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An Overview of Medical Uses and Chemical Composition of *Arctium tomentosum* Mill.

Alibek Ydyrys[1, 2, 3]

Abstract

The objective of this study is to present current and important scientific data regarding the traditional, dietary, phytochemical, and biological functions of *Arctium tomentosum*. The geographical spread was also examined. PubMed, Web of Science, and Science Direct were used as various search engines to conduct the thorough literature search. This study emphasized the significance of *Arctium tomentosum*, an edible herb with a wealth of therapeutic benefits and great nutritional value. *Arctium tomentosum's* anticancer, hepatoprotective, antidiabetic, hypoglycemic, antioxidant, anti-microbial activities were demonstrated in preclinical studies, supporting the clinical significance of plant-derived bioactive compounds for the treatment of various diseases. In this regard, this review highlights fresh insight into the medicinal use, chemical composition, pharmacological properties, and safety profile of *Arctium tomentosum's* to guide future works to thoroughly estimate their clinical value.

Keywords: *Arctium tomentosum*; Medical uses; Phytochemistry; Pharmacological properties; Chemical composition.
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1. Introduction

Arctium tomentosum, also in Kazakh language referred to as "Oshagan or Kiyz Shongaina", also known as woolly burdock, is a perennial herbaceous plant that belongs to the *Asteraceae* family.[1] It is native to Asia and Europe but has spread to other parts of the world, including North America. The plant has been used for centuries in traditional medicine to treat various ailments. *Arctium tomentosum* is known for its medicinal properties, including its diuretic, anti-inflammatory, antimicrobial, antioxidant, and detoxifying effects. This review article aims to provide a comprehensive overview of the scientific research on *Arctium tomentosum* and its potential health benefits.[2]

This plant originated mostly from European and Asian, such as Altay, Austria, Baltic States, Belarus, Belgium, Bulgaria, Central European Rus, Czechoslovakia, Denmark, East European Russia, Finland, France, Germany, Greece, Hungary, Irkutsk, Italy, Kazakhstan, Kirgizstan, Krasnoyarsk, Krym, Mongolia, Netherlands, North Caucasus, North European Russi, Northwest European R, Norway, Poland, Romania, South European Russi, Spain, Sweden, Switzerland, Tadzhikistan, Transcaucasus, Tuva, Ukraine, Uzbekistan, West Siberia, Xinjiang, Yakutskiya, Yugoslavia.[3]

The majority of the information from these research highlighted the excellent antirheumatoid, anti-gout, anti-inflammatory, immunomodulatory, and antioxidant effects that Arctium species have, all of which help to protect joints. It has also been shown to be very effective in the treatment of cancer, jaundice, stomach disorders, snakebites, diabetes, liver and kidney issues, wounds, diuretic, libido, pulmonary diseases, hypotension, blood purification, allergic rhinitis, prostate disorders, hemorrhoids, galactagogue, and as a depurative. The use of these species for exorcism, postcalving care, sprains, bone fractures, hematuria, neck sores, and yolk sores has also been documented.[4,5]

From prehistoric time, *Arctium tomentosum* has been consumed by ancient Egyptians and Romans for several

[1] *Key Biomedical Research Centre, Al-Farabi Kazakh National University, Al-Farabi ave. 71, 050040, Kazakhstan.*
[2] *The Elliott School of International Affairs, George Washington University, 1957 E St NW, Washington, DC 20052, USA.*
[3] *Scientific Research Institute for Issues in Biology and Biotechnology, Al-Farabi Kazakh National University, Al-Farabi ave. 71, 050040, Kazakhstan.*
**Email:* ydyrys.alibek@gmail.com, alibek.ydyrys@kaznu.kz, alibek05@gwu.edu.kz (A. Ydyrys)

health-promoting benefits.[6] Traditionally, *Arctium tomentosum* was used for the treatment of various diseases like asthma, tumors of the uterus, ulcers, hemorrhoidal haemorrhage, coughing, wounds, dermatomycosis, dysmenorrhea, sciatica, and nasal polyps. The seeds of this species have been utilized as a galactagogues and abortive agent and were also used to treat sore throat, headache, cough, asthma, malaria, syphilis, and impotence.[7,8] A seed paste prepared in water was used for skin problems and sunburns while the mucus of seeds was used against diarrhoea and irritation of the intestines in dysentery, and germinating seeds were used for constipation. The leaves of *Arctium tomentosum* are diuretic, mildly stimulant, and also used in liver problems and scorbutic diseases.[9]

Arctium tomentosum is also known as the woolly burdock or downy burdock[10] Philip Miller first described the genus in 1768.[11] The floral bracts beneath their hooked ends were covered in a thick layer of cobwebby hairs, which distinguishes woolly burdock from other burdocks (Arctium). The stems of woolly burdock are used in traditional European medicine.[12]

2. Methodology

The following scientific databases were searched: PubMed/MedLine, Scopus, Web of Science, ScienceDirect, Google Scholar, Springer, and Wiley using the following MeSH terms: "Biological Products/pharmacology," "Drug Discovery/methods," "Ethnopharmacology, Medical," "Traditional/methods," "Arctium /chemistry," "Plant Extracts/pharmacology," and "Phytochemicals/chemistry", "Phytochemicals/pharmacology", "Plants, Medicinal".

Inclusion requirements: (i) pertinent works that comprised contemporary pharmacological investigations, phytochemistry, and traditional usage (ii) research that comprised in vitro and in vivo tests as well as possible mechanisms of action (iii) English, Kazakh, Russian, Chinese -language papers. Exclusion criteria include: (i) duplicate and incomplete information; (ii) abstracts; (iii) letters to the editor; (iv) experiments employing linked homeopathic medications. The plant's chemical components were discovered, and Chem Spider and PubChem were used to confirm their IUPAC designations, structural formulas, and chemical formulas. According to WFO, the plant's taxonomy has been verified.

3. Botanical Features and Geographical Location

Arctium tomentosum is a herbaceous, biennial shrub. With ascending limbs, the stem is upright. It has a 6-7 in maximum height. The leaves are green and glabrous toward the stalk and are a grayish-white color and quite felted. Petiolate leaves are on the base. Heart-shaped leaf blades with more denticulate edges are present. They can grow to be 7.9–19.7 in long and 10.9–11.8 in wide. Flowers are reddish-purplish and range 0.35–0.47 in width. Because of the white woolly hairs on the underside of the leaves, this species can be differentiated from closely related ones. From July to September, flowers and fruits start to emerge.[13]

Burdock, or burdock (Arctium) is a genus of plants of the family Asteraceae with subulate-pointed and hooked leaves at the ends. The generic name Arctium comes from the Latinized Greek name arcion, or arceion and arktion. Some of them live in humid and shady forests and were never found in dry conditions.[14,15] According to the database The Plant List, the genus Arctium includes 19 species.[16]

The range of the genus is extensive, burdocks were found in the Russian Federation, Siberia and Central Asia, Europe, the USA, Uruguay, Argentina, the Himalayas, China and Japan. Researchers attribute this to the ability of plants to travel long distances, clinging to animal fur and clothing with their hooked leaves.[17] According to the data given in Flora Kazakhstan (2012), there are 2 species of the genus burdock - smooth seed burdock (*Arctium leiospermum*), felt burdock (*Arctium tomentosum*).[18] Oak burdock grows in deciduous and mixed forests, forest clearings and forest edges, along the banks of water bodies and among shrubs in the geographical regions of the European part of Russia.[19] Burdock Palladina is a weed plant and, along with weedy meadows and garbage places, is found in forests, along the banks of rivers in all regions of the Caucasus.[20] Thus, species of the genus Arctium grow in different ecological conditions, forming significant thickets suitable for harvesting.[21,22] However, we have not found scientific data on the actual state of stocks of raw materials of wild-growing species of the genus Arctium in the literature. There was a single information "on sufficient thickets of great burdock in the Altai Territory, the productivity of the roots of which in dense thickets was 730–790 kg/ha, in sparse thickets 350–460 kg/ha".[23] Some authors emphasize the expediency of introducing burdock into cultivation due to the difficulty of harvesting roots in a non-mechanized way and "responsiveness" to the applied agrotechnical measures, which consists in the formation of sufficient biomass, in a much shorter time than under natural conditions in nature.[24] Morphological and anatomical analysis of the fruits of *A. tomentosum* made it possible to identify the diagnostic features of this raw material. Narrow ovoid shape. The surface of the achenes was wavy with a longitudinal rib in the center. Seed color was light brown to dark brown. Striped spotting was pronounced. Wavy outline of the cross sections of the fetus due to unevenly developed mesocarp. Rectangular or

rhombic cells of the exocarp from the surface. The presence of an amorphous layer between the meso and endocarp, containing an accumulation of single crystals of calcium oxalate of a prismatic or rhombic shape. On the cross section, the achene of *A.tomentosum* is oval. The main volume of the cut is the fetal cavity occupied by the seed embryo. The embryo often falls out during analysis. The surface of the pericarp of the achene is unevenly wavy due to the mesocarp of the fruit shell. The burdock achene has a weakly expressed endosperm represented by living cells with drops of fatty oil.[25,26]

4. Plant growth

Many wild plants have ample reserves of raw materials in nature, but the rapid loss of forest land caused by anthropogenic pressure, unplanned development and excessive use of cultivated plants contributes not only to a decline in their number but also to the extinction of any species in nature,[27] a decline in species diversity,[28] and the extinction of endemism.[29] As a result, growing medicinal plants in botanical gardens or agricultural fields is an alternative strategy for obtaining more raw materials.[30] Many scientists were currently working to cultivate medicinal plants in a variety of methods,[31] such as by growing and preserving them organically without the use of fertilizers or agricultural chemicals. As an alternative, cultivating therapeutic plants using fresh agricultural biogums.[32] Growth is a key sign of a plant's capacity to adapt to its environment.[33] In this research, the types of metals and their concentrations had a significant impact on the growth of *A. tomentosum*. Root elongation was typically blocked in solutions with low metal concentrations (1.0 or 10 M) and high metal concentrations (1.0 mM and above). With the exception of Ni, almost all of the metals under investigation had root lengths that were comparable to the control. *A. tomentosum* root development was severely hampered by an increase in the concentration of all metals in the growth medium. The most poisonous Pb and Zn ion solutions were 10 millimolar concentrations. Unlike the roots, the shoot length of *A. tomentosum* seedlings tended to inhibit shoot development at very high concentrations of metal. Some concentrations have stimulated the development of shoots. Therefore, compared to below-ground sections, the growth of above-ground parts was more metal-resistant. Notably, a key determinant of plant development is the dry mass of the plant.[34] According to Anjum *et al*.'s review, some metals, such as Cu, Zn, or Ni, were regarded as important trace elements whose excess or deficiency can harm plant development.[35]

The interplanar spacing (Fig. 1) was 0.35 nm, which corresponded to the (002) plane of graphite. It's worth mentioning that no Co nanoparticles were observed from SEM and TEM observations. This was also true in our current research, where the accumulation of shoot biomass was nearly halted at both the lowest and highest metal concentrations (aside from Ni). The biomass accumulation in connection to water control was not significantly inhibited by any treatments, though. The optimum concentration to induce the accumulation of shoot biomass was found to be 0.1 mM for all metals. Metals generally had a stronger impact on changes in shoot biomass than they did on changes in root biomass. Currently, many scientists were engaged in the cultivation of medicinal plants in various ways,[36,37] for example, growing and storing them in the system of organic farming without the use of fertilizers and agricultural drugs. Alternatively, growing medicinal plants using new biogums was used in agriculture.[38]

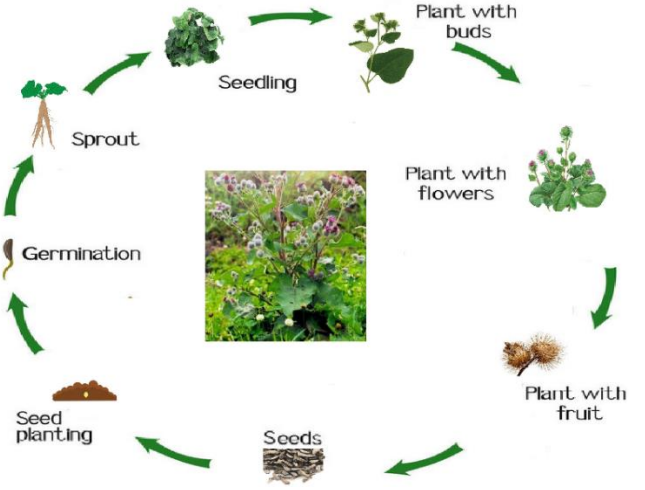

Fig. 1 Growth cycle of Arictum L.

5. Phytoconstituents

The European Medicines Agency's monograph mentions *Arctium tomentosum* as a variety that can provide an alternative plant material to *Arctium lappa*-Arctii radix (Bardanae radix).[39] There were no comparative studies on the activity of both species, despite the fact that in the available sources the activity of woolly burdock extracts was similar to the activity of greater burdock extracts.[40] *A. tomentosum* extracts' molecular makeup has not yet been extensively studied. It has been established that extracts from its seeds contained arctiin and arctigenin.[41] Few flavonoids (derivatives of kaempferol, quercetin, luteolin, and apigenin), chlorogenic acid, lupeol 3-acetate, and 3-O-glucoside were extracted from methanolic extracts of *A. tomentosum* leaves and inflorescences (Fig. 2). Furthermore, the concentration of phytosterols, tocopherols, and -amyrin was measured in lipophilic extracts, and the fatty acid composition was investigated.[42]

Arctium tomentosum resembles *Arctium lappa* in

appearance, but the flower head was heavily coated in cobwebby hairs. It and larger burdock were interchangeable terms in conventional medicine. It has a diuretic impact, eases stomach discomfort, and is used to treat skin inflammations. *Arctii radix* (Bardanae radix), according to the European Medicines Agency's monography, has historically been used as a diuretic in conditions of the urinary system, as a stimulant of gastric secretion in cases of temporary lack of appetite, and as a treatment for seborrheic skin conditions. It can be produced from related species, hybrids, or mixtures of *Arctium lappa*, *Arctium minus*, and *Arctium tomentosum*. In light of this, a comparison of the chemical makeup and biological activity of extracts from *Arctium lappa* and *Arctium tomentosum* aerial parts and roots, gathered from various natural locations in southeast Poland, was made.

Derivatives of the isomers of dicaffeoylquinic acid were also found in the aerial portions of *Arctium tomentosum*. In the examined extracts, derivatives of kaempferol and quercetin predominated among flavonoids. Chlorogenic acid, the hexoside and malonylhexosides of quercetin, and the hexoside and malonylhexosides of kaempferol showed the highest peaks. The concentrations of chlorogenic acid, dicaffeoylmaloylquinic acid, and dicaffeoylsuccinoylquinic acid were the most prevalent in the roots of both species.

Arctium tomentosum extracts' chemical makeup has not yet been extensively studied. The presence of arctiin and arctigenin in fruit extracts has been verified. Few flavonoids (derivatives of kaempferol, quercetin, luteolin, and apigenin), chlorogenic acid, lupeol 3-acetate, and -sitosterol 3-O-glucoside were recovered from methanolic preparations of A. tomentosum leaves and inflorescences. Additionally, the concentration of phytosterols, tocopherols, and -amyrin was evaluated in lipophilic extracts, and the fatty acid composition was investigated.[43]

In light of the aforementioned, this research makes the hypothesis that Arctium ecotypes showing a notable tolerance to multiple metals in soils may be candidates for metal phytoremediation schemes. Here, it was intended to investigate *A. tomentosum*'s reaction to various metals in an experimental setting. In addition to analyzing the metal buildup in the roots, stems, and leaves of *A. tomentosum*, biochemical characteristics (such as superoxide production, lipid peroxidation, and total peroxide content, collectively known as oxidative stress biomarkers) and growth characteristics were also.

6. Oxidative stress biomarker status in multi-metal-exposed *A. tomentosum*

According to Gill and Tuteja, A plant's level of oxidative stress was decided by the production of activated oxygen species, peroxides, and damage brought on by oxidation's byproducts (such as LPO damage to membrane lipids, for example).[44] The most easily produced reactive oxygen species in plant cells was the superoxide anion. It was unstable, and plants' levels of it were constantly fluctuating. O2 levels were low in a normal environment, but they drastically increase when biotic or abiotic stressors were present.[45]

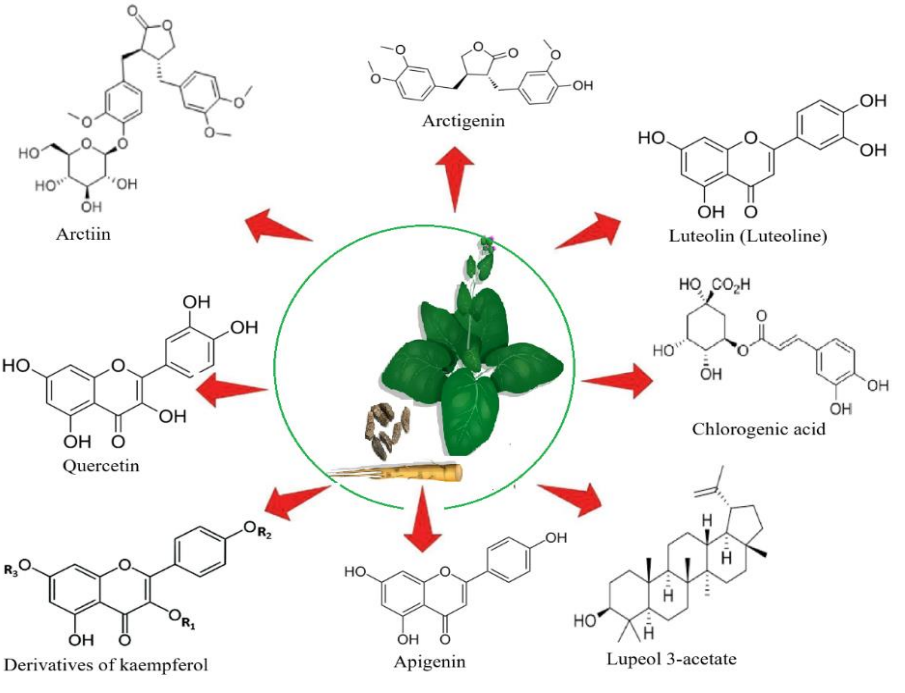

Fig. 2 Chemical structure of the important bioactive compounds from *Arctium tomentosum*.

The amount of superoxide in *A.tomentosum* leaves increased in most treatments in direct proportion to the concentration of a metal in the growth medium. Superoxide levels were 3.5 or 2.5 times lower than the control in liquids containing Ni or Zn ions, respectively. One could contend that *A. tomentosum* seedlings were well-suited to resist Zn and Ni ions. Cu and Zn ions significantly increased the concentration of total peroxides, another oxidative stress biomarker, from 2.9 to 4.7 folds with all the examined concentrations of these metals. In plant feeds, phytic acid and its salt form, phytate, account for 60%–80% of total phosphorus. Because phytate is a polyanionic molecule, it can chelate positively charged cations such as calcium, iron, and zinc.[46]

The lowest concentrations of total peroxides (on the control level) were observed in the presence of Ni or Pb in the seedlings' growth medium. The levels of total peroxides and superoxides in plant tissues have been considered as major biomarkers of oxidative stress in metal-exposed plant types. Notably, usual plant exposure and their differential response to multiple metals (in isolation and/or in mixture) have been credibly reported in earlier studies.[47]

7. Pharmacological activities

The most studied species of the genus Arctium was greater burdock (739 references in the Scopus database), followed by lesser burdock (67 references), felted burdock (40 references), smooth seeded burdock (4 references), oak burdock (2 references), Palladina burdock. Biological activity of total extracts and metabolites of species of the genus Arctium L. The biological activity of species of the genus Arctium has been studied to varying degrees, for example, to date, in the available literature and international citation databases, there was no information on the pharmacological activity of one of the species growing on the territory of the Russian Federation - smooth seed burdock, there were few publications about oak burdock, Palladin's burdock, felted burdock and small burdock. There was no information on the activity of other species: *Arctium atlanticum, Arctium debrayi, Arctium leiobardanum, Arctium neumani, Arctium platylepis, Arctium pseudarctium, Arctium sardaimionense, Arctium scanicum*. In the review by N. Mamedov *et al*. provides an analysis of plants of the flora of Central Asia, which were used in prescription and over-the-counter pharmaceuticals for the treatment of allergic rashes, skin irritations, boils, wounds, dermatitis and pyoderma, including oak burdock, Palladina burdock, felt burdock, large burdock, lesser burdock.[48]

Arctium tomentosum has been studied extensively for its potential medicinal properties. One of the most well-known uses of the plant was as a diuretic. It has been shown to increase urine output and help with conditions like edema and high blood pressure. In addition to its diuretic properties, *Arctium tomentosum* has also been found to have anti-inflammatory and antioxidant effects. These properties make it useful for treating conditions like arthritis and other inflammatory diseases. Some studies have also suggested that *Arctium tomentosum* may have antimicrobial properties. It has been shown to be effective against certain strains of bacteria, including Staphylococcus aureus, which was a common cause of skin infections. Like any herbal remedy, it can interact with other medications and may not be appropriate for everyone. As with any supplement or medication, it was best to consult with a healthcare professional before using *Arctium tomentosum*. *Arctium tomentosum* was a versatile plant with a wide range of potential health benefits. Its diuretic, anti-inflammatory, antioxidant, antimicrobial, and detoxifying properties make it a promising candidate for treating a variety of health conditions (Fig. 3). However, more research is needed to fully understand its effects and ensure its safety.[49]
The ointment of Arctium is an effective remedy in the treatment of many diseases: anal fissures, hemorrhoids, various types of wounds, proctitis, polyposis of the rectum and nasal cavity, as well as a number of other diseases that require the removal of pain and inflammatory reactions.[50] The effectiveness of the ointment is ensured by the selection of the components that make up its active part, and their quantity. In particular, the roots and rhizomes of elecampane contain a complex of biologically active substances, which includes essential oils, alantolactone, and various levorotatory polysaccharides. Celandine leaves contain alkaloids, carotene, vitamins; flowers of toadflax common glucosides, linaracrine, phytosterol, various acids and other substances; flowers of fumes chemist's were mainly alkaloids. Spider burdock also has a strong anti-inflammatory, anti-constipation, anti-edematous effect. The main target of licopide in the body is the cells of the monocyte-macrophage system. Licopid increases the activity of lysosomal enzymes, the formation of reactive oxygen species, the absorption and killing of microbes, leads to an increase in the synthesis of interleukin - 1 and the expression of HLADR antigens on monocytes, which leads to the stimulation of the humoral and cellular immune response.[51]

By stimulating the activity of monocytes and macrophages, licopid affects the three main links of immunity: phagocytosis, cellular and humoral immunity. Licopid improves microcirculation, which ensures an increase in the concentration of neighboring drugs in the focus of infection. At the same time, licopid increases the sensitivity of microorganisms to antibacterial drugs, reduces their toxic

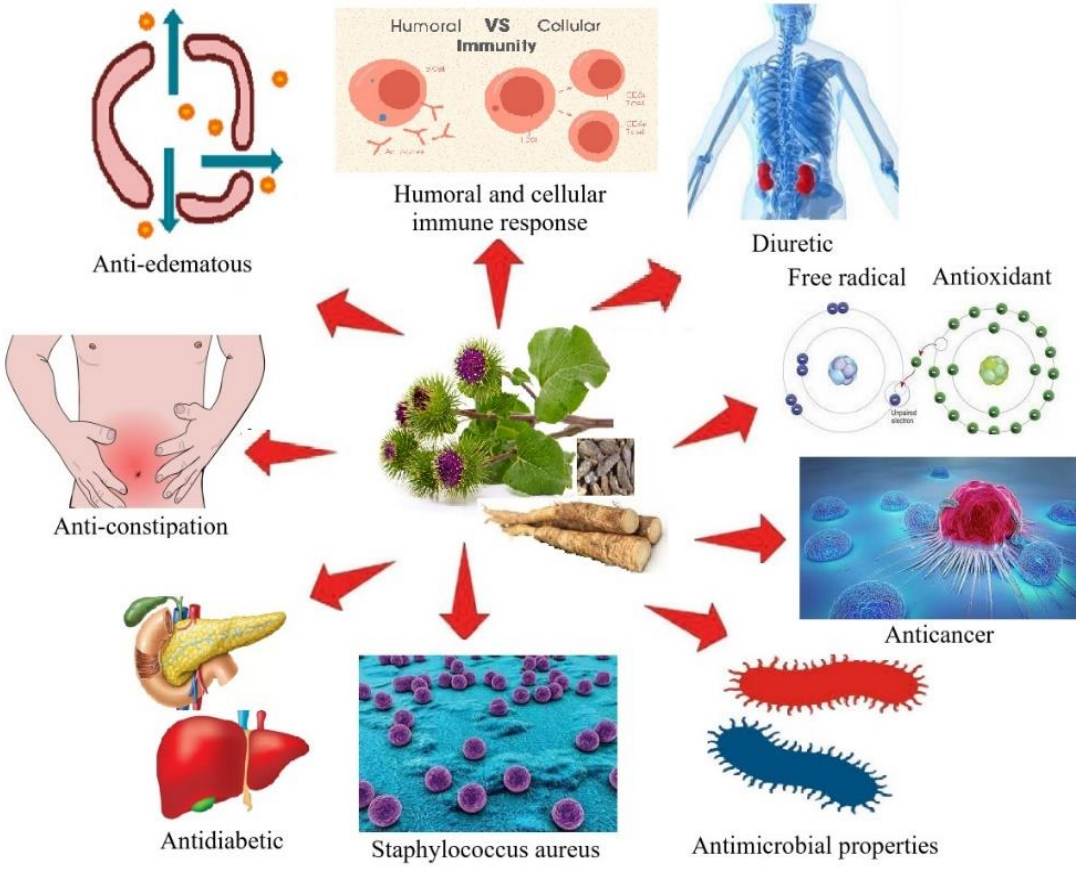

Fig. 3 Various application of *Arctium tomentosum.*

effect and activates the production of interferon. Thus, the complex, combined use of components of plant origin, containing a large number of substances that were diverse in their activity, together made it possible to obtain a therapeutic drug that has an immunostimulanting, wound healing, anti-inflammatory effect, which was the basis for its widespread use in the treatment of many diseases. At the same time, the ointment contains components in such quantities that, when used together, provide the most pronounced therapeutic effect, and the fatty base used contributes to the effective release of active components and their rapid absorption.[52]

As a result of the studies, the presence in the object of simple phenolic compounds of the C6 and C6 -C1 series was revealed, which confirms the literature data. In addition, the amount of falavonoids (1.2%) was found. Comparison with standards and spectral characteristics of water-alcohol extracts led to the conclusion about the aglycone nature of the detected flavonoids, probably of the flavanol group.[53]

By extrapolating the experimentally obtained data on transpiration by plants for the entire calendar year, taking into account the absence of evaporation from the plant surface during the cold season.[54] Thus, when the claimed plants were used for biodrainage during the reclamation of solid waste landfills, the amount of moisture consumed by plants exceeds the amount of atmospheric precipitation remaining after evaporation from the soil surface, that is, it exceeds the amount of available moisture for the climatic conditions.[55] At the same time, the resulting moisture deficit allows plants to consume the entire flood volume of water on the surface of the waste mass. It can be concluded that the use of cobwebbed burdock (Arctium), as well as narrow-leaved fireweed as plant crops leads to a significant change in a significant expenditure item of the water balance - evaporation. It has been experimentally proven that with the help of the above plants, it was possible to significantly reduce the amount of toxic filtrate formed. At the same time, it was experimentally established that the plants recommended by the current regulatory documents for the biological stage of reclamation of solid waste landfills have practically no effect on the water balance of the solid waste landfill and do not allow reducing the amount of leachate formed after the landfill was closed. The level of transpiration of these plants during the warm period of the year is from 85 to 120% of the annual precipitation layer. Thus, the claimed method allows to compensate for the penetration of atmospheric precipitation into the soil in the post-operational period of the life cycle of the landfill and, therefore, to reduce the amount of toxic formed to the minimum possible during waste destruction.[56]

7.1. Traditional Uses

Arctium tomentosum has been used for centuries in traditional medicine to treat a variety of ailments. In Kazakhstan, it is known as "Oshagan" or “Kiyz Shongaiana” and has been used to treat colds, sore throats, and fever. In Korea, it is called "Udeungcho" and has been used to treat skin diseases, inflammation, and hypertension. In Europe, it has been used as a diuretic, a digestive aid, and a remedy for skin conditions like acne and eczema.

The use of burdock as a source of food and medicine dates back several millennia. The roots, due to their sweet taste, were baked, fried, stewed, used in cooking soup (instead of potatoes), in the production of confectionery, bread, fritters, marmalade, jam, marmalade, alcoholic beverages, fried roots were used instead of chicory.[57] Burdock is most widespread in Asian countries. So, in China, burdock is known as "lupan" and can often be found on the stalls of vegetable shops. Here it is eaten raw, added to various dishes, baked bread.[58] In Japan, great burdock is cultivated as an important crop used for garnishing, soups, functional foods, specialty human foods, animal feed supplements, fertilizers, plant protection products, and more.[59] The annual production of burdock was 200 thousand tons, but even such a huge amount does not cover the needs of the Japanese, who were forced to import this raw material from Australia, the Philippines, China, and Vietnam. Burdock was also cultivated in France and Belgium for the needs of the domestic market, as in these countries it was considered an exquisite delicacy.[60] Since ancient times, burdock oil has been used to strengthen and nourish hair, as well as a remedy for lice, rashes, lichen, and trophic ulcers. Fresh leaves of burdock in Russian folk medicine were used for burns, rashes, itchy skin, eczema, ulcers and dermatitis, mold lesions of the mouth and eyes. Juice, decoctions were used for gout, to stimulate metabolism, treat arthritis and arthrosis, articular rheumatism, gout, sciatica, bad breath, urolithiasis, stomach ulcers. The antibacterial properties of burdock were used for sore throats, syphilis, inflammation of the mucous membranes of the genital organs, initial forms of diseases of the upper respiratory tract, inflammation of the mucous membranes of the mouth, gums, throat, due to the antiparasitic effect, they were used for worms.[61] In folk medicine of the Kazakh, a decoction of burdock roots was used for constipation, delayed menstruation, and skin diseases.[62] Traditional medicine has accumulated experience in the treatment of prostate adenoma and other oncological diseases with fresh juice, herbal preparations of burdock roots, leaves, inflorescences. In folk medicine in India and Germany, burdock is considered a blood-lymph purifier.[63] In Brazilian folk medicine, burdock roots were used as an antibacterial agent.[64] In Tibetan, Bulgarian folk medicine, burdock roots were recommended for use in tumors, the presence of kidney and bladder stones, gastritis, stomach ulcers, and to stimulate metabolism.[65]

In Central Asia medicine, a decoction of the roots is used for rashes, kidney stones, rheumatism, and gout. In China, the seeds and roots of burdock are used for insect bites and poisonous snakes, edema, hemorrhages, boils, and also as a choleretic, diuretic.[66] In the official medicine of Russia, several types of burdock are allowed for harvesting and use - large burdock - *Arctium lappa* L., spider web (felt) burdock - *Arctium tomentosum* Mill., small burdock - *Arctium minus* (Mill.) Pharmacopoeia article on the roots of which was in the State Pharmacopoeia of Russia XIV edition.[67] In Kazakh medicine, fresh roots of greater burdock (*Arctium lappa* L.), harvested in the autumn of the first year or in the spring of the second year before flowering, are used to obtain pharmacopoeial homeopathic preparations, several domestic manufacturers produce powdered burdock roots as a medicine, which are recommended as a diuretic, choleretic, and anti-inflammatory agent. A number of foreign companies produce various types of products based on burdock. Also, burdock was included in the Milk Thistle Complex complex dietary supplement manufactured by Kyzyl may, which includes an extract of milk thistle seeds, dandelion roots and burdock.[68] In Kazakhstan and some neighboring countries, several manufacturers (Fitoleum LLP, SANTO LLC, Phytochemistry LLC, Lazurin LLC, Nobel Pharmsanoat LLC, Alkimyogar Farm LLC, Altai Grass LLC) produce 100% burdock root oil (burdock oil), oil with various additives (calendula and hops, ginkgo biloba, nettle extract, string, propolis, horsetail extract (with ceramides), tea tree extract, lecithin, nettle and chamomile, red pepper extract), tea drinks with burdock root, juice from aerial burdock parts.[69] Burdock is of great value as a honey plant. Thus, the study of nectar, sugar and honey productivity of felt burdock led to the conclusion that there is no competition of pollinating insects for plant nectar.[70] Burdock seed oil can be used in soap making as a substitute for glycerin, in the production of high quality drying oil. The successful experience of using burdock in folk medicine for a wide range of diseases could not but attract the attention of researchers from different countries to the study of the chemical composition and pharmacological properties. However, as the analysis of international citation databases shows, they have been studied to varying degrees.

7.2 Anti-inflammatory and Antimicrobial Properties

One of the most well-known uses of *Arctium tomentosum* is as a diuretic. A diuretic is a substance that increases urine output

and helps to remove excess fluids from the body. *Arctium tomentosum* has been shown to have diuretic effects in several studies. For example, a study published in the Journal of General Virology found that a water extract of *Arctium tomentosum* had significant diuretic effects in rats.[71] Another study published in the Plants found that *Arctium tomentosum* increased urine output in rats and had a mild blood pressure-lowering effect. These findings suggest that *Arctium tomentosum* may be useful for treating conditions like edema and high blood pressure.

Experimental studies of different years have shown that the tincture of Arctium in all models of ulceration exhibits a pronounced gastroprotective effect, reduces the level of pepsin in gastric juice, accelerates the evacuation of intestinal contents,[72] and the extract from achenes leads to significant changes in the functional activity of the stomach and an increase in protective properties. epithelial mucosal layer of the small intestine.[73] Extracts from burdock exhibit antimutagenicity, anticarcinogenicity, and antiaging, may originate from the antioxidant ability of its component[74]; leaf extract exhibits high wound healing activity, pronounced antiexudative and antiproliferative effects in chronic inflammation models, and moderate anti-inflammatory activity in animals with acute inflammation. An ethanolic extract of the roots exhibits analgesic activity.[75]

Several works of different years are devoted to the study of the antibacterial activity of burdock. A group of Turkish scientists studied in vitro the immunomodulatory activity of extracts that are statistically active in tests for neutrophil chemotaxis and random migration, and also reduce the amount of active radicals.[76] Anti-inflammatory, antinociceptive, antioxidant activity was studied in a comprehensive study of ethanol and aqueous extracts of leaves. The authors of the study concluded that crude burdock seed extract could be used as an adjuvant for gout to reduce pain due to irritants.[77] Some scientists in the study of burdock root decoctions on inbred goto-kakizaki (GK) rats with type 2 diabetes mellitus concluded that the decoction was contraindicated in this pathology. After a 4-week administration, decoctions were found to have no significant effect on glycemic control, and long-term use caused a deleterious effect on cellular metabolism (significant reduction in mitochondrial respiration rates (RCR and FCCP stimulated respiration).[78,79] The pharmacological activity of this species is the most studied. Several studies have studied the antimicrobial activity of the extract, the dry residue of the aqueous extract, the essential oil, the resinous substances of the roots and leaves against gram-negative bacteria.[80] The results showed the possibility of using burdock for the disinfection of dental canals; dosage forms with a regenerative, deodorizing and anti-inflammatory effect, drugs for the treatment of gastroenterological, gynecological, dermatological diseases, diseases of the upper respiratory tract with a pronounced antibacterial effect were proposed.[81] Leaf juice was effective in purulent-septic processes caused by gram-negative bacteria.[82] In several works, the antioxidant activity of aqueous and hydroalcoholic extracts from roots and individual substances was studied in vitro and in vivo. It has been established that chlorogenic and caffeic acids were inhibitors of lipid peroxidation processes, while the destruction of acids as a result of heat treatment of raw materials leads to a decrease in the antioxidant properties of extracts.[83-85]

Extraction complexes from roots and leaves of *Arctium* on various models of liver damage exhibit high hepatoprotective activity, while the authors associate the hepatoprotective effect of extracts with antioxidant activity.[86] In liver damage caused by chronic exposure to ethanol, carbon tetrachloride, and acetophene, extracts from the roots significantly improve various biochemical parameters, protecting hepatocytes from toxic effects.[87] Water, ethanol extracts of fruits reduce the production of histamine and pro-inflammatory cytokines (interleukin (IL)-1c, IL-6, IL-8, TNF-b in mast cells). Both extracts and arctigenin inhibit Maps and NF-kB phosphorylation in activated mast cells. Root tea, arctigenin, and arctiin exhibit anti-inflammatory properties in animal experiments and in clinical studies on patients with osteoarthritis.[88] It has been experimentally shown that extracting from the roots inhibits the development of the tumor process, which makes it possible to use it in combination with chemotherapy for the treatment of malignant neoplasms; arctiin and arctigenin, isolated from fruit extract, have a cytotoxic effect on human tissue culture of the Hep G2 line and Chang hepatocytes; fractions of the juice and methanolic extract of the roots also have antitumor properties.[89]

The methanolic extract of burdock roots has an antimutagenic effect, blocks the formation of neoplasts in mouse hepatoma cells by inducing the marker enzyme quinone reductase, and can be used to prevent cancer.[90] The immunostimulating properties of the root juice were studied on rats subjected to emotional stress, irradiated with a sublethal dose of ionizing radiation. The authors revealed in animals leukopenia, lymphocytosis, an increase in antibody-forming cells in the spleen, a decrease in the phagocytic activity of neutrophils, a decrease followed by an increase in the functional activity of T-lymphocytes, an increase in the concentration of immune complexes in the blood serum, an increase in the activity of some enzymes of energy and purine metabolism, a decrease in the number of lymphoid cells in the

bone marrow, an increase in their number in the thymus and lymph nodes of the small intestine.[91] There was evidence that regular consumption of the roots in the evening contributes to the maintenance of a healthy gut microbiota.[92] Burdock roots have promising antidiabetic activity, which was manifested by improved glucose homeostasis and reduced insulin resistance. In one of the reviews of Chinese scientists, information was provided on the discovery of compounds with antioxidant and antidiabetic properties in the roots. Certain compounds in the seeds have anti-inflammatory and strong inhibitory effects on the growth of tumors such as pancreatic cancer. Substances with antibacterial activity, inhibiting the growth of microorganisms in the oral cavity, were isolated from the leaf extract. The same review reports on the medicinal use of burdock for the treatment of diabetes and AIDS. The authors also provide information on the side effects of burdock - contact dermatitis and other allergic / inflammatory reactions.[93] Injections of a hydroalcoholic extract of burdock in in vivo experiments reduce tumor growth and increase the survival rate of mice. The results obtained suggested that burdock extract regulates the migration and activation of immune cells, which correlates with a favorable outcome in a model of acute inflammation and melanoma progression.[94]

The study of the pharmacological properties of burdock was not limited to the study of the activity of total complexes; in some works, only individual substances of a polysaccharide, lignan, and phenolic nature were studied.[95] The polysaccharide fraction of burdock leaves exhibits antioxidant activity.[96] Arctiin has the potential to sensitize colorectal cancer cells by activating autophagy, which induces apoptosis and inhibits cell growth.[97] Lignan isolated from burdock, arctigenin inhibits the growth of stomach, lung, liver, and colon cancer cells. Lappaol F and arctiin of burdock leaves have similar properties. Due to estrogenic properties, burdock seed arctigenin inhibits metastasis processes in breast cancer. Arctigenin has antioxidant and anti-inflammatory activity.[98] The cytotoxicity of arctiin, arctigenin, and other burdock seed lignans has been proven in experiments in vitro and in vivo on cell cultures and transplanted tumors.[99] One study showed that arctigenin exhibits 100% cytotoxicity during forced starvation of tumor cells.[100] Experimental studies on animals have shown that alcohol extracts have a stimulating effect on the processes of spermatogenesis. Arctigenin prevents damage to nerve cells by amyloid and ethyl alcohol. Appointment of burdock extracts prevents damage to the testicular apparatus and liver by cadmium salts. Arctiin from seeds has been shown to be effective in experimental glomerulonephritis by protecting the urinary system from Schistosoma haematobium damage, thereby preventing the development of bladder cancer. When applied externally, Arctiin improves skin trophism and prevents the formation of wrinkles. Clinical studies have shown that burdock has a therapeutic effect on acne vulgaris.[101] Randomized, placebo, controlled clinical trials have shown that burdock seed mucus has a therapeutic effect on dry, itchy, and burned skin. Arctiin has radioprotective properties. Pectic substances, acidic arabinogalactans have the ability to bind atherogenic low-density lipoproteins in blood serum, which may indicate a possible antiatherosclerotic effect.[102]

The mono- and dicaffeoylquinic acids contained in the leaves of burdock have antiulcer activity.[103] Scientists from China have for the first time determined the in vitro and in vivo antitumor activity of lappaol F, which has a strong inhibitory effect on the growth of tumor cells depending on time and dose in human cancer cell lines of various types of tissues, and a minimal cytotoxic effect on the tested non-morbid epithelial cells.[104] Burdock root inulin was used for the prevention and treatment of diabetes mellitus and normalization of pancreatic function.[105] Burdock smooth seed. In different years, in this form, researchers reported the discovery and isolation of a sesquiterpene lactone, the lignan glycoside arctiin.[106] When studying seed lipids by GC, it was found that the main ones were acylglycerides of common fatty acids and oxygenated fatty acids.[107]

Ascorbic acid, lactones, alkaloids, carotenoids, coumarins, flavones, essential oil, resinous and tannins were also found in this form.[108] An early study of *Arctium tomentosum* reported the discovery of bioflavonoids. The mature, dry fruits of *Arctium lappa* L. were known as Arctii Fructus (Niubangzi in Chinese). Natural lignans from Arctii Fructus may prevent P-gp from functioning. Furthermore, UGTs were inhibited by arctiin and arctigenin. Palmitic and linoleic acids and their ethyl esters were found in the fatty oil of the leaves. The lignans arctigenin and arctiin were isolated from the methanol extract of the leaves.[109] The leaves, according to liquid chromatography-mass spectrometry, contain several mono- and dicapheoylquinic acids. Burdock, and among the groups of burdock biologically active substances were lignans, polyacetylenes, fatty oils, hydroxycinnamic acids and their derivatives, polysaccharides, amino acids. The results of studying the chemical composition of great burdock in different growing seasons demonstrate significant differences in the content of biologically active substances, which requires additional studies of the pharmacological action of raw materials and possible changes and additions to the current pharmacopoeial monograph on burdock roots and instructions for their medical use. The results of studying the pharmacological activity of extractive preparations and some

individual compounds of various types of burdock show the promise of their further study, and the creation of medicines, parapharmaceutical and other types of products on their basis.[110] Plant groups contain many beneficial nutrients and bioactive compounds. These compounds exhibit antimicrobial, anticancer, antidiabetic, antiplatelet aggregation, and anti-inflammatory activities.[111] However, while the antimicrobial properties of some polymers have been extensively investigated, the biocidal properties of natural products are often overlooked.[112,113] The recognition that these natural products have beneficial effects on cancer treatment has sparked researchers' interest in conducting more comprehensive studies to explore the use of herbal medicine for anticancer purposes.[114] Most of the studies on the anticancer potential with the corresponding mechanisms were still in the experimental preclinical stage and were missing evidence from clinical trials to support the research.[115] Traditional plant-based remedies rich in phytochemicals have been used against human cancers and phenolic compounds were known for their chemopreventive properties. One of the most important compounds that exhibit a wide range of biological activities with especially strong antioxidant action are plant polyphenols.[116-119]

8. Safety, Drug-Drug Interaction, and Adverse Effect

Burdock may help persons with type 2 diabetes lower their blood sugar levels. Blood sugar levels are also reduced by diabetes medicines. Burdock consumption combined with diabetes treatments can result in dangerously low blood sugar levels. Monitor your blood sugar levels closely. Your diabetes medication may need to be taken at a different dose.

There was not enough reliable information available about the safety of taking burdock while pregnant or breast-feeding. Burdock can delay clotting. Burdock consumption could make bleeding more likely for those with bleeding problems. Those who are allergic to members of the Asteraceae/Asteraceae family may experience an allergic reaction to burdock. Ragweed, chrysanthemums, marigolds, daisies, and numerous more plants were members of this family. Before using burdock, make sure to see your doctor if you have any allergies. It is safe to eat burdock in Kazakhstan. when taken in quantities typically found in foods. Burdock's safety at therapeutic levels cannot be determined based on the available data. People who allergic to particular flowers and plants may experience an allergic reaction after consuming burdock. If administered to the skin, it might lead to a rash. One of the unique properties of *Arctium tomentosum* is its ability to bind to heavy metals and other toxins in the body. This makes it useful for detoxifying the body and protecting against environmental toxins. Despite its many potential benefits, it is important to note that *Arctium tomentosum* should be used with caution.[120]

9. Conclusions and Perspectives

In conclusion, *Arctium tomentosum* appeared as the most reported species when summing the ethnopharmacological studies on the usage of *Arctium tomentosum*, offering a rich source of active principles for creating novel therapeutic approaches. The current research has revealed that *Arctium tomentosum* has renowned pharmacological potentialities, including anti-inflammatory, anticancer, antioxidant, antidiabetic, antimicrobial, and an-tiviral effects that correlate, on the one hand, with some traditional uses and, on the other hand, with the bioactive phytochemicals present, including phenolic compounds. This is despite its ancient use by people from different cultures and in different regions for the treatment of various ailments. However, there is currently a sizable gap in in vivo studies and clinical trials using plant-based remedies or isolated phytochemicals from *Arctium tomentosum*, which must be addressed quickly in order to open new doors for preventive, therapeutic, and agro-industrial uses. According to the project of author "Comprehensive studies of some promising medicinal plant species from the Asteraceae family for industrial development", in the future, to compile maps on the distribution of the *Arctium tomentosum*, to determine the raw material supply, productivity, to conduct anatomical and morphological studies, biologically active in the vegetative and generative organs scientific research work is carried out, such as determining the localization of substances, conducting serial experiments on testing acute and chronic toxicity of the obtained chemical fractions on experimental animals. In this way, it is determined that the resources of *Arctium tomentosum* will be efficiently used, raw materials will be increased, and bioactive natural compounds obtained (depending on their activity) will be used as medicines, nutritional supplements or ingredients for the treatment of various diseases.

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Conflict of Interest

There is no conflict of interest.

Supporting Information

Not applicable.

References

[1] Illustrated determinant of plants of Kazakhstan, Science Alma-Ata, 1972, **2**, 386-387.

[2] G. Guna, Therapeutic value of arctium lappa Linn. - a review, *Asian Journal of Pharmaceutical and Clinical Research*, 2019, 53-59, doi: 10.22159/ajpcr.2019.v12i7.33870.

[3] W. Skowrońska, S. Granica, M. Dziedzic, J. Kurkowiak, M. Ziaja, A. Bazylko, Arctium lappa and arctium tomentosum, sources of arctii radix: comparison of anti-lipoxygenase and antioxidant activity as well as the chemical composition of extracts from aerial parts and from roots, *Plants*, 2021, **10**, 78, doi: 10.3390/plants10010078.

[4] S. P. M. Fischer, I. Brusco, C. Camponogara, M. Piana, H. Faccin, L. A. Gobo, L. Machado Carvalho, S. M. Oliveira, Arctium minus crude extract presents antinociceptive effect in a mice acute gout attack model, *Inflammopharmacology*, 2018, **26**, 505-519, doi: 10.1007/s10787-017-0384-6.

[5] G. R. Romualdo, E. dos Anjos Silva, T. C. Da Silva, T. P. A. Aloia, M. S. Nogueira, I. A. De Castro, M. Vinken, L. F. Barbisan, B. Cogliati, Burdock (*Arctium lappa* L.) root attenuates preneoplastic lesion development in a diet and thioacetamide-induced model of steatohepatitis-associated hepatocarcinogenesis, *Environmental Toxicology*, 2020, **35**, 518-527, doi: 10.1002/tox.22887.

[6] European Medicines Agency, Community Herbal Monograph on Arctium lappa L., Radix, Amsterdam, The Netherlands, 2010, 44, EMA/HMPC/246763/2009.

[7] A. Ozarowski, W. Jaroniewski, Rośliny lecznicze a ich praktyczne zastosowanie, Inst. Wyd. Zwiazkow zawodowych, 1987.

[8] Y.-C. Wu, L.-F. Lin, C.-S. Yeh, Y.-L. Lin, H.-J. Chang, S.-R. Lin, M.-Y. Chang, C.-P. Hsiao, S.-C. Lee, Burdock essence promotes gastrointestinal mucosal repair in ulcer patients, *Fooyin Journal of Health Sciences*, 2010, **2**, 26-31, doi: 10.1016/s1877-8607(10)60010-0.

[9] R. S. Boev, Substance with cytostatic and apoptosis-inducing activity from burdock roots, *Chemistry for sustainable development*, 2005, **1**, 119-122.

[10] USDA, NRCS (n.d.). Arctium tomentosum, Nat. Plan. Data Team., 2016.

[11] Flora of North America, Woolly burdock, bardane tomenteuse, Arctium tomentosum Miller, 19, 169.

[12] D. Daniela, Herrera-Balandrano, Effect of *in vitro* gastro-intestinal digestion on the phenolic composition and antioxidant capacity of Burdock roots at different harvest time, *Food Chemistry*, 2021, **358**, 129897, doi: 10.1016/j.foodchem.2021.129897.

[13] Flora of Kazakhstan. Alma-Ata, 1956-1966, 1-9.

[14] De Materia Medica by Dioscorides Pedanius, https://hdl.loc.gov/loc.wdl/wdl.10632.

[15] M. Tanga, Yield and morphological characteristics of Burdock (*Arctium lappa* L.) in response to mineral fertilizer application, *Asian Journal of Agriculture and Biology*, 2020, doi: 10.35495/ajab.2019.11.524.

[16] S. López-Vinyallonga, M. Arakaki, N. Garcia-Jacas, A. Susanna, M. A. Gitzendanner, D. E. Soltis, P. S. Soltis, Isolation and characterization of novel microsatellite markers for *Arctium minus* (Compositae), *American Journal of Botany*, 2010, **97**, e4-e6, doi: 10.3732/ajb.0900376.

[17] S. V. Yuzepchuk, E. V. Sergievskaya, Burdock, Flora of the USSR, 1962.

[18] J. Bourdillon, F. Bruckner, The publishing house of the academy of sciences of the USSR, 2000.

[19] N. V. Pavlov, V. L. Komarova, Vegetable raw materials of Kazakhstan, AS, SSSR, 1947, **551**, 486-487.

[20] K. F. Blinova, G. P. Yakovlev, Botanical-pharmacognostic dictionary,1990.

[21] E. I. Demyanov, Botanical resource science, 172, 2007.

[22] I. M. Krasnoborov Flora Sibiri., 1997, **13**, 472.

[23] Arctium. The Plant List. URL: http://www.theplantlist.org/tpl1.1/record/gcc-52146.

[24] Rudskiy V.V. Rastitel'nyye resursy Altaya: uch. pos. dlya studentov geogr. fak, Rastitel'nyye resursy Altaya, 1993, 30.

[25] European Food Safety Authority, Unit on Dieteic products, nutrition and allergies, Parma, 2011.

[26] A. A. Iurmanov, M. Romanov, A. V. F. C. Bobrov, Fruit morphology and histology of *Zostera asiatica* Miki and *Phyllospadix iwatensis* Makino (Zosteraceae) in connection with comparative carpology of higher Alismatales, *Botany Letters*, 2021, **168**, 570-576, doi: 10.1080/23818107.2021.1914157.

[27] L. S. Bondarenko, V. M. Ryzhov, L.V. Tarasenko, Microscopic examination of the fruits of burdock Arctium tomentosum mill., Pharm. bot., 2021.

[28] A. Ydyrys, N. Abdolla, A. Seilkhan, M. Masimzhan, L. Karasholakova, Importance of the geobotanical studying in agriculture (with the example of the Sugaty region), *E3S Web of Conferences*, 2020, **222**, 04003, doi: 10.1051/e3sconf/202022204003.

[29] A. Ydyrys, B. Yeszhanov, N. Baymurzaev, S. Sharakhmetov, A. Mautenbaev, B. Tynybekov, T. Baidaulet, Technology of landscaping in arid zones by using biohumus from sheep wool, *E3S Web of Conferences*, 2020, **169**, 02012, doi: 10.1051/e3sconf/202016902012.

[30] R. Pezzani, M. Jiménez-Garcia, X. Capó, E. Sönmez Gürer, F. Sharopov, T. Y. Lauve Rachel, D. Ntieche Woutouoba, A. Rescigno, S. Peddio, P. Zucca, P. V. Tsouh Fokou, M. Martorell, Z. Gulsunoglu-Konuskan, A. Ydyrys, T. Bekzat, T. Gulmira, C. Hano, J. Sharifi-Rad, D. Calina, Anticancer properties of bromelain: state-of-the-art and recent trends, *Frontiers in Oncology*, 2023, **12**, 1068778, doi: 10.3389/fonc.2022.1068778.

[31] A. Ydyrys, N. Mukhitdinov, A. Ametov, B.Tynybekov, A. Akhmetova, K. Abidkulova, The states of coenpopulations of endemic, relict and rare species of plant Limonium michelsonii and their protection, *World Applied Sciences Journal*, 2013, **26**, 934-940. doi: 10.5829/idosi.wasj.2013.26.07.13525.

[32] Y. Alibek, N. Abdolla, M. Masimzhan, Z. Abdrasulova, S. Syraiyl, Cultivation and resource of Artemisia schrenkiana L. for increased pharmaceutical perspective, *Research on Crops*, 2023, **24**, 171-178, doi: 10.31830/2348-7542.2023.roc-881.
[33] A. Ydyrys, A. Serbayeva, S. Dossymbetova, A. Akhmetova, A. Zhuystay, The effect of anthropogenic factors on rare, endemic plant species in the Ile Alatau, *E3S Web of Conferences*, 2020, **222**, 05021, doi: 10.1051/e3sconf/202022205021.
[34] A. Ydyrys, N. Zhaparkulova, A. Aralbaeva, A. Mamataeva, A. Seilkhan, S. Syraiyl, M. Murzakhmetova, Systematic analysis of combined antioxidant and membrane-stabilizing properties of several Lamiaceae family kazakhstani plants for potential production of tea beverages, *Plants*, 2021, **10**, 666, doi: 10.3390/plants10040666.
[35] N. A. Anjum, H. P. Singh, M. I. R. Khan, A. Masood, T. S. Per, A. Negi, D. R. Batish, N. A. Khan, A. C. Duarte, E. Pereira, I. Ahmad, Too much is bad-an appraisal of phytotoxicity of elevated plant-beneficial heavy metal ions, *Environmental Science and Pollution Research*, 2015, **22**, 3361-3382, doi: 10.1007/s11356-014-3849-9.
[36] A. Seilkhan, S. Syraiyl, G. Turganova, E. Satbayeva, N. Erkenova, Determination of laboratory seed yield of Artemisia schrenkiana Ledeb and Chorispora bungeana Fisch, *IOP Conference Series*: *Earth and Environmental Science*, 2021, **699**, 012014, doi: 10.1088/1755-1315/699/1/012014.
[37] A.S. Seilkhan, R. Mirzadinov, A. Aksoy, A. Abulgaziyev, and G. Kanat, Assessment of recovery of medicinal plants of the Kurti district of the Almaty region, Kazakhstan, *Ecology, Environment and Conservation*, 2018, **24**, 1653-58.
[38] E. A. Bukenova, Z. M. Bassygarayev, A. B. Akhmetova, Z. K. Zhunusbayeva, A. Ydyrys, Development of the method of obtaining the endogenic biostimulator from wheat green spike glumes, *Research on Crops*, 2019, **20**, 210-214, doi: 10.31830/2348-7542.2019.030.
[39] European Medicines Agency, Community Herbal Monograph on Arctium lappa L., Radix, The Netherlands, 2010, 44.
[40] B. Šarić-Kundalić, C. Dobeš, V. Klatte-Asselmeyer, J. Saukel, Ethnobotanical study on medicinal use of wild and cultivated plants in middle, south and west Bosnia and Herzegovina, *Journal of Ethnopharmacology*, 2010, **131**, 33-55, doi: 10.1016/j.jep.2010.05.061.
[41] S. Jarić, O. Kostić, Z. Mataruga, D. Pavlović, M. Pavlović, M. Mitrović, P. Pavlović, Traditional wound-healing plants used in the Balkan region (Southeast Europe), *Journal of Ethnopharmacology*, 2018, **211**, 311-328, doi: 10.1016/j.jep.2017.09.018.
[42] X. Zhou, H. Zhang, L. Ge, H. Gong, S. Tian, Determination of arctiin and arctigenin contents in*Arctium Tomentosum*Mill. by HPLC method, *E-Journal of Chemistry*, 2011, **8**, S372-S376, doi: 10.1155/2011/517681.
[43] J. Strawa, A. Wajs-Bonikowska, K. Jakimiuk, M. Waluk, M. Poslednik, J. Nazaruk, M. Tomczyk, Phytochemical examination of woolly burdock arctium tomentosum leaves and flower heads, *Chemistry of Natural Compounds*, 2020, **56**, 345-347, doi: 10.1007/s10600-020-03027-w.
[44] S. S. Gill, N. Tuteja, Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants, *Plant Physiology and Biochemistry*, 2010, **48**, 909-930, doi: 10.1016/j.plaphy.2010.08.016.
[45] R. Mittler, Oxidative stress, antioxidants and stress tolerance, *Trends in Plant Science*, 2002, **7**, 405-410, doi: 10.1016/S1360-1385(02)02312-9.
[46] W. E. Q. AL Harbawee, A. N. Kluchagina, N. A. Anjum, D. I. Bashmakov, A. S. Lukatkin, E. Pereira, Evaluation of cotton burdock (Arctium tomentosum Mill.) responses to multi-metal exposure, *Environmental Science and Pollution Research*, 2017, **24**, 5431-5438, doi: 10.1007/s11356-016-8244-2.
[47] S. M. G. Pires, R. S. Reis, S. M. Cardoso, R. Pezzani, E. Paredes-Osses, A. Seilkhan, A. Ydyrys, M. Martorell, E. Sönmez Gürer, W. N. Setzer, A. F. Abdull Razis, B. Modu, D. Calina, J. Sharifi-Rad, Phytates as a natural source for health promotion: a critical evaluation of clinical trials, *Frontiers in Chemistry*, 2023, **11**, 1174109, doi: 10.3389/fchem.2023.1174109.
[48] N. Mamedov, Z. Gardner, L. E. Craker, Spices and Medicinal Plants, *Journal of Herbs*, 2004, **11**, 191-222, doi: 10.1300/J044v11n01_07.
[49] A. E. Aitynova, N. A. Ibragimova, T. M. Shalakhmetova, T. E. Gapurkhaeva, A. V. Krasnoshtanov, S. T. Kenesheva, Antimicrobial effect of extract from root of Arctium tomentosum Mill. (woolly burdock) against several reference strains, *International Journal of Biology and Chemistry*, 2022, **15**, 10-17, doi: 10.26577/ijbch.2022.v15.i2.02.
[50] https://www.nhs.uk/conditions/discoid-eczema/treatment/.
[51] V. L. C. Vale, M. da Costa Silva, A. P. de Souza, S. C. Trindade, L. F. de Moura-Costa, E. K. N. dos Santos-Lima, I. L. de Oliveira Nascimento, H. S. P. Cardoso, E. de Jesus Marques, B. J. A. Paule, R. J. M. Nascimento, Humoral and cellular immune responses in mice against secreted and somatic antigens from a Corynebacterium pseudotuberculosis attenuated strain: immune response against a C. pseudotuberculosis strain, *BMC Veterinary Research*, 2016, **12**, 1-8, doi: 10.1186/s12917-016-0811-8.
[52] M. H. Alu'datt, T. Rababah, M. N. Alhamad, M. A. Al-Mahasneh, A. Almajwal, S. Gammoh, K. Ereifej, A. Johargy, I. Alli, A review of phenolic compounds in oil-bearing plants: distribution, identification and occurrence of phenolic compounds, *Food Chemistry*, 2017, **218**, 99-106, doi: 10.1016/j.foodchem.2016.09.057.
[53] M. Gavrilescu, Water, soil, and plants interactions in a threatened environment, *Water*, 2021, **13**, 2746, doi: 10.3390/w13192746.
[54] W. Verstraeten, F. Veroustraete, J. Feyen, Assessment of evapotranspiration and soil moisture content across different scales of observation, *Sensors*, 2008, **8**, 70-117, doi: 10.3390/s8010070.
[55] S. M. Vicente-Serrano, D. G. Miralles, N. McDowell, T. Brodribb, F. Domínguez-Castro, R. Leung, A. Koppa, The uncertain role of rising atmospheric CO_2 on global plant transpiration, *Earth-Science Reviews*, 2022, **230**, 104055, doi:

10.1016/j.earscirev.2022.104055.
[56] D.-H. Kuo, M.-C. Hung, C.-M. Hung, L.-M. Liu, F.-A. Chen, P.-C. Shieh, C.-T. Ho, T.-D. Way, Body weight management effect of burdock (*Arctium lappa* L.) root is associated with the activation of AMP-activated protein kinase in human HepG2 cells, *Food Chemistry*, 2012, **134**, 1320-1326, doi: 10.1016/j.foodchem.2012.03.023.
[57] K.-C. Wu, H.-K. Weng, Y.-S. Hsu, P.-J. Huang, Y.-K. Wang, Aqueous extract of *Arctium lappa* L. root (burdock) enhances chondrogenesis in human bone marrow-derived mesenchymal stem cells, *BMC Complementary Medicine and Therapies*, 2020, **20**, 1-14, doi: 10.1186/s12906-020-03158-1.
[58] S. M. El-Darier, S. G. Salama, Arctium lappa (Asteraceae); a new invasive highly specific medicinal plant growing in Egypt, *Pyrex Journal of Agricultural Research*, 2016, **2**, 44-53.
[59] M. Gilca, G. S. Tiplica, C. M. Salavastru, Traditional and ethnobotanical dermatology practices in Romania and other Eastern European countries, *Clinics in Dermatology*, 2018, **36**, 338-352, doi: 10.1016/j.clindermatol.2018.03.008.
[60] K. N. Eduardovna, K. Stepan Alexandrovich, I. N. Valentinovna, A. N. Yurievna, K. Darya Vladimirovna, B. R. Sergeevich, Z. L. Vladimirovna, A. A. Hasan, B. R. Anatolevich, Pharmacognostic studies of the leaves and fructus of *Arctium lappa* L. (Asteraceae bercht. & J. presl), *Pharmacognosy Journal*, 2021, **13**, 1734-1745, doi: 10.5530/pj.2021.13.224.
[61] N. Chomchalow, H. V. Henle, Medicinal and Aromatic plants in Asia breeding and improvement, Regional Office for Asia and the Pacific, Arom. plan., 1995, 196.
[62] A. Price, Lym. Sys. and Skin, Burdock root detoxes blood, lymph system and skin, 2023, https://draxe.com/nutrition/burdock-root/.
[63] F. B. Holetz, G. L. Pessini, N. R. Sanches, D. A. G. Cortez, C. V. Nakamura, B. P. Dias Filho, Screening of some plants used in the Brazilian folk medicine for the treatment of infectious diseases, *Memórias Do Instituto Oswaldo Cruz*, 2002, **97**, 1027-1031, doi: 10.1590/s0074-02762002000700017.
[64] L. M. da Silva, A. Allemand, D. A. G. B. Mendes, A. C. dos Santos, E. André, L. M. de Souza, T. R. Cipriani, N. Dartora, M. C. A. Marques, C. H. Baggio, M. F. Werner, Ethanolic extract of roots from *Arctium lappa* L. accelerates the healing of acetic acid-induced gastric ulcer in rats: involvement of the antioxidant system, *Food and Chemical Toxicology*, 2013, **51**, 179-187, doi: 10.1016/j.fct.2012.09.026.
[65] A. C. dos Santos, C. H. Baggio, C. S. Freitas, J. Lepieszynski, B. Mayer, A. Twardowschy, F. C. Missau, É. P. dos Santos, M. G. Pizzolatti, M. C. A. Marques, Gastroprotective activity of the chloroform extract of the roots from *Arctium lappa* L, *Journal of Pharmacy and Pharmacology*, 2010, **60**, 795-801, doi: 10.1211/jpp.60.6.0016.
[66] R. Ferracane, G. Graziani, M. Gallo, V. Fogliano, A. Ritieni, Metabolic profile of the bioactive compounds of burdock (*Arctium lappa*) seeds, roots and leaves, *Journal of Pharmaceutical and Biomedical Analysis*, 2010, **51**, 399-404, doi: 10.1016/j.jpba.2009.03.018.
[67] http://resource.rucml.ru/feml/pharmacopia/14_4/HTML/index.html.
[68] https://fitoleum.kz/en/products/oil-extracts/kyzyl-may-polyphyto-composed-oil/.
[69] https://fitoleum.kz/enciklopedija-fitoleum/lopuha-korni/.
[70] Y.-S. Chan, L.-N. Cheng, J.-H. Wu, E. Chan, Y.-W. Kwan, S. M.-Y. Lee, G. P.-H. Leung, P. H.-F. Yu, S.-W. Chan, A review of the pharmacological effects of *Arctium lappa* (burdock), *Inflammopharmacology*, 2011, **19**, 245-254, doi: 10.1007/s10787-010-0062-4.
[71] C. Wei, T. Po, Z. Yu Xiang, L. Yong, Viroid-like RNAs associated with burdock stunt disease, *Journal of General Virology*, 1983, **64**, 409-414, doi: 10.1099/0022-1317-64-2-409.
[72] X.-M. Li, Y. Miao, Q.-Y. Su, J.-C. Yao, H.-H. Li, G.-M. Zhang, Gastroprotective effects of arctigenin of *Arctium lappa* L. on a rat model of gastric ulcers, *Biomedical Reports*, 2016, **5**, 589-594, doi: 10.3892/br.2016.770.
[73] T.-C. Huang, Effect of*Arctium lappa*L. in the dextran sulfate sodium colitis mouse model, *World Journal of Gastroenterology*, 2010, **16**, 4193, doi: 10.3748/wjg.v16.i33.4193.
[74] H. Ohigashi, T. Osawa, J. Terao, S. Watanabe, T. Yoshikawa, Food factors for cancer prevention, 1997, 55–57.
[75] C. Tamayo, D. M. A. Richardson, S. Diamond, I. Skoda, The chemistry and biological activity of herbs used in Flor-Essence™ herbal tonic and Essiac, *Phytotherapy Research*, 2000, **14**, 1-14, doi: 10.1002/(SICI)1099-1573(200002)14: 11: AID-PTR580>3.0.CO;2-O.
[76] N. Erdemoglu, N. N. Turan, E. K. Akkol, B. Sener, N. Abacıoglu, Estimation of anti-inflammatory, antinociceptive and antioxidant activities on *Arctium minus* (Hill) Bernh. ssp. minus, *Journal of Ethnopharmacology*, 2009, **121**, 318-323, doi: 10.1016/j.jep.2008.11.009.
[77] S. İlgün, G. Ş. Karatoprak, D. Ç. Polat, E. K. Şafak, G. Yıldız, E. Küpeli Akkol, E. Sobarzo-Sánchez, Phytochemical composition and biological activities of *Arctium minus* (hill) bernh.: a potential candidate as antioxidant, enzyme inhibitor, and cytotoxic agent, *Antioxidants*, 2022, **11**, 1852, doi: 10.3390/antiox11101852.
[78] J. Cao, Antidiabetic effect of burdock (*Arctium lappa* L.) root ethanolic extract on streptozotocin-induced diabetic rats, *African Journal of Biotechnology*, 2012, **11**, 9079-9085, doi: 10.5897/ajb11.4107.
[79] J. Cui, S. Zeng, C. Zhang, Anti-hyperglycaemic effects of Burdock (*Arctium lappa* L.) leaf flavonoids through inhibiting α-amylase and α-glucosidase, *International Journal of Food Science & Technology*, 2022, **57**, 541-551, doi: 10.1111/ijfs.15026.
[80] N. Petkova, I. Hambarlyiska, Y. Tumbarski, R. Vrancheva, Miglena, Raeva, I. G. Ivanov, Phytochemical composition and antimicrobial properties of burdock (*Arctium lappa* L.) roots extracts, 2021.
[81] S.-H. Bok, S. S. Cho, C.-S. Bae, D.-H. Park, K.-M. Park, Safety of 8-weeks oral administration of *Arctium lappa* L, *Laboratory Animal Research*, 2017, **33**, 251-255, doi: 10.5625/lar.2017.33.3.251.

[82] M. Miazga-Karska, K. Michalak, G. Ginalska, Anti-acne action of peptides isolated from burdock root—preliminary studies and pilot testing, *Molecules*, 2020, **25**, 2027, doi: 10.3390/molecules25092027.
[83] J. M. F. Rodriguez, A. R. C. de Souza, R. Letícia Krüger, M. C. M. Bombardelli, C. S. Machado, M. L. Corazza, Kinetics, composition and antioxidant activity of burdock (*Arctium lappa*) root extracts obtained with supercritical CO_2 and co-solvent, *The Journal of Supercritical Fluids*, 2018, **135**, 25-33, doi: 10.1016/j.supflu.2017.12.034.
[84] M.-K. Ku, H.-C. Liu, S.-R. Lin, Efficacy analysis of preserved great burdock essence compounds, *Biomarkers and Genomic Medicine*, 2013, **5**, 67-70, doi: 10.1016/j.gmbhs.2013.04.002.
[85] Z. Lou, C. Li, X. Kou, F. Yu, H. Wang, G. M. Smith, S. Zhu, Antibacterial, antibiofilm effect of burdock (*Arctium lappa* L.) leaf fraction and its efficiency in meat preservation, *Journal of Food Protection*, 2016, **79**, 1404-1409, doi: 10.4315/0362-028x.jfp-15-576.
[86] Q. Gao, M. Yang, Z. Zuo, Overview of the anti-inflammatory effects, pharmacokinetic properties and clinical efficacies of arctigenin and arctiin from *Arctium lappa* L, *Acta Pharmacologica Sinica*, 2018, **39**, 787-801, doi: 10.1038/aps.2018.32.
[87] Y.-S. Kim, S.-H. Kim, Physicochemical and antioxidant characteristics of hot water extracts on pre-treatment conditions of burdock (*Arctium lappa* L.), *Journal of the Korean Society of Food Science and Nutrition*, 2018, **47**, 612-619, doi: 10.3746/jkfn.2018.47.6.612.
[88] C.-H. Yen, H.-F. Chiu, S.-Y. Huang, Y.-Y. Lu, Y.-C. Han, Y.-C. Shen, K. Venkatakrishnan, C.-K. Wang, Beneficial effect of Burdock complex on asymptomatic *Helicobacter pylori*-infected subjects: a randomized, double-blind placebo-controlled clinical trial, *Helicobacter*, 2018, **23**, e12469, doi: 10.1111/hel.12469.
[89] K. Tian, J. Wang, Z. Zhang, L. Cheng, P. Jin, S. Singh, B. A. Prior, Z.-X. Wang, Enzymatic preparation of fructooligosaccharides-rich burdock syrup with enhanced antioxidative properties, *Electronic Journal of Biotechnology*, 2019, **40**, 71-77, doi: 10.1016/j.ejbt.2019.04.009.
[90] A. Ahangarpour, A. A. Oroojan, H. Heidari, E. Ghaedi, R. Taherkhani, Effects of hydro-alcoholic extract from *Arctium lappa* L. (burdock) root on gonadotropins, testosterone, and sperm count and viability in male mice with nicotinamide/streptozotocin-induced type 2 diabetes, *The Malaysian Journal of Medical Sciences*, 2015, **22**, 25.
[91] M.Y. Park, Y.O. Park, Y.H. Park, Antioxidant activities of Burdock root (Arctium lappa L.) with various heat treatment conditions, *Journal of The Korean Society of Food Culture*, 2018, **33**, 78-85.
[92] N. Petkova, L. Ivanova, G. Filova, I. Ivanov, P. Denev, Antioxidants and carbohydrate content in infusions and microwave extracts from eight medicinal plants, *Journal of Applied Pharmaceutical Science*, 2017, **7**, 055–061, doi: 10.7324/japs.2017.71008.
[93] W.-J. Tsai, C.-T. Chang, G.-J. Wang, T.-H. Lee, S.-F. Chang, S.-C. Lu, Y.-C. Kuo, Arctigenin from *Arctium lappa* inhibits interleukin-2 and interferon gene expression in primary human T lymphocytes, *Chinese Medicine*, 2011, **6**, 1-8, doi: 10.1186/1749-8546-6-12.
[94] J. Shao, M. Guo, X. Yu, L. Zhao, W. Duan, Determination of total lignanoids and arctinin in different parts of *Arctium lappa* L., 2012, **29**, 506-508.
[95] Y. Yuan, D. Dou, T. Kang, Evaluating the quality of *Arctium Lappa* L with different origins, *Shijie Kexue Jishu-Zhongyiyao Xiandaihua*, 2008, **10**, 75-77.
[96] A. R. C. de Souza, T. Latansio de Oliveira, P. Dias Fontana, M. C. Carneiro, M. L. Corazza, I. J. de Messias Reason, L. Bavia, Phytochemicals and biological activities of burdock (*Arctium lappa* L.) extracts: a review, *Chemistry & Biodiversity*, 2022, **19**, e202200615, doi: 10.1002/cbdv.202200615.
[97] S. Awale, J. Lu, S. K. Kalauni, Y. Kurashima, Y. Tezuka, S. Kadota, H. Esumi, Identification of arctigenin as an antitumor agent having the ability to eliminate the tolerance of cancer cells to nutrient starvation, *Cancer Research*, 2006, **66**, 1751-1757, doi: 10.1158/0008-5472.can-05-3143.
[98] S. Y. Park, S. S. Hong, X. H. Han, J. S. Hwang, D. Lee, J. S. Ro, B. Y. Hwang, Lignans from *Arctium lappa* and their inhibition of LPS-induced nitric oxide production, *Chemical and Pharmaceutical Bulletin*, 2007, **55**, 150-152, doi: 10.1248/cpb.55.150.
[99] T. Maxwell, S.-Y. Chun, K.-S. Lee, S. Kim, K.-S. Nam, The anti-metastatic effects of the phytoestrogen arctigenin on human breast cancer cell lines regardless of the status of ER expression, *International Journal of Oncology*, 2017, **50**, 727-735, doi: 10.3892/ijo.2016.3825.
[100] C.-C. Lin, J.-M. Lin, J.-J. Yang, S.-C. Chuang, T. Ujiie, Anti-inflammatory and radical scavenge effects of *Arctium lappa*, *The American Journal of Chinese Medicine*, 1996, **24**, 127-137, doi: 10.1142/s0192415x96000177.
[101] K. M. M. Koriem, Z. H. Idris, H. F. Haron, N. A. Omar, H. S. Lazain, Therapeutic effect of *Arctium lappa* in Schistosoma haematobium associated kidney disturbance: biochemical and molecular effects, *Journal of Parasitic Diseases*, 2016, **40**, 1246-1254, doi: 10.1007/s12639-015-0662-4.
[102] B. Hou, W. Wang, H. Gao, S. Cai, C. Wang, Effects of aqueous extract of*Arctium lappa*L. roots on serum lipid metabolism, *Journal of International Medical Research*, 2018, **46**, 158-167, doi: 10.1177/0300060517716341.
[103] K. Rybczyńska-Tkaczyk, A. Grenda, A. Jakubczyk, K. Kiersnowska, M. Bik-Małodzińska, Natural compounds with antimicrobial properties in cosmetics, *Pathogens*, 2023, **12**, 320, doi: 10.3390/pathogens12020320.
[104] Z. Ma, Y. Fan, Y. Wu, D. Kebebe, B. Zhang, P. Lu, J. Pi, Z. Liu, Traditional Chinese medicine-combination therapies utilizing nanotechnology-based targeted delivery systems: a new strategy for antitumor treatment, *International Journal of Nanomedicine*, 2019, **14**, 2029-2053, doi: 10.2147/ijn.s197889.
[105] S. Sukhikh, O. Babich, A. Prosekov, O. Kalashnikova, S. Noskova, A. Bakhtiyarova, O. Krol, E. Tsvetkova, S. Ivanova,

Antidiabetic properties of plant secondary metabolites, *Metabolites*, 2023, **13**, 513, doi: 10.3390/metabo13040513.
[106] N. El Khatib, S. Morel, G. Hugon, S. Rapior, G. Carnac, N. Saint, Identification of a sesquiterpene lactone from *Arctium lappa* leaves with antioxidant activity in primary human muscle cells, *Molecules*, 2021, **26**, 1328, doi: 10.3390/molecules26051328.
[107] Anna, Sólyomváry, A simple and effective enrichment process of the antiproliferative lignan arctigenin based on the endogenous enzymatic hydrolysis of *Serratula tinctoria* and *Arctium lappa* fruits, *Process Biochemistry*, 2015, **50**, 2281-2288, doi: 10.1016/j.procbio.2015.09.011.
[108] G. Berganayeva, B. Kudaibergenova, Y. Litvinenko, I. Nazarova, S. Sydykbayeva, G. Vassilina, N. Izdik, M. Dyusebaeva, Medicinal plants of the flora of Kazakhstan used in the treatment of skin diseases, *Molecules*, 2023, **28**, 4192, doi: 10.3390/molecules28104192.
[109] L. Ye, S. Fan, P. Zhao, C. Wu, M. Liu, S. Hu, P. Wang, H. Wang, H. Bi, Potential herb-drug interactions between anti-COVID-19 drugs and traditional Chinese medicine, *Acta Pharmaceutica Sinica B*, 2023, **13**, 3598-3637, doi: 10.1016/j.apsb.2023.06.001.
[110] S. Liu, K. Chