledge is also developing – **nutriceology**, the science of nutrition. She studies the role and significance of food substances – nutrients (primary and secondary metabolites, vitamins, trace elements) for human life. BAD and SHP, which are being developed in Ukraine, are intended for:

- to increase (due to the strengthening of cell protection) the body's resistance to the action of harmful environmental factors, especially adaptation to adverse conditions in environmentally dangerous areas;
- accelerate the binding and removal of foreign and toxic substances from the body;
- to normalize the microbiocenosis of the gastrointestinal tract; to purposefully change the damaged metabolism of individual substances;
- to regulate (within the physiological limits of functional activity) the action of organs and systems, in particular the nervous system.

In Ukraine, dietary supplements and dietary supplements include products with vitamin, immunomodulatory, adaptogenic, antioxidant, general stimulating, and anti-stress effects. As evidenced by the main provisions of the theory of adaptation, the necessary conditions for reducing the risk of developing pathological conditions are the mobilization of the body's adaptogenic mechanisms under the influence of harmful factors. This happens when BARs of multicomponent herbal preparations, food additives or substances simultaneously act on key links of the adaptation system.

The adaptogenic effect depends on the composition of BARs, which can be divided into groups: compounds that regulate and normalize neuroendocrine mechanisms; they include di- and triterpenoids, triterpenic acids, components of essential oils and bitterness, specific glycosides; compounds that normalize the body's functional systems, including antioxidant and immune systems; these are bioflavonoids, carotenoids, vitamins, complexes of metals with organic compounds, mostly with polysaccharides and proteins, etc.

It is fundamental for Ukrainian scientists to search for food products with radioprotective and immunomodulating effects, which increase the body's resistance to adverse environmental factors,

reduce the negative impact of radiation and the risk of radiation-induced cancer. It is known that metabolic disorders caused by radiation energy can be corrected with the help of nutrition, which, on the one hand, is a factor that increases the dose load on the body, and on the other, protects it. Reduction of internal radiation doses can be achieved by reducing the proportion of products contaminated with radionuclides in the daily diet, as well as by increasing the biological value of traditional food products and creating new ones that have given properties. Enriching the diet with food substances that prevent the entry of radionuclides into the body or accelerate their removal (dietary fibers, alginates, pectins) is essential. Ukrainians should significantly increase the consumption of BAR, antioxidants, immunomodulators, which include vitamins, amino acids, complexes of mineral salts and essential fatty acids, bioflavonoids, which increase the body's resistance. The problems of radioprotective nutrition of the population living in ecologically unfavorable regions were reflected in the National Program of Ukraine for liquidation of the consequences of the accident at the Chornobyl NPP.

Work on the study of food substances and food products is carried out in Ukraine in the following directions: development of recipes for bread, bakery and confectionery products with the addition of dietary supplements; the use of beekeeping products (honey, pollen (bee pollen), perga, royal jelly) - valuable adaptogens of a wide spectrum of action, which have concentrated not only nutrients of plant origin, but also a complex of biologically active compounds; these products activate the body's defenses, improve the function of the heart, liver, gastrointestinal tract, stimulate hematopoiesis, increase mental and physical activity, and also have a radioprotective effect; there is a National Program for the development of such products; industrial production of β-carotene and water-soluble carotene, development of products enriched with them in order to reduce the risk of cancer; development of food compositions from hydrobiots (hydrolysates, protein-carbohydrate concentrates); the results of clinical studies indicate the expediency of their use in the treatment of hematological, oncological, endocrine diseases; production of concentrates (pastes, purees, nectarines) made by vacuum concentration of sugar-free fruit and berry juices; they contain two to five times more micro- and macroelements, vitamins, pectins, bioflavonoids, etc. than in fruit and berry raw materials; use of adsorbing properties (regarding

radionuclides and heavy metals) of pectins, alginates, other polysaccharides; they are recommended to be added to the recipes of almost all food products, nutritional supplements and dietary supplements; a separate scientific direction – works on the use of food albumin from animal blood as a biologically active substance, which is characterized by a unique chemical composition and a high concentration of heme iron.

So, in Ukraine, the industry of preventive and therapeutic nutrition begins to develop, which is paid attention to by enterprises not only of the food industry, but also of the pharmaceutical industry: Borshchagivsky KhFZ, Halychpharm JSC, Lubnypharm JSC, Kyiv Vitamin Plant.

LABORATORY WORKS

Laboratory work 3

Theme: Medicinal plants and its raw materials containing primary metabolites

Goal: to study the biological functions of carbohydrates in medicinal plants and the peculiarities of their action on the human body; get acquainted with the species composition of plants containing carbohydrates, proteins, and vegetable fats.

Tasks

1. Familiarize yourself with the classification of carbohydrates according to the size of the molecule (Independent work Theme 2). Choose the most common monosaccharides and oligosaccharides that have medical applications. Consider the proposed herbarium samples of medicinal plants. Present the results in the form of a table.

Table 3.1

Compounds	Chemical composition of raw materials	Distribution in nature or other compounds	Biological action and application
Monosaccharides			
	pentose		
	pentose		
	hexose		
	hexose		
Oligosaccharides			
	disaccharide		
	disaccharide		

2. Consider the proposed herbarium samples of medicinal plants. Using the materials of Independent work Themes 2, 3 and the Supplement C, study the species composition of medicinal plants containing carbohydrates (polysaccharides), proteins, enzymes, lipids. Choose 1–3 medicinal plant species, the raw materials of which are a source of cellulose, starch, inulin, gum, pectin, medicinal enzyme preparations of plant origin, non-drying, semi-drying and drying fatty oils, solid vegetable fats. Present the results in the form of a table.

Table 3.2

Compounds/ sources of compounds	Medicinal plant raw materials	Latin name of the plant	Pharmacological action	Active substances
Carbohydrates (Polysaccharides)				
Homopolysaccharides and their derivatives				
cellulose				
starch				
inulin				
Heteropolysaccharides				
gum				
pectin				
Medicinal enzyme preparations of plant origin				
Lipids				
non-drying fatty oils				
semi-drying fatty oils				
drying fatty oils				
solid vegetable fats				

Self-control test

1. D-Fructose is:
   1) a carbohydrate of the monosaccharide group belonging to the aldoses
   2) a carbohydrate from the group of monosaccharides belonging to ketoglycosides
   3) it is a component of the common disaccharide primrose, participates in the synthesis of polysaccharides (xylans), gums, pectins and hemicelluloses
   4) There is no correct answer
2. *Echinacea purpurea* is:
   1) a perennial herb. Together with purple echinacea, narrow-leaved echinacea *Echinacea angustifolia* and pale echinacea *Echinacea pallida* are used. Both species are widely cultivated. The polysaccharides contained in all parts of the plant are heteroxylans in structure

2) short-lived, does not contain enzymes and trace elements: selenium, cobalt, silver, molybdenum, zinc, manganese, etc.

3) the annual plant, does not have immunostimulating antioxidant, membrane stabilizing effect

3. What are lecithins?
   1) transparent substances
   2) oil substances
   3) fat-like substances
   4) acidic substances
4. Toxins are:
   1) high molecular weight natural organic substances consisting of amino acids, which are the basis of the structure and function of living organisms
   2) substances whose molecules consist of α-amino acid residues connected by peptide bonds -C(O)-NH-
   3) substances that cause disruption of biochemical processes, resulting in symptoms of intoxication, and in severe cases - death of the organism
   4) proteins or glycoproteins that are able to bind sugar and thus provide the ability to agglutinate cells and precipitate glycoconjugates
5. Food and storage proteins:
   1) play an important role in the development and functioning of the organism;
   2) are located on the outer surface of plasma membranes and receive information about the state of the environment
   3) those that control the biosynthesis of proteins and nucleic acids, as well as hormones
   4) the basis of bone and connective tissue, wool, etc. (e.g. collagen)

Sources

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.56–155. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Laboratory work 4

Theme: Medicinal plants and their raw materials containing tannins

Goal: to get acquainted with the species composition of plants containing tannins, study the biological functions of tannins in medicinal plants and the peculiarities of their action on the human body

Tasks

Familiarize yourself with the classification of tannins according their natural structure and chemical properties (Independent work Theme 6, Supplement D). Consider the proposed herbarium samples of medicinal plants, set the biomorph of the plant (tree, bush, perennial, or annual herb). Present the results in the form of a table.

