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BIOCHEMICAL ACTIVITY, SIGNIFICANCE, PROTECTION AND POSSIBILITIES OF APPLICATION OF NATURAL MATERIALS IN PHARMACY AND MEDICINE

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Abstract: Medicinal raw materials originating from nature are intensively used in pharmacy and medicine. The sources of the mentioned raw materials, which are designated as drugs in pharmacognosy, primarily include biological species, i.e., plants, animals, fungi, and microorganisms; however, raw materials of mineral origin are also used. Natural substances of biological and mineral origin differ in their biochemical activity and pharmacological effect on the human body. Accordingly, in pharmacy and medicine, the most attention is paid to medicinal plants, as well as to other biological species that are pharmacologically active. Meanwhile, medicinal raw materials of mineral origin are used to a lesser extent. Due to the presence of various biochemical substances, plants exhibit pronounced pharmacological effects on the human body. Thus, for example, numerous mechanisms of action of alkaloids have been proven, as the most pharmacologically active substances of plants. Alkaloids derived from herbal drugs act on the central and autonomic nervous systems, exhibiting anesthetic, cytostatic, cytotoxic, antiarrhythmic, antibacterial, and numerous other effects. Alkaloids are also carriers of the toxicity of herbal drugs. Flavonoid and phenolic heterosides, tannins, and other plant polyphenolic substances exhibit strong antioxidant, antimutagenic, and anticancer properties and are particularly important from the aspect of application in nutrition and prevention of cardiovascular and malignant diseases. Natural raw materials of animal origin are also used in pharmacy and medicine, such as collagen, which is obtained by partial hydrolysis of ligaments and cartilage of cattle, and is used in dermatology and cosmetology. In addition, the most important proteolytic enzymes used in dermatological and cosmetic preparations are most often of animal as well as bacterial origin. Given that minerals are necessary for the normal functioning of the body, natural mineral raw materials are also used in pharmacy and medicine. Studying and knowing the biochemical and pharmacological activity of natural raw materials contributes to the possibility of finding new drugs and their application in medicine. Considering the growing pollution of all components of the environment and endangering biodiversity, it is necessary to actively implement the protection of the very important natural raw materials. The paper discusses biochemical activity, importance, protection, and possibilities of application of natural raw materials in pharmacy and medicine.

Keywords: Raw materials, Biochemical activity, Pharmacy and medicine

INTRODUCTION

Medicinal raw materials of natural origin are widely used in pharmacy and medicine. The sources of these materials, which are called drugs in pharmacognosy, primarily include

biological species - plants, animals, fungi and microorganisms, but also raw materials of mineral origin. Despite the development of synthetic drugs, herbal drugs still occupy an important place in modern pharmacy. The increasing demand for natural medicines and therapy with fewer side effects has contributed to the increased interest in phytotherapy and herbal preparations. Natural remedies are used as auxiliary medicinal products in the treatment of chronic diseases, to strengthen the immune system, in the prevention of oxidative stress, as well as in dermatology. Herbal drugs also represent a significant basis for the research and development of new medicinal substances. Many modern active pharmaceutical substances (morphine, aspirin) originate from plant sources. In this context, research, development, and possibilities of application of phytotherapeutic preparations, standardized plant extracts, and supplements rich in biochemically and pharmacologically active substances are based on a combination of traditional knowledge and modern scientific achievements. Natural raw materials of animal, microorganism, and mineral origin are also significantly used, especially in dermatological and cosmetic preparations (Kovačević, 2004; Popović et al., 2021). In this paper, the biochemical activity, importance, protection, and possibilities of application of natural materials in pharmacy and medicine are considered.

MATERIAL AND METHODS

The paper employs data analysis methods collected from relevant studies. A systematic review of scientific literature was performed, focusing on biochemical properties, pharmacological activity, significance, and applications of natural materials in pharmacy and medicine. Scientific data published in journals, conference proceedings, and works authored by the authors (self-citations) were analyzed and processed.

RESULTS AND DISCUSSION

The use of herbal drugs, which are among the oldest foundations of health treatment and preservation, dates back to ancient civilizations. Herbal drugs are plant-based raw materials used to prepare medicinal products, typically in the form of dry, whole, chopped, or powdered plant parts. These raw materials contain biologically active compounds that have therapeutic or preventive effects on various diseases. Active components such as alkaloids, flavonoids, phenolic acids, saponins, tannins, glycosides, essential oils, and others, influence different body systems and can have analgesic, anti-inflammatory, antioxidant, antimutagenic, anticancer, antiseptic, antimicrobial, diuretic, spasmolytic, and many other properties. Herbal drugs usually come from wild or cultivated medicinal plants that are collected, dried, and processed according to good manufacturing and pharmaceutical standards. They are widely used in phytotherapy, the pharmaceutical industry, cosmetology, and dietary supplement production. The biochemical components of plants determine their pharmacological action and are vital for their therapeutic effects (Kovačević, 2004; Roy, 2017; Popović et al., 2021; Šarčević-Todosijević and Malivuk, 2019; Šarčević-Todosijević et al., 2024a; Šarčević-Todosijević et al., 2025).



Figure 1. *Taxus* sp., natural habitat, locality: the western part of Bosnia and Herzegovina (collection of authors)

The most important plant that produces alkaloids is the genus *Taxus*, whose species are intensively used in pharmacy and medicine. *Taxus* sp. in nature grows as a low tree or bush (Figure 1). All parts of the plant, especially the bark, contain a mixture of diterpene alkaloids, which are extracted. Biohemijaska aktivnost i mehanizam citostatskog dejstva zasnivaju se na vezivanju alkaloida za mikrotubule deobnog vretena, čime se sprečava njihova depolimerizacija u tubulinske dimere. Biochemical activity and the mechanism of cytostatic action are based on the binding of alkaloids to the microtubules of the mitotic spindle, which prevents their depolymerization into tubulin dimers. In addition to cytostatic, alkaloids originating from herbal drugs exhibit cytotoxic, antiarrhythmic, antibacterial, anesthetic, and numerous other effects. Also, they act on the central and autonomic nervous system (Jančić, 2004; Kovačević, 2004; Šarčević-Todosijević and Malivuk, 2019; Šarčević-Todosijević et al., 2019a; Heinrich et al., 2021).

Gao et al. (2024) analyzed the chemical composition, as well as the biochemical and pharmacological activity of species of the genus *Taxus*, which, due to their significant medicinal value, represent a central object of research in the fields of medicinal chemistry and botany. All parts of the plant are rich in phytochemical ingredients, which primarily contain paclitaxel and its derivatives, various alkaloids, and flavonoids. Analysis of different medicinal parts, including bark, fresh leaves, and seeds, has led to the identification of over 800 compounds. The leaves and branches are rich in flavonoid compounds, including kaempferol, aromadendrin, apigenin, sciadopitysin, ginkgetin, luteolin, quercetin, amentoflavone, and others. They also contain 4-hydroxy-benzaldehyde, p-hydroxybenzoic acid and pyrocatechol, as well as other phenolic compounds. The total extraction of flavonoids from leaves and branches is about 128.1 mg/g of dry weight. As products of the plant's primary metabolism, polysaccharides are present in different amounts in leaves and twigs, ranging from 1.1781 to 3.0115%, with an average content of 2.1367%. The molecular weight of these polysaccharides is about 59.2 kilodaltons (kD), with a ratio of rhamnose, arabinose, mannose, glucose, and galactose of approximately 4:6:1:1:4. The essential oil content varies, being higher in the leaves, making them the primary source for extraction. Using steam distillation and gas chromatography-mass

spectrometry (GC-MS) in the examination of the essential oils of leaves and twigs of the genus *Taxus*, 30 chemical components were identified. The authors conclude that species of the genus *Taxus* are characterized by significant and diverse pharmacological activities. In addition to cytostatic and anticancer properties, they also exhibit antibacterial, antidiabetic, anti-inflammatory, and antioxidant effects (Gao et al., 2024). In addition, Šarčević-Todosijević et al. (2019b) indicate the possibility of using this plant taxon in allelopathic relationships in plant cultivation, as a basis for biological control of pathogens and parasites, safe health plant production, and environmental protection.

Flavonoids and phenolic compounds, which are often found in the form of heterosides, represent an important group of secondary plant metabolites. Binding to sugar molecules affects their biochemical activity and pharmacological effectiveness. These substances exhibit numerous biochemical activities: antioxidant, anti-inflammatory, antimicrobial, anti-cancer, anti-allergic, and cardioprotective. Thanks to their ability to neutralize free radicals and reduce inflammatory processes, they belong to the group of natural bioactive compounds of particular importance for the prevention and treatment of chronic diseases. In pharmaceutical practice, herbal drugs with flavonoid and phenolic heterosides are used in various pharmaceutical forms: teas, tinctures, extracts, capsules, and tablets, as well as in dermal preparations. Some of the well-known representatives of herbal drugs include ginkgo leaf (*Ginkgo bilobae folium*), hawthorn leaf and flower (*Crataegi folium et flos*), *Solidaginis herba*, birch leaf (*Betulae folium*), linden flower (*Tiliae flos*), and many others, which are traditionally used as auxiliary medicinal agents (Sarić, 1983; Kovačević, 2004; Šarčević-Todosijević et al., 2024a,b; Šarčević-Todosijević et al., 2025). *Ginkgo biloba* L. is one of the most important plant species used in pharmacy and medicine. *Ginkgo biloba* L. (figure 2) is a deciduous tree and the only surviving representative of the once large Ginkgophyta group (Jančić, 2024). In phytotherapy, the leaf (*Ginkgo bilobae folium*) is used, most often in the form of standardized dry extracts (e.g., EGb 761), which are obtained by a controlled extraction process (Kovačević, 2004; Šarčević-Todosijević et al., 2024a).



Figure 2. *Ginkgo biloba* L., locality: Nova Pazova, Serbia (collection of authors)

Mohammadi Zonouz et al. (2024) state that chemical analyzes revealed that *Ginkgo biloba* contains hundreds of biochemically active metabolites, such as terpene-lactones, as well as bilobalide, then flavonols - quercetin, rutin, isorhamnetin, kaempferol glycosides and procyanidin B2. Due to its active compounds, *Ginkgo biloba* exhibits anti-inflammatory,

anti-apoptotic, anticancer, neuroprotective, cardioprotective, hepatoprotective, antiviral, antibacterial, pulmonoprotective, renoprotective, retinoprotective and other beneficial properties (Mohammadi Zonouz et al., 2024). The plant genus *Echinacea* is also a significant source of phenolic and flavonoid heterosides, which have antioxidant, anti-inflammatory, and immunostimulating effects. It is used in phytotherapy to strengthen the immune system and to prevent and alleviate colds and infections, as well as in the preparation of various herbal formulations (Kovačević, 2004). Manayi et al. (2015) stated that different classes of secondary plant metabolites, such as alkamides, caffeic acid derivatives, flavonoids, polysaccharides and glycoproteins are the main biologically and pharmacologically active constituents of *Echinacea* sp. Capek et al. (2015) state that numerous clinical trials have been conducted to test the efficacy of constituents isolated by different procedures from different species of the *Echinacea* genus, describe their active principles; however, the identification of all metabolites has not yet been completed. The authors further report that *E. purpurea*, *E. angustifolia*, and *E. pallida*, the three most studied *Echinacea* species, are particularly rich in pharmacologically active metabolites such as alkamides, polysaccharides, glycoproteins, phenylpropanoids, phenolic heterosides, and flavonoids, which are obtained from different plant parts, including roots, stems, leaves, and flowers. It has been demonstrated that these compounds are responsible for the observed immunostimulatory and anti-inflammatory activities. Immunomodulatory effects are mainly attributed to polysaccharides. They increase the chemotaxis of macrophages, stimulate the production of IL-10 (interleukin-10), IL-6 and IL-1- β , have an adjuvant effect on the cytokine responses of human T-cells and inhibit the growth of pathogenic fungi. The polysaccharide-phenolic complex also has an anticoagulant effect (Capek et al., 2015). Rutin, a flavonoid heteroside present in buckwheat (*Fagopyrum esculentum*), black elderberry (*Sambucus nigra*), horse chestnut (*Aesculus hippocastanum*) and many other plants, is one of the most researched natural antioxidants in the field of phytotherapy. Rutin prevents oxidative damage to lipids, proteins and DNA and contributes to the prevention of numerous chronic diseases (Kovačević, 2004; Šarčević-Todosijević et al., 2024a; Šarčević-Todosijević et al., 2025). Rahmani et al. (2022) state that the antioxidant, anti-inflammatory and anti-apoptotic properties of rutin have been scientifically proven. The authors emphasize the hepatoprotective, renoprotective and cardioprotective effects of rutin. The antioxidant effects of rutin are manifested by increasing the activity of antioxidant enzymes such as GST (glutathione-S-transferase - participates in the metabolism of glutathione, one of the most important antioxidants), GGT (γ -glutamyltransferase), CAT (catalase) and others (Rahmani et al., 2022). Ren et al. (2024) report that *Sambucus nigra* exhibits multiple biological activities, including antidiabetic, anti-infective, antineoplastic, and antioxidant effects. *Sambucus nigra* L. is a widespread deciduous shrub. The fruits are used in the food industry for the production of various types of dietary supplements (Kovačević, 2004). A commercial extract preparation, Sambucol®, has been used clinically in the treatment of viral respiratory infections. The main components responsible for the biochemical and pharmacological activities are phenolic compounds, such as simple phenolic acids, anthocyanins, and other flavonoids, as well as tannins. Ren et al. (2024) emphasize that dapagliflozin, an antidiabetic drug approved by the U.S. Food and Drug Administration (FDA), was developed from the hydrolysable tannin β -pentagalloylglucose, a secondary metabolite found in *Sambucus* species and other plants.

Due to their pronounced biochemical activity, herbal drugs play a significant role in the treatment and alleviation of respiratory disease symptoms. Plants used in the therapy of respiratory diseases exhibit various pharmacological effects, which include anti-inflammatory, antimicrobial, expectorant, and bronchodilator effects. Herbal drugs such as eucalyptus, thyme and liquorice have been proven to be effective in the treatment of various symptoms of respiratory diseases (Kovačević, 2004; Šarčević-Todosijević et al., 2019a). In addition, phytotherapy may help reduce side effects associated with the long-term use of pharmaceutical drugs. Many synthetic drugs, especially those that act as bronchodilators, can have side effects such as tachycardia, insomnia, or headache. Plants such as *Ephedra sinica* achieve a similar bronchodilator effect, without the side effects (Dousari et al., 2022). *Plantago lanceolata* L., a plant from the Plantaginaceae family, is often used in pharmacy and medicine as an expectorant, as well as to relieve inflammation of the mucous membrane of the mouth and throat. It exhibits antimicrobial, spasmolytic, and astringent activities. It is used externally for the treatment of injuries and wounds. *Plantago* sp. is a perennial herbaceous plant. It grows along roadsides, in settlements, and on meadows and clearings. The herbal drug is derived from dried leaves (*Plantaginis lanceolatae folium*). It is dried in a thin layer at 44-50°C. The leaf is slimy and bitter in taste, odorless. The leaf contains monoterpene iridoid heterosides. The most important are aucubin (2.5%) and catalpol. The drug is also rich in polyphenols, phenolic acid heterosides, coumarin (esculetin), flavonoids and tannins. It also contains saponins, mucilage, and silicic acid salts (Jančić, 2004; Kovačević, 2004; Petrović et al., 2022). Adom (2017) points out that antitussive, anti-inflammatory and antimicrobial effects are the key effects of *Plantago* sp. in the therapy of diseases of the respiratory system. Polysaccharides and iridoid glycosides, especially aucubin, are responsible for the anti-inflammatory effect on the mucous membrane of the respiratory tract. Flavonoids, such as luteolin and apigenin, act as antioxidants and mild bronchodilators, which can relieve asthma symptoms. The results of the study indicate that extracts of *Plantago* sp. exhibit antimicrobial activity against bacteria that cause respiratory tract infections, such as *Streptococcus pneumoniae* and *Haemophilus influenzae*. Animal studies and human observations have shown that syrups and extracts of *Plantago* species can reduce coughing and improve breathing in cases of acute bronchitis (Adom, 2017).

Although plants are used significantly more in pharmacy and medicine, materials of animal origin are also used in these fields. Animal drugs can be isolated from the animal organism by simple procedures. Fish oil, lard, beef tallow, lanolin, gelatin, and ambergris are most often used in pharmacy and medicine. Ambergris is a pathological, hardened mass obtained from the intestinal tract of the biological species *Physeter catodon*, Physeteridae. Ambergris has long been used in cosmetology and perfumery because of its pleasant aroma and its fragrance-fixing properties. The main ingredients are coprosterol, coprostanone, and triterpene alcohol ambrein (25%). The largest quantities of ambergris are obtained from killed animals. The collection of ambergris is regulated by the "Marine Mammal Protection Act", and its trade is illegal today. Proteolytic and amylolytic enzymes of plant, animal, and microorganism origin are intensively used in cosmetic preparations, as well as for therapeutic purposes. Bromelain is a complex of proteolytic enzymes from the fruit of *Ananas comosus* (Bromeliaceae) and is used as an anti-inflammatory and anti-edematous agent. Protein complexes from plants and marine organisms are increasingly used in dermatology and cosmetology. They are important due to diseases affecting livestock, whose tissues (such as ligaments and cartilage) are used to obtain collagen. Collagen is a

polypeptide that makes up about 70% of connective tissue, as well as skin, bone and tooth tissue. In dermal preparations, it forms a protective film, enables hydration of dry skin and contributes to its elasticity. It is obtained by partial hydrolysis of the ligaments and cartilage of cattle. The results of conducted scientific research suggest that hydrolyzed collagen (HC) supplementation may have a positive effect on skin health. However, further large-scale randomized controlled trials are needed to confirm these findings (Kovačević, 2004; Popović et al., 2021; Pu et al., 2023).



Figure 3. *Ovis* sp. and ecosystems of xerophilous meadows and pastures, locality: Manjača, Bosnia and Herzegovina (collection of authors)

Bee products are intensively used in nutrition, dietetics, pharmacy, medicine, and cosmetology. Bee products are: honey, royal jelly, pollen, bee venom, beeswax, and propolis. There is great interest in the use of bee products in medical practice, and a new branch of medicine, apitherapy, has even been established. The importance of bees is not limited to their products, which are valuable both nutritionally and medicinally. Bees are responsible for 87.5% of the pollination of plants of the Magnoliophyta division, which is especially important in agricultural production. Due to the intensification of agricultural production, climate change and environmental pollution, it is necessary to develop sustainable strategies that will ensure safe food production. In this sense, the importance of bees in the pollination of Magnoliophyta, and consequently in achieving higher yields of fruits and seeds, especially of cultivated plants, is increasing. Without bees, there would be a decrease in the number of Magnoliophyta and a disruption of the ecological balance in the entire biosphere (Oljača, 2008; Šarčević-Todosijević et al., 2023a,b,c). In addition, Popović et al. (2023) report that the world economy is reduced by 212 billion dollars due to the mass death of bees, and 30% of bee colonies in the USA and about 20% in EU countries have already been destroyed. Bee losses due to pesticide poisoning are rising each year. Most pesticides registered for agricultural use do not pose significant risks to bees, but only when populations are exposed to individual compounds. However, their combination, especially insecticides and acaricides with fungicides, is more toxic to bees than the individual compounds. Insecticides weaken bees' resistance and promote the development of diseases, such as increased susceptibility to the parasitic species *Nosema ceranae*. The risk of pesticides to bees can be reduced by applying insecticides in the evening, when bees are inactive. It has even been suggested to place beehives on house rooftops as a measure to help prevent the decline of bee populations (Popović et al., 2023).

Mineral substances are essential for the structure and proper functioning of the body, which is why natural mineral raw materials are widely used in pharmacy and medicine. Numerous plant species, such as birch, nettle, yarrow, beans and seaweed, are important sources of these substances and are used to treat conditions resulting from their deficiency in the body.

In pharmacy and medicine, plants are used most frequently, although other biological species are also utilized, while medicinal raw materials of mineral origin are used to a lesser extent. Natural inorganic raw materials used in pharmacy and cosmetology are chalk, diatomaceous earth, clay, kaolin, and talc. Clay is a colloidal substance of sedimentary origin. Pure clay, or combined with plant materials and plant extracts, is used in cosmetic masks. Sterilized kaolin can be used as an adsorbent in the treatment of gastrointestinal diseases. More commonly, it is used in dermatology in the form of a powder or paste. Talc is a white, soft mineral powder, composed of magnesium silicate with water. It is used in cosmetics as a protective and absorbent agent; it is the basis of powder (Kovačević, 2004; Kovačević, 2009; Popović et al., 2021; Šarčević-Todosijević et al., 2022).

Intensive environmental pollution, climate change, and the rise in global average temperatures represent a serious threat to biodiversity and ecosystems, which are the only sources of food, oxygen, but also materials necessary for the progress of pharmacy, medicine, and other areas of human activity. Preserved biodiversity, especially plant diversity, helps mitigate climate change by absorbing carbon dioxide from the atmosphere. That is why the protection of biodiversity is one of the key conditions for preserving the stability of the planet and ensuring a sustainable future for humanity (Šarčević-Todosijević et al., 2023c; Šarčević-Todosijević et al., 2024b).

CONCLUSION

Biodiversity provides key natural resources and materials for the technological progress of various industries, with plants having particularly great economic and health importance. Thanks to their biochemical and pharmacological activity, plant taxa and their metabolites, as well as natural substances of animal and mineral origin, are widely used not only in medicine and pharmacy, but also in agriculture and environmental protection. That is why the protection of plant and animal species, as well as abiotic components of the ecosystem, is a priority for the survival and further progress of humanity.

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