Table 4.1

Medicinal plant raw materials	Plant Latin name	Biomorph	Pharmacological action

Self-control test

1. Medicinal plants containing tannins:
   1) *Rhus coriaria, Cotinus coggygria* (Anacardiaceae family)
   2) *Sanguisorba officinalis (*Rosaceae family)
   3) *Quercus robur* (Fagaceae family)
   4) all answers are correct
2. Tannins are detected
   1) binding action
   2) anti-inflammatory effect
   3) antimicrobial effect
   4) all answers are correct
3. The fruits of which plant are used as an astringent and dietary agent to improve eyesight
   1) alder – FRUCTUS ALNI
   2) hawthorn – FRUCTUS CRATAEGI
   3) cherries – FRUCTUS RADI
   4) blueberries – FRUCTUS MYRTILLI
4. Which plant material is used as a dietary remedy for acute and chronic disorders of the digestive tract, diarrhea in children and acute enterocolitis in adults:
   1) alder fruits – FRUCTUS ALNI

2) leaves of sumac -- FOLIA COTINI COGGYGRIAE
3) cherry fruits – FRUCTUS RADI
4) blueberry fruits – FRUCTUS MYRTILLI

5. The bark of which tree is used as a decoction is used externally as an astringent and anti-inflammatory agent for rinsing with gingivitis and stomatitis, burns and frostbite
1) oak *Quercus robur*
2) lindens *Tilia cordata*
3) common pine *Pinus sylvestris*
4) larches *Larix decidua*

Sources

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.296–316. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Laboratory work 5

Theme: Medicinal plants and their raw materials containing essential oil

Goal: to study the biological functions of essential oils in medicinal plants and the peculiarities of their action on the human body; to get acquainted with the species composition of plants containing essential oils

Tasks

1. Using the materials of Independent work Theme 7 and the Supplement E, study the species composition of medicinal plants containing essential oils. Present the results of 5-10 plant species from the two groups (Essential oils that mainly contain terpenoids, Essential oils containing aromatic compounds) in table form.

Table 5.1

Medicinal plant raw materials	Latin name of the plant	Biomorph (tree, bush, perennial, or annual herb)	Pharmacological action

2. Get acquainted with Individual compounds extracted from essential oils (Supplement E) and indicate the pharmacological effect of the essential oil of 5 compounds.

Self-control test

1. Medicinal lemon balm is used for…
   1) general nervous excitement
   2) insomniacs
   3) vascular-vegetative dystonia
   4) all answers are correct
2. Essential oils are...
   1) multicomponent mixtures of volatile organic compounds that are formed in plants and cause their smell
   2) multicomponent mixtures of volatile organic compounds that are formed in plants and cause their smell and colored liquid
   3) multicomponent mixtures of volatile organic compounds formed in tree branches
   4) multicomponent mixtures of volatile organic compounds formed in river waters
3. Medicinal chamomile preparations....
   1) stimulate the appetite, reflexively stimulate the activity of the glands of the digestive tract, increase the secretion of bile, pancreatic and gastric juice
   2) have secretolytic, antispasmodic, carminative and weak diuretic properties
   3) increase the secretory activity of the digestive glands, stimulate bile secretion and stimulate appetite, eliminate spasms of the abdominal organs, exhibit pain-relieving, anti-inflammatory, anti-allergic, antimicrobial effects
   4) exhibit expectorant, antibacterial, antispasmodic and analgesic effects; have a calming effect on the central nervous system, stimulate the secretion of gastric juice
4. Essential oils are detected …
   1) bacteriostatic effect
   2) antiseptic effect
   3) disinfectant effect
   4). All the options listed above
5. Choose a medicinal plant raw materials containing sesquiterpene lactones.

1). Rhizomes of ryegrass – RHIZOMATA SALAMI
2). The grass of the ordinary swamp – HERBA LEDI PALUSTRIS
3). Chamomile flowers – FLORES CHAMOMILLAE
4). The fruit of hops – STROBILI LUPULI

Sources

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.335–389. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Laboratory work 6

Theme: Medicinal plants and their raw materials containing alkaloids

Goal: to get acquainted with the chemical properties of alkaloids in medicinal plants and the features of their use; to study the species composition of plants containing alkaloids.

Tasks

1. Get acquainted with the botanical and pharmaceutical classifications of alkaloids. List the most common plant alkaloids.

2. Using the herbarium, study the species composition of medicinal plants containing alkaloids. Present the results in the form of a table using Supplement F.

Table 6.1

Latin name of the plant	Medicinal raw materials	Chemical composition of raw materials	Biological action	Application

Self-control test

1. On what principles are the classifications of alkaloids based?
   1) into account the path of biosynthesis
   2) on the construction of the carbon-nitrogen skeleton
   3) according to the botanical or phylogenetic principle
   4) according to their pharmacological properties

2. A group of organic nitrogen-containing substances, mainly of plant origin, which have an alkaline character and a high physiological effect on the human and animal body, are:
   1) vitamins
   2) steroids
   3) alkaloids
   4) there is no correct answer
3. Medicinal plants and raw materials containing tropane alkaloids:
   1) belladonna leaves of common *Atropa belladonna* – FOLIA BELLADONNAE
   2) belladonna roots of common *Atropa belladonna* – RADICES BELLADONNAE
   3) common belladonna herb *Atropa belladonna* – HERBA BELLADONNAE
   4) all answers are correct
4. Medicinal plants and raw materials containing protoalkaloids:
   1) digitalis purpurea leaves *Digitalis purpurea* – FOLIA DIGITALIS
   2) horsetail ephedra herb *Ephedra equisetina* – HERBA EPHEDRAE
   3) herb *Tribulus terrestris* – HERBA *TRIBULI TERRESTRIS*
   4) all answers are correct
5. Alkaloids of antispasmodic action ... are used in the treatment of peptic ulcer disease, spasms, in ophthalmic practice
   1) atropine, platyphyllin (belladonna of common *Atropa belladonna*, broad-leaved yellow herb *Senecio platyphylloides*)
   2) morphine, codeine (hypnotic poppy *Papaver somniferum*)
   3) reserpine (Rauwolfia snake *Rauwolfia serpentina*)
   4) sanguinarine, chelerythrine (pure body large *Chelidonium majus*)

Sources

Kovalev V. M., Pavliy O. I., Isakova T. I. Pharmacognosy with the basics of plant biochemistry. Kharkiv: Prapor, 2000. P.445–551. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf (in Ukrainian)

Laboratory work 7

Theme: Practical use of medicinal plants in folk medicine

Goal: to get acquainted with the peculiarities of the use of medicinal plants in human life.

Topics of presentations «Practical use of medicinal plants in folk medicine and everyday life»

1. Medicinal plants used for the treatment of diseases of the nervous system.
2. Medicinal plants used for the treatment of diseases of the cardiovascular system.
3. Medicinal plants used for the treatment of joint diseases.
4. Medicinal plants used for the treatment of respiratory diseases.
5. Medicinal plants used for the treatment of diseases of the digestive system.
6. Medicinal plants used for the treatment of kidney diseases.
7. Medicinal plants used for the treatment of diseases of the urinary tract.
8. Medicinal plants used for the treatment of diseases of the endocrine system.
9. Medicinal plants used for the treatment of metabolic disorders.
10. Medicinal plants used for the treatment of anemia.
11. Medicinal plants used for the treatment of gynecological diseases.
12. Medicinal plants used for the treatment of skin diseases.
13. Culinary use of medicinal plants. Classification of wild edible plants according to taste properties.
14. Use of medicinal plants in cosmetics.
15. Plants and herbal preparations for combating pests and plant diseases.

Tasks

Familiarize yourself with herbarium specimens of plants used in folk medicine, organize them into groups according to their medicinal properties. Consider the proposed herbarium samples of medicinal plants. Using identifiers, literature and presentations, write down their systematic position and the names of human diseases for which the proposed types of plants are used. Submit the results in the form of a table.

Table 7.1

Latin name of the plant	Family, division	Medicinal raw material	Disease	Physiological action

Self-control test

1. What are the necessary conditions for reducing the risk of developing pathological conditions according to the main provisions of the adaptation theory?
   1). Search for food products with radioprotective and immunomodulating effects
   2). Use of food albumin as a biologically active substance
   3). Mobilization of the body's adaptogenic mechanisms under the influence of harmful factors
   4). Increasing the biological value of traditional food products
2. From which chlorophyll do plants get their green color for use in food products in Ukraine
   1) nettles *Urtica dioica*
   2) birch *Betula pendula*
   3) wormwood bitter *Artemisia absinthium*
   4) aphid *Polygonum aviculare*
3. Antioxidants:
   1) are included in food products in order to improve the technological process of their production
   2) prevent damage to products by microorganisms
   3) prevent oxidation and rancidity of fats
   4) used for the purpose of providing the diet with therapeutic or therapeutic and preventive properties
4. Plant polysaccharides belonging to natural thickeners:
   1) starch, peptin, agar;
   2) food gelatin, urotropin;
   3) β-carotene; extract from the rhizomes of the tropical turmeric plant, crocin from saffron;
   4) ascorbic acid and its salts, esters of gallic acid and tocopherols
5. Biologically active food additives are:
   1) prevention of damage to products by microorganisms.
   2) substances that prevent oxidation and rancidity of fats. Among natural antioxidants, ascorbic acid and its salts, gallic acid esters, and tocopherols are widely used
   3) substances that are introduced into the composition of food products for the purpose of improving the technological process of their production, structure, physico-chemical and organoleptic properties, extending the shelf life, increasing the biological or nutritional value.
   4) products that are used for the purpose of providing the diet with therapeutic or therapeutic and preventive properties. Most of them are produced from medicinal plant raw materials.

LIST OF QUESTIONS

The subject and main tasks of pharmacognosy as a science of medicinal plants.

The history of the use of medicinal plant raw materials.

Medicinal forms from raw materials of plant origin.

Chemical composition of medicinal plants.

Essential mineral substances of medicinal plants and their functions.

Modern directions of biotechnology of medicinal plants, their tasks and methods.

Scientific basis of harvesting medicinal plants: types of raw materials, their collection, drying.

Protection of wild medicinal plants and their resources. The place of medicinal plants in the Red Book of Ukraine.

Biologically active substances of medicinal plants are products of primary metabolism, their use.

Biologically active substances of medicinal plants are products of secondary metabolism, their use.

Carbohydrates, their structure, biological action and application. Medicinal plants and raw materials containing carbohydrates.

Peptides, their structure, biological action and application. Medicinal plants and raw materials containing peptides.

Enzymes, their structure, biological action and application. Medicinal plants and raw materials containing enzymes.

Lipids, their structure, biological action and application. Sources of vegetable fats.

Glycosides, their structure, biological action and application. Medicinal plants and raw materials containing glycosides.

Simple phenols, their structure, biological action and application. Medicinal plants and raw materials containing simple phenols.

Coumarins, their structure, biological action and application. Medicinal plants and raw materials containing coumarins.

Flavanoids and cantons, their structure, biological action and application. Medicinal plants and raw materials containing flavonoids and cantons.

Tanning substances, their structure, biological effect and application. Medicinal plants and raw materials containing tannins.

Essential oils, their structure, biological effect and application. Medicinal plants and raw materials containing essential oils.

Saponins, their structure, biological action and application. Medicinal plants and raw materials containing saponins.

Steroids, their structure, biological action and application. Medicinal plants and raw materials containing steroids.

Cardiac glycosides, their structure, biological action and application. Medicinal plants that contain cardenoids.

Alkaloids, their physical and chemical properties, biological action and application. Medicinal plants that contain alkaloids.

Vitamins, their chemical structure and classifications according to physical and chemical characteristics. Medicinal plants that contain different groups of vitamins.

Prevention and treatment of diseases with medicinal plants.

Culinary use of medicinal plants.

The use of medicinal plants in cosmetics.

Phytotherapy of plants.

REFERENCES

Main literature (in Ukrainian):

1. Ковальов В. М., Павлій О. І. , Ісакова Т. І. Фармакогнозія з основами біохімії рослин. Харків: Прапор, 2000. 703 с. URL: https://college.nuph.edu.ua/wp-content/uploads/2015/10/ Фармакогнозія -з-основами-біохімії-рослин.pdf

2. Мінарченко В. М., Тимченко І. А. Атлас лікарських рослин України (хорологія, ресурси та охорона). Київ: Фітосоціоцентр, 2002. 172 с.

3. Мінарченко В. М. Лікарські судинні рослини України (медичне та ресурсне значення). Київ: Фітосоціоцентр, 2005. 324 с.

4. Червона книга України. Рослинний світ / за ред. Я. П. Дідуха. Київ: Глобалконсалтинг, 2009. 900 с. URL: http://irbis-nbuv.gov.ua/cgibin/ua/elib.exe?Z21ID=&I21DBN=UKRLIB&P21DBN=UKRLIB&S21STN=1&S21REF=10&S21FMT=online_book&C21COM=S&S21CNR=20&S21P01=0&S21P02=0&S21P03=FF=&S21STR=ukr0000008

Additional literature (in Ukrainian):

1. Гречаний І. Великий ілюстрований довідник лікарських трав і рослин. Харків: Книжковий Клуб «Клуб Сімейного Дозвілля», 2015. 544 с.

2. Закон України «Про рослинний світ». *Відомості Верховної Ради*. 1999. № 22-23. URL: https://zakon.rada.gov.ua/laws/show/591-14#Text

3. Мінарченко В. М., Середа П. І. Ресурсознавство. Лікарські рослини : навчально-методичний посібник. Київ: Фітосоціоцентр, 2004. 71 с.

4. Положення про дистанційне навчання у Волинському національному університеті (2022). URL: https://vnu.edu.ua/sites/default/files/2022-11/ПОЛОЖ%20ПРО_ДН_2022.pdf

5. Смоленська М. О., Королюк В. І., Галицька Л. Г. Лікарські рослини Буковини : довідник. Ч. 1. Природна флора. Чернівці: Рута, 2002. 295 с.

6. Фармакогнозія : базовий підруч. для студ. вищ. фармац. навч. закл. (фармацевтичних факультетів) IV рівня акредитації /

В. С. Кисличенко, І. О. Журавель, С. М. Марчишин, О. П. Хворост. ; за ред. В. С. Кисличенко. Харків: НФаУ; Золоті сторінки, 2015. 736 с. URL: http://dspace.nuph.edu.ua/handle/ 123456789/9823

Additional literature **(in Ukrainian):**

Енциклопедія лікарських рослин. URL: https://liktravy.ua/useful/articles

Червона книга України. Рослинний світ. URL: https://redbook-flora.land.kiev.ua/

Additional literature **(in Chinese):**

English Wikipedia. URL: https://en.wikipedia.org/wiki/

BASIC CONCEPTS AND TERMS

Biologically active substances – substances that affect biological processes in the body of animals and humans.

Plant biotechnology – growing isolated plant cells and tissues for the release of biologically active substances.

Active substances – biologically active substances that can change the state and functions of the body or have a prophylactic, diagnostic or therapeutic effect and are used in the production of ready-made medicinal products.

A medicinal plant – a plant that contains biologically active substances and is used for the preparation of medicinal plant raw materials.

Medicinal plant raw materials – whole medicinal plants or their parts, which are used in dried (sometimes fresh) form to obtain medicinal substances, medicinal products of plant origin (phytopreparations) and medicinal forms and are allowed for use.

Medicinal form – a medicinal product, which has been given a convenient state for use and achieving the required therapeutic effect (tablets, powders, collections, teas, decoctions, suppositories, drops, ointments, etc.).

Medicinal plant cultivation – identification, acclimatization and introduction of medicinal plants, their cultivation, selection of high-yielding varieties.

Medicinal products – substances or their mixtures of natural, synthetic or biotechnological origin, which are used for the prevention, diagnosis and treatment of human diseases or changes in the state and functions of the body.

Pharmacognosy – a science that studies the biological, biochemical and medicinal properties of plants, medicinal raw materials of plant and animal origin, as well as their processing products.

The period of regularity of procurement of medicinal plant raw materials

MARCH
- *Betula pendula* – buds
- *Pinus sylvestris* – buds
- *Vaccinium myrtillus* – leaves

APRIL
- *Arctostaphylos uva-ursi* – leaves
- *Betula pendula* – buds
- *Dryopteris filix-mas* – rhizomes
- *Inula helenium* – rhizomes with roots
- *Persicaria bistorta* – rhizomes
- *Pinus sylvestris* – buds
- *Populus nigra* – buds
- *Potentilla erecta* – rhizomes
- *Quercus robur* – bark
- *Vaccinium myrtillus* – leaves
- *Viburnum opulus* – bark

MAY
- *Adonis vernalis* - grass
- *Angelica archangelica* - roots
- *Arctostaphylos uva-ursi* - leaves
- *Asarum europaeum* – leaves
- *Betula pendula* – leaves, buds
- *Capsella bursa-pastoris* – grass
- *Convallaria majalis* – grass, leaves, flowers
- *Crataegus coccinea* – flowers, fruits
- *Dryopteris filix-mas* – rhizomes
- *Elymus repens* – rhizomes
- *Frangula alnus* – bark
- *Ledum palustre* – branches with leaves
- *Lycopodium clavatum* – grass
- *Paeonia officinalis* – roots
- *Pinus sylvestris* – needles, buds
- *Plantago major* – grass
- *Populus nigra* – buds
- *Primula veris* – leaves, flowers
- *Quercus robur* – bark
- *Ribes nigrum* – leaves
- *Symphytum officinale* – roots
- *Taraxacum officinale* – herb, roots
- *Tussilago farfara* – flowers, leaves
- *Urtica dioica* – leaves
- *Viburnum opulus* – bark
- *Viola tricolor* – grass

JUNE
- *Adonis vernalis* – grass
- *Angelica archangelica* – roots

- *Arctium lappa* – roots
- *Artemisia absinthium* – leaves
- *Asarum europaeum* – leaves
- *Betula pendula* – leaves, buds
- *Capsella bursa-pastoris* – grass
- *Carum carvi* – herb
- *Centaurea cyanus* – flowers
- *Centaurium erythraea* – grass
- *Convallaria majalis* – grass, leaves, flowers
- *Crataegus coccinea* – flowers, fruits
- *Dryopteris filix-mas* – rhizomes
- *Hyoscyamus niger* – leaves
- *Ledum palustre* – branches with leaves
- *Leonurus quinquelobatus* – grass
- *Matricaria recutita* (~*Chamomilla recutita*) – flower baskets
- *Melilotus officinalis* – herb
- *Menyanthes trifoliata* – leaves
- *Orchis* spp. – tuberous roots
- *Pastinaca sativa* – grass
- *Plantago major* – leaves
- *Polygonum aviculare* – grass
- *Taraxacum officinale* – herb, roots
- *Tilia cordata* – flowers
- *Tussilago farfara* – flowers, leaves
- *Urtica dioica* – leaves

AUGUST

- *Achillea millefolium* – grass
- *Acorus calamus* – rhizomes, grass
- *Angelica archangelica* – roots
- *Arctium lappa* – roots
- *Arctostaphylos uva-ursi* – leaves
- *Calendula officinalis* – inflorescence
- *Capsella bursa-pastoris* – grass
- *Carum carvi* – fruits
- *Centaurium erythraea* – grass
- *Crataegus coccinea* – flowers, fruits
- *Daucus carota* subsp. *sativus* – seeds, roots
- *Dryopteris filix-mas* – rhizomes
- *Epilobium angustifolium* – grass
- *Helichrysum arenarium* – inflorescence
- *Ledum palustre* – grass
- *Lycopodium clavatum* – spores, grass
- *Melilotus officinalis* – herb
- *Origanum vulgare* – grass
- *Petroselinum crispum* – grass, roots
- *Sorbus aucuparia* – fruits
- *Taraxacum officinale* – herb, roots
- *Tussilago farfara* – flowers, leaves
- *Urtica dioica* – leaves

- *Valeriana officinalis* – roots, rhizomes
- *Verbascum thapsiforme* – corollas of flowers
- *Viburnum opulus* – bark, fruits

SEPTEMBER

- *Achillea millefolium* – grass
- *Alnus incana* – cones
- *Angelica archangelica* – rhizomes with roots
- *Arctium lappa* – roots
- *Arctostaphylos uva-ursi* – leaves
- *Artemisia absinthium* – herb
- *Brassica oleracea* – leaves
- *Calendula officinalis* – inflorescence
- *Capsella bursa-pastoris* – grass
- *Carum carvi* – herb
- *Daucus carota* subsp. *sativus* – seeds, roots
- *Dryopteris filix-mas* – rhizomes
- *Equisetum arvense* – grass
- *Lycopodium clavatum* - spores
- *Matricaria recutita* (~*Chamomilla recutita*) – flower baskets
- *Petroselinum crispum* – grass, roots
- *Plantago major* – leaves
- *Polemonium caeruleum* – rhizomes with roots
- *Potentilla erecta* – rhizomes
- *Primula veris* – rhizomes with roots
- *Rhamnus cathartica* – fruits
- *Sorbus aucuparia* – fruits
- *Taraxacum officinale* – roots
- *Urtica dioica* – leaves
- *Vaccinium oxycoccos* (~*Oxycoccus palustris)* – fruits
- *Valeriana officinalis* – rhizomes with roots
- *Viburnum opulus* – fruits, bark
- *Viola tricolor* – grass

OCTOBER

- *Alnus incana* – cones
- *Angelica archangelica* – rhizomes with roots
- *Arctostaphylos uva-ursi* – leaves
- *Cichorium intybus* – roots
- *Dryopteris filix-mas* – rhizomes
- *Elymus repens* – rhizomes
- *Juniperus communis* – pine cones
- *Persicaria bistorta* – rhizomes
- *Potentilla erecta* – rhizomes
- *Primula veris* – rhizomes with roots
- *Rosa cinnamomea*- fruits
- *Rumex confertus* – rhizomes and roots
- *Taraxacum officinale* – roots
- *Vaccinium oxycoccos* (~*Oxycoccus palustris)* – fruits
- *Valeriana officinalis* – rhizomes with roots
- *Viburnum opulus* – fruits, bark

Supplement **B**

The most common medicinal plants of Ukraine, their use and protection

Type of medicinal plants	Medicinal plant raw materials	State of resources	Period of procurement egularity of medicinal plant raw materials (years)	
			in culture	in nature
Adonis vernalis L.	grass	1	1	3-5
Huperzia selago (L.) Bernh.ex Schrank et Mert.)	grass	1	1	6-7
Rhodiola rosea L.	rhizomes	0	1	7-10

Notes (State of resources):

3 – significant resources, the species does not need to limit harvesting;

2 – limited resources, the species needs to limit harvesting;

1 – very limited resources, the species requires strict harvesting limitations;

0 – there are no resources sufficient for harvesting.

Supplement **C**

Pharmacological action and use of plant raw materials, which contains primary metabolites (according to [Kovalyov and others])

Medicinal plant raw materials /Latin name of the plant	Pharmacological action	Active substances
Pharmacological action and use of plant raw materials, which contains homopolysaccharides and their derivatives		
Sources of cellulose		
Raw cotton fibers; Cotton – *Gossypium* spp., Malvaceae	Adsorbing, hemostatic	Cellulose Cellulose with an antibiotic
Cellulose derivatives – carboxymethyl cellulose (CMC)	Adsorbent of bacteria, toxins and hurt secretions	Viscose fabric treated with nitrous oxide 20% CMC + chlorhexidine
Sources of starch		
Potato tubers – Amylum Solani; *Solanum tuberosum,* Solanaceae	Enveloping, corrective	Homopolysaccharide, amylose and amylopectin
Wheat grain – Amylum Tritici; *Triticum* spp., Poaceae. Corn grain – Amylum Maydis; *Zea mays,* Poaceae.	Improves the rheological characteristics of blood	Oxyethylated amylopectin starch
Rice grain – Amylum Orizae; *Oryza sativa*, Poaceae	Drying	Starch, talc
Sources of inulin		

Jerusalem artichoke tubers (earthen pear) – Tubera Helianthi tuberosi; *Helianthus tuberosus,* Asteraceae. Chicory roots – Radices Cichorii intybi; *Cichorium intybus*, Asteraceae. The roots of delusion – Radices Inulae; *Inula helenium,* Asteraceae. Burdock roots – Radices Taraxaci; *Taraxacum officinale,* Asteraceae. Корені лопуха – Radices Bardanae (R. Arctii lappae); *Arctium lappa,* Asteraceae. Dahlia tubers – Tubera Dahliae variabilis; *Dahlia variabilis,* Asteraceae	Affects carbohydrate metabolism, particularly in diabetes, diagnostic tool	Fructana
Rhizomes and roots of purple echinacea– Rhizomata et radices; *Echinaceae purpureae, E.purpureae,* Asteraceae All Asteraceae medicinal plants	Immunostimulating, antioxidant, membrane stabilizing, anti-inflammatory	Fructans, phenolic compounds
Heteropolysaccharides (gums, mucus and pectin substances)		
Sources of gum		
Species of astragalus– *Astragalus* spp., subgenus *Tragacantha,* Fabaceae Species of acacia – *Acacia* spp., Fabaceae Ordinary apricot *Armeniaca vulgaris,* Rosaceae	Emulsifying, adsorbing, prolonging the action of other biologically active substances	A mixture of neutral and acidic polysaccharides, proteins and mineral salts
Guar (carob) seeds –*Cyamopsis tetragonolobus,* Fabaceae	Hypoglycemic, hypocholesterolemic, antihypertensive	Guar resin in the form of gel-forming fibers
Althea roots– Radices Althaeae; Althea herb – Herba Althaeae officinalis; Althea medicinal – *Althaea officinalis,* Malvaceae; Althea Armenian *Althaea armeniaca,* Malvaceae	Expectorant, anti-inflammatory, enveloping, emollient Enveloping, pain-relieving, reparative, protective for stomach diseases Expectorant	Mixture of polysaccharides, asparagine, betaine Mucus Mixture of polysaccharides
Flax seeds – Semina Lini; Common flax *Linum usitatissimum,* Linaceae	Enveloping, softening Weakening due to swelling and increase in volume	Mucus
Seeds of plantain – Semina Psyllii; Plantain *Plantago psyllium,* Plantaginaceae	Anti-inflammatory, emollient, slightly relaxing in chronic colitis	Mucus, cellulose from seeds

Egg-shaped plantain seeds – Semina Plantaginis ovatae; *Plantago ovata,* Plantaginaceae	Emollient	Mucus and cellulose of the seed coat
Leaves of large plantain – Folia Plantaginis majoris; Large plantain *Plantago major,* Plantaginaceae	Anti-inflammatory, expectorant, stimulating regenerative processes, antispasmodic, anti-ulcer at reduced acidity of gastric juice	Pectin substances, aucubin, flavonoids. Purified polysaccharide complex with a high content of uronic acids
Fresh plantain herb – Herba Plantaginis majoris recens; Fresh plantain herb – Herba Plantaginis psyllii recens; *Plantago* psyllium, Plantaginaceae	Anti-inflammatory, expectorant, stimulating regenerative processes, antispasmodic, anti-ulcer in case of reduced acidity of gastric juice and for the treatment of diseases of the upper respiratory tract	Iridoid aucubin, flavonoids, polysaccharides, vitamins, peptides
The leaves of the ordinary (mother-and-stepmother)– Folia Farfarae; Mother-and-stepmother *Tussilago farfara,* Asteraceae	Expectorant, anti-inflammatory	Mucus
Leaves of hybrid flint – Folia Petasites officinalis; Hybrid flint *Petasites hybridus,* syn. *P. officinalis,* Asteraceae	Expectorant	Inulin; sesqui- and triterpenoids, saponins, pyrrolizidine alkaloids, flavonoids
Wheatgrass rhizomes – Rhizomata Graminis; Creeping heather *Elytrigia repens,* Poaceae	Diuretic, diaphoretic, expectorant, regulating metabolism	Triticin fructan (up to 10%), free fructose (up to 4%), mannitol, meso-inosit, phenolic compound avenin, saponins, salts of K, Fe, silicic acid
Inflorescence of linden ("linden flower") – Flores Tiliae; Heart-shaped linden – *Tilia cordata,* Tiliaceae	Anti-inflammatory, enveloping, immunostimulating	A set of biologically active substances together with polysaccharides
Flowers of the wild – Flores Verbasci, Species of the wild – *Verbascum spp.*, Scrophulariaceae	Emollient, expectorant, antispasmodic	Mucus, pectins, monosaccharides, saponins
Chamomile flowers – Flores Chamomillae; Chamomile *Matricaria chamomilla,* Asteraceae	Anti-inflammatory, anti-ulcer	Complex of polysaccharides and flavonoids
Herb of the dark honeysuckle – Herba Pulmonariae obscurae; Dark honeydew *Pulmonaria obscura*, Boraginaceae	Expectorant	Dehydrated extract

Sources of pectin		
Fruits of the domestic apple tree – Fructus Mali domesticae; *Malus domestica,* Rosaceae Beet roots – Radices Betae vulgaris; *Beta vulgaris,* Amaranthaceae	Enterosorbent, gastroprotective, antacid, hypocholesterolemic	Pectic acid and its salts
Fig fruits (fig tree) – Fructus Fici caricae; *Ficus carica,* Moraceae	Relaxing, absorbing	Pectin substances
Plum fruits – Fructus Pruni domesticae; *Prunus domestica,* Rosaceae	Emollient, sorbing	Pectin substances
Medicinal enzyme preparations of plant origin		
Black seed – Semina Nigella; Black damask *Nigella damascena,* Ranunculaceae	Lipolytic, regulates digestive processes	Nigedase, nigedata-oraz
Papain – Papainum; Melon tree *Carica papaya,* Caricaceae	Proteolytic	Papain, lysozyme, chymopapain
Common watermelon – *Citrullus lanatus,* Cucurbitaceae	Hydrolyzes urea	Urease
Pharmacological action and use of plant raw materials containing lipids		
Non-drying fatty oils		
Olive fruit – Fructus Olivae; European olive *Olea europaea,* Oleaceae	Solvent for fat-soluble preparations; base for liniments; laxative, with gastric ulcer, gallstone disease	Glycerides of oleic acid
Almond seeds – Semina Amygdalae; Common almond *Amygdalus communis,* Rosaceae	Olive oil substitute	Glycerides of oleic acid
Peach seeds – Semina Persici; Common peach *Persica vulgaris,* Rosaceae	Olive oil substitute	Glycerides of oleic acid
Semi-drying fatty oils		
Sunflower seeds – Semina Helianthi; One-year sunflower – *Helianthus annuus,* Asteraceae	Weak choleretic; base for plasters; a solvent for medicinal substances	Mainly glycerides of linoleic acid, as well as oleic and saturated acids
Corn embryos – Embryonis Maydis; Common corn *Zea mays,* Poaceae	For the prevention of atherosclerosis and hypertension, weak choleretic	Glycerides of linoleic, oleic and saturated acids; vitamin E, phytosterols
Pumpkin seeds – Semina Cucurbitae; Common pumpkin – *Cucurbita pepo,* Cucurbitaceae	Hepatoprotective, choleretic, antisclerotic, reparative; with prostate adenoma	Glycerides of linoleic, oleic, linolenic acids, carotene, vitamin E, phosphatides
Walnut seeds – Semina Juglandis; Walnut *Juglans regia,* Juglandaceae	Immunomodulating, venotonic, capillary strengthening	Glycerides of linoleic acid, tocopherols

Drying fatty oils		
Flax seeds – Semina Lini; Common flax *Linum usitatissimum,* Linaceae	Hypocholesterolemic, reparative	Mainly glycerides of linoleic acid, as well as oleic, linoleic and saturated acids; in linetol - a mixture of esters of these acids
Fatty oils that contain specific acids		
Castor bean seeds – Semina Ricini; Common castor bean *Ricinus communis,* Euphorbiaceae	Laxative externally – for the treatment of trophic ulcers, seborrhea in the composition of ointments	Glycerides of ricinoleic acid, oleic, linoleic and saturated acids
Sources of phospholipids		
Soybean seeds – Semina Sojae; Bristle soybean – *Glycine hispida,* Fabaceae	Hepatoprotective, venotonic, correcting metabolic processes	Glycerides of linoleic and linolenic acids, phospholipids

Supplement D

Pharmacological action and use of LRS, which contains Tannins

Medicinal plant raw materials /Latin name of the plant	Pharmacological action	Active substances
Hydrolyzable tannins, halotannin group		
Sumac leaves – Folia Rhois coriariae; Tanning sumac *Rhus coriaria*, Anacardiaceae	Bactericidal, anti-inflammatory, reparative	Tannin
Leaves of sumac — Folia Cotini coggygriae; Common sumac *Cotinus coggygria*, Anacardiaceae	Anti-inflammatory, capillary-strengthening, reparative, astringent. Choleretic, hepatoprotective	Tannin, gallic acid The sum of flavonoids and tannins
Badan rhizomes – Rhizomata Bergeniae; *Bergenia crassifolia,* Saxifragaceae	Astringent, anti-inflammatory, regenerating	Tannins, catechins, bergenin (isocoumarin with residual gall acids)
Rhizomes and roots of the genus – Rhizomata et radices Sanguisorbae; *Sanguisorba officinalis*, Rosaceae	Anti-inflammatory, hemostatic	Tannins, gallic and ellagic acids
The rhizomes of the coil – Rhizomata Bistortae; Snake bitter gourd *Polygonum bistorta*, Polygonaceae	Astringent, anti-inflammatory, hemostatic	Tannins, gallic and ellagic acids
Hydrolyzable tannins, ellagotannin group		
Alder infructescence – Fructus Alni; Gray alder *Alnus incana*, sticky alder *Alnus glutinosa,* Betulaceae	Astringent, anti-inflammatory	Tannins, ellagic and gallic acids

Condensed tannins		
Oak bark – Cortex Quercus; Common oak *Quercus robur*, rock oak *Q. petraea,* Fagaceae	Astringent, anti-inflammatory	Tannins, gallic and ellagic acids, flavonoids
Foxglove rhizomes – Rhizomata Tormentillae; *Potentilla erecta* (*Potentilla tormentilla*),Rosaceae	Anti-inflammatory, astringent, reparative, wound-healing Choleretic	Tannins Gallic and ellagic acids
Blueberry fruits – Fructus Myrtilli; Blueberry leaves – Folia Myrtilli; Common blueberry *Vaccinium myrtillus,* Ericaceae	Astringent Hypoglycemic	Tannins Myrtilin
Cherry fruits – Fructus Radi; *Padus racemosa* (*Prunus padus*), Rosaceae	Astringent	Tannins
Tea leaves – Folia Theae; Chinese tea *hea sinensis* (*Camellia sinensis*), Theaceae	Anti-inflammatory, radioprotective, tonic	Tannins, catechins, flavonoids
The herb of common witch hazel – Herba Alchemillae; *Alchemilla vulgaris,* Rosaceae	Anti-inflammatory, hemostatic, antiseptic	Tannins, catechins, leucoanthocyanids, flavonoids
Rhizomes and roots of six-petalled viper – Rhizomata et radices Filipendulae hexapetalae; Six-petal viper (ordinary) *Filipendula hexapetala*, Rosaceae	Anti-inflammatory, astringent	Condensed tannins (up to 6%), phenolic glycosides (halterin), salicylic acid esters, flavones and chalcones

Supplement E

Chemical composition and biological effect of essential oils (according to [Kovalyov and others])

Medicinal plant raw materials /Latin name of the plant	Chemical composition	Pharmacological action
Essential oils that mainly contain terpenoids		
Rose essential oil – Oleum Rosae, *Rosa alba, R. gallica, R. damascena, R. centifolia,* Rosaceae	Geraniol (50–60%), citronellol (25–30%), nerol, citral, phenylethyl alcohol	Anti-inflammatory, antiseptic, anesthetic, antispasmodic, litholytic
Lemon essential oil – Oleum Citri (2–6 %), *Citrus limon*, Rutaceae	Limonene (70%), citral geranyl acetate, citronellol, γ-terpinene, myrcene, sabinene	Calming, hypotensive
Lavender essential oil – Oleum Lavandulae *Lavandula spica,* Lamiaceae	Complex esters of linalool and acids: acetic, butyric, valerian, caproic, as well as geraniol, citral, 1,8-cineole, camphor	Calming, antispasmodic, antimicrobial

Coriander essential oil – Oleum Coriandri, *Coriandrum sativum,* Apiaceae	Linalool (50–80%), terpinene, phellandrene, pinene, borneol, geraniol, geranyl acetate, camphor, carvone	Bactericidal, weak cytotoxic, choleretic, improves digestion, reduces flatulence
Peppermint essential oil – Oleum Menthae piperitae, *Mentha piperita,* Lamiaceae	Menthol (50–80%), menthone (20–30%), isomenthone, menthyl acetate, α-pinene, limonene, 1,8-cineole, pulegone	Antiseptic, antispasmodic, choleretic, antipyretic, secretolytic
Melissa essential oil – Oleum Melissae, *Melissa officinalis,* Lamiaceae	Hexane, β-pinene, limonene (30–50%), citronellal (15–25%), geranyl acetate, geraniol, β-citronellol	Sedative, antimicrobial
Essential oil of medicinal sage – Oleum Salviae, *Salvia officinalis,* Lamiaceae	Hexane, α- and β-pinene, camphene, sabinene, β-myrcene, limonene, 1,8-cineole, paracymene, camphor, sabinyl acetate, borneol	Bactericidal, antispasmodic
Rosemary essential oil – Oleum Rosmarini, *Rosmarinus officinalis, Lamiaceae*	α- and β-Pinene, camphene, limonene, cineol, borneol, camphor, linalool, terpineol, verbenol	Bactericidal, fungicidal, antioxidant
Eucalyptus essential oil – Oleum Eucalypti, *Eucalyptus globulus, E. cinerea, E. viminalis,* Myrtaceae	α- and β-Pinene, 1,8-cineole, paracymene, isofenchone, α-terpineol	Antiseptic
Essential oil of hops – Oleum Lupuli, *Humulus lupulus,* Cannabaceae	α- and β-Caryophyllene (humulene), myrcene, α- and β-selinene, α- and β-pinene, limonene, cineole, geraniol, linalool, farnesene	Antimicrobial, antispasmodic, hypotensive, sedative
Fir essential oil – Oleum Abietis, *Abies sibirica,* Pinaceae	Tricyclene, α- and β-pinene, camphene, Δ3-carene, limonene, β-phellandrene, bornyl acetate, borneol	Antiseptic
Pine essential oil – Oleum Pini, *Pinus sylvestris,* Pinaceae	α and β-Pinene (35–40%), camphene, carene (45–50%), β-myrcene, sabinene, limonene, β-phellandrene, α-terpinolene	Antimicrobial, antiviral, anesthetic
Purified turpentine essential oil (turpentine)– Oleum Terebinthinae, *Pinus sylvestris,* Pinaceae	α-Pinene (55–65 %), β-pinene (30–40 %), camphene β-myrcene, limonene, β-phelandrene, α-terpinolene, trans-caryophyllene	Local irritant

Juniper essential oil – Oleum Juniperi, *Juniperus communis,* Cupressaceae	α- and β-Pinene, sabinene, Δ3-carene, β-myrcene, α- and β-phellandrene, γ-terpinene, terpinen-4-ol, caryophyllene, α-terpineol	Diuretic, irritating, expectorant
Essential oil of yarrow – Oleum Calami, *Acorus calamus,* Araceae	Azarone, camphor, α- and β-pinene, camphene, β-elemene, α-calamene, acorone	Spasmolytic, choleretic, diuretic, anti-inflammatory
Essential oils containing aromatic compounds		
Cinnamon essential oil – Oleum Cinnamomi, *Cinnamomum verum, C. aromaticum, C. cassia,* Lauraceae	3-Phenyl-2-propenal (80–88%), eugenylacetate, cinnamic aldehyde, isocaryophyllene, α-pinene, terpinen-4-ol	Antiseptic, stimulates digestion, reduces flatulence
Clove oil – Oleum Caryophylli; *Syzygium aromaticum (=Caryophyllum aromaticus),* Myrtaceae	Eugenol (70–90%), α-humulene, trans-caryophyllene	Antiseptic, stimulates digestion
Essential oil of basil (cornflower) – Oleum Basilici, *Ocimum basilicum,* Lamiaceae	Eugenol (50–80%), ocimene	Bactericidal, immunomodulating
Essential oil of common thyme – Oleum Thymi, *Thymus vulgaris,* Lamiaceae	Thymol, carvacrol, camphene, limonene, γ-terpinene, paracymene, linalool, borneol	Antiseptic, expectorant
Essential oil of anise – Oleum Anisi, *Anisum vulgare,* Apiaceae	Trans-anethole (80–95%), limonene, hexane, β-pinene	Expectorant, reduces flatulence
Fennel essential oil – Oleum Foeniculi, *Foeniculum vulgare,* Apiaceae	Fenchon, trans-anethole (75–85%), α- and β-pinene, limonene	Bactericidal, fungicidal, antioxidant, expectorant, reduces flatulence
Dill essential oil– Oleum Anethi; *Anethum graveolens,* Apiaceae	α-Carvone (близько 60 %), apiol (about 60%), (up to 40%), flandrene, α-limonene, β-pinene, myristicin	Antispasmodic, reduces flatulence, improves digestion
Individual compounds extracted from essential oils		
Menthol – *Mentholum*		Soothing, pain-relieving, antispasmodic, antiseptic
Camphor– *Camphora*		Antiseptic, irritant, analgesic, cardiotonic, sedative
Thymol – *Thymolum*		Antiseptic

Eugenol – *Eugenolum*		Antiseptic, local irritant, anesthetic, antioxidant
Azulen – *Asulenum*		Antiseptic, reparative, anti-inflammatory

Addition **F**

Pharmacological action and use of plant raw materials containing alkaloids

The name of the plant material	Pharmacological action	Active substances
Biogenic amines and protoalkaloids		
Goat grass —Herba Galegae; *Galega officinalis*, Fabaceae	Hypoglycemic	Guanidine derivatives (galegin)
Capsicum fruits – Fructus Capsici; One-year capsicum *Capsicum annuum*, Solanaceae	Capsitrin irritantsTincture forstimulation of appetite and digestion	Capsaicinoids, glycoalkaloids, flavonoids
Ephedra herb – Herba Ephedrae; *Ephedra equisetina*, Ephedraceae	Vasoconstrictor, bronchodilator and antiallergic	Ephedrine
Bulbotubera –Colchici recens; *Colchicum speciosum*, Melanthiaceae	Antitumor	Colchamine
Alkaloids with condensed pyrrolidine and piperidine rings (Tropane alkaloids)		
Belladonna leaves – Folia Belladonnae; Belladonna herb – Herba Belladonnae; Belladonna roots – Radices Belladonnae; *Atropa belladonna*, Solanaceae	Spasmolytic and pain-relieving	Hyoscyamine, atropine, scopolamine
Black leaves – Folia Hyoscyami; *Hyoscyamus niger*, Solanaceae	External with neuralgia, rheumatism	Hyoscyamine, atropine, scopolamine
Datura leaves – Folia Stramonii; Common dope *Datura stramonium,* Solanaceae	Rubbing. External with neuralgia, rheumatism	Hyoscyamine and scopolamine
Dope seeds Indian – Semina Daturae innoxiae; Indian dope *Datura innoxia*, Solanaceae	Calming at seadisease, injection	Scopolamine, hyoscyamine, norhyoscyamine, methyloidin, pseudoatropin
Rhizoma ta Scopoliae carniolicae – Rhizomata Scopoliae carniolicae; *Scopolia carniolica*, Solanaceae	In psychiatry as sedative for parkinsonism, seasickness, in ophthalmology - instead of atropine	Hyoscyamine and scopolamine

Pyrrolizidine alkaloids		
Rhizomes with yellow-green roots – Rhizomata cum radicibus; *Senecio platyphylloides*, Asteraceae	Spasmolytic	Platyphyllin
Pyridine-piperidine alkaloids		
Leafless hedgehog herb — Herba Anabasidis Leafless; hedgehog *Anabasis aphylla*, Chenopodiaceae	Facilitates tobacco withdrawal	Anabazin
Lobelia bloated grass – Herba Lobelii; *Lobelia inflata*, Lobeliaceae	Removes nicotine withdrawal, analeptic	Lobelin
Quinolizidine alkaloids		
The grass of the thick-fruited sophora – Herba Sophorae pachycarpae; *Sophora pachycarpa,* Fabaceae	Ganglioblocker for spasms of peripheral vessels, obliterating endarteritis, myopathy, to stimulate labor	Pachycarpine, sophocarpine, sophoramin, gebelin, isosophoramine
Herb of lanceolate thermopsis – Herba Thermopsidis lanceolatae; Thermopsis seeds – Semen Thermopsidis; *Thermopsis lanceolata*, Fabaceae	Expectorant Breathing stimulator — reflexively excites the respiratory center in cases of respiratory arrest or asphyxia; strengthens the heart activity	Thermopsin, anagirin, homothermopsin, pachycarpine, methylcytisine; thermopsis lancin glycoside. The seeds contain 2–3% of alkaloids, of which about 0.6% of cytisine
Alternate-flowered thermopsis herb – Herba Thermopsidis alterniflorae; *Thermopsis alterniflora,* Fabaceae	Analeptic To facilitate nicotine withdrawal	Cytisine, pachycarpine, n-methylcytisine, thermopsin
Sekurinega shoots —Cormus Securinegae; *Securinega suffruticosa*, Euphorbiaceae	Stimulates the central nervous system, tonic at asthenic conditions, weakening of the cardiovascular system, impotence	Up to 0.4% of securinin, as well as sufruticodin, sufruticodin, allosekurinin
The grass of the ram's head is Herba Huperziae; *Huperzia selago*, Huperziaceae	For treatment chronic alcoholism; shows the emetic effect of	Alkaloids at least 0.4%: lycopodine, pseudoselagin, acrifoline
Quinoline alkaloids		
Henna bark – Cortex Chinae (Cortex Cinchonae); *Cinchona pubescens, C.calisaya, C.officinalis*, Rubiaceae	Antiprotozoal for treatment In the food industry as source of cinchotannic acid malaria	Quinine, quinidine, cinchonine and cinchonidine, as well as quinodubile acid, tetrahydroxy trachinones, quinovine glycoside, the

		aglycone of which is quinova acid
Isoquinoline alkaloids		
Boxes of poppy seeds – Capita Papaveris; Sleeping poppy – *Papaver somniferum*, Papaveraceae	Narcotic analgesic Antitussive action Antispasmodic and sedative	Morphine, narcotin, codeine, papaverine, thebaine
Poppies – Yellow cat grass – Herba Glaucii flavi; Poppy yellow *Glaucium flavum*, Papaveraceae	Antitussive agent – non-narcotic substitute for codeine	More than 15 alkaloids, biologically active – glaucine
Celandine grass – Herba Chelidonii; *Chelidonium majus*, Papaveraceae	Cholesterol, diuretic, pain-relieving, relaxing, antitumor	Cheledonine, homo-, methoxy-, oxycheledonine, chelerythrine, sanguinarine, protopine, berberine, sparteine
Macleay grass – Herba Macleayae; *Macleaya macrocarpa*, Papaveraceae	Antimicrobial, anticholinesterase	Sanguirithrine Sanguinarine, chelerythrine, protopine and allocryptopine
Barberry leaves – Folia Berberidis, Barberry roots – Radix; barberry – *Berberis vulgaris*, Berberidaceae	Hemorrhagic Bile-inducing	Berberine, oxiacanthin, berbamine, etc.
Tubers with roots smooth Stephania – Tubera cum radicibus; *Stephania glabra*, Menispermaceae	Sedative, mild hypnotic and hypotensive Anticholinesterase	Hyndarin, Stephaglabrin, Hyndarinin, Stephanin etc.
Victor's ungernia leaves – Folia Ungerniae victoris; *Ungernia victoris*, Amaryllidaceae	Anticholinester various	Galantamine and lycorine
Indole alkaloids		
Uterine horns – Secale cornutum ergot — *Claviceps purpure*a ergot, Clavicepitaceae; Class marsupial mushrooms – Ascomycetes	Uterotonic Calming, hypotensive, adrenolytic Suppresses prolactin secretion	Ergotamine, ergosine, ergostin, ergocristine, ergocriptine, ergometrine, as well as amines: histamine, tyramine, trimethylamine, choline, acetylcholine
The roots of the snake rauwolfia – Radices Rauwolfiae serpentinae; *Rauwolfia serpentina*, Apocynaceae	Hypotensive, calming, tranquilizing Antiarrhythmic	Reserpine, serpentine, aimaline, etc.
Small periwinkle herb – Herba Vincae minoris; Small periwinkle – *Vinca minor*, Apocynaceae	Hypotensive, improves blood supply to the brain	Vincamine (minrin), vinkamidine, vinoxin, vincin, vinkaminorin, etc.

The pink catharanthus grass is Herba Catharanthi rosei; *Catharanthus roseus,* Apocynaceae	Cytostatic, antitumor	Vincristine (vinca-leukocristine), vinblastine (vincaleucoblastin), catharanthine, vindoline, aimalicin, etc.
Passionflower grass – Herba Passiflorae Passionflower incarnate (flesh red) — Passiflora incarnata — Passifloraceae	Soothing	Garmin, harmol, Harman, Norharman, etc.
Chilibuha seeds (vomit nut) – Semen Strychni (Semen Nux vomicae); *Strichnos nux-vomica*, Loganiaceae	Stimulates the central nervous system Stimulates metabolism	Strychnine and brucine
Purine alkaloids		
Tea leaves – Folia Theae Chinese tea – *Thea sinensis*, Theaceae	Tonic and stimulating central nervous system, cardiac activity and breathing, antidote	Alkaloids: 1.5–3.5% caffeine, traces of theophylline
Coffee seeds – Semen Coffeae Arabian coffee – *Coffea arabica,* Rubiaceae	Stimulates the central nervous system, antidote for drug poisoning	Caffeine, theobromine, theophylline
Isoprenoid alkaloids Sesquiterpene alkaloids		
Rhizomes of yellow pitcher plants – Rhizomata Nupharis lutei; *Nuphar luteum*, Nymphaeaceae	Antimicrobial, contraceptive and anti-inflammatory	Nufaridines: nuphalein, nufarin, α- and β-nufaridine, nufamine, etc.
Diterpene alkaloids		
The grass of the net-fruited delphinium – Herba Delphinii dictyocarpae; *Delphinium dictyocarpum*, Ranunculaceae	Muscle relaxant (curare-like action) with increased muscle tones	Alkaloids: groups of atizine – methyllycaconitine, eldelin, elatin; groups of aconitine – condelphin
Delphinium grass confused - Herba Delphinii confuse; *Delphinium confusum*, Ranunculaceae	Muscle relaxant	Alkaloids of the aconitine group — condelphin
Dzungarian aconite herb fresh – Herba Aconiti soongorici recens Dzungarian aconite – *Aconitum soongoricum*, Ranunculaceae	Externally for sciatica	Alkaloids of the aconitine group — aconitine, of the atizine group — zongyrin, acetylzonyrin
White-lipped aconite herb – Herba Aconiti leucostomi; *Aconitum leucostomum*, Ranunculaceae	Antiarrhythmic	Lappaconitin, lappaconitin, mesaconitin, axin, etc.
Yew berry – *Taxus baccata,* Taxaceae	Cytostatic	Taxol Semi-synthetic compound

Steroidal alkaloids (glycoalkaloids)		
Nightshade grass lobed - Herba Solani laciniate; *Solanum laciniatum*, Solanaceae	Source of steroidal anti-inflammatory agents Externally atradiculitis, burns	Solasonin, sola-margin
Rhizomes with chervil roots – Rhizomata cum radicibus Veratri Lobel's chanterelle – *Veratrum lobelianum*, Melantiaceae	In veterinary medicine for combating skin parasites of animals	Yerverate alkaloids: yervin, iso-yervin, rubiyervin, isorubiyervin, etc.

Навчально-методичне видання

Кузьмішина Ірина Іванівна

Medicinal Plants and Medicinal Plant Raw Materials: Theory and Practice

[Лікарські рослини та лікарська рослинна сировина: теорія і практика]

Навчально-методичний посібник друкується в авторській редакції

Формат 60х84 1/16. Обсяг ____ ум. друк. арк., ___ обл.-вид. арк.
Наклад 100 пр. Зам. 126. Виготовлювач – Вежа-Друк
(м. Луцьк, вул. Шопена, 12, тел. 38 066 936 25 49).
Свідоцтво Держ. комітету телебачення та радіомовлення України
ДК № 4607 від 30.08.2013 р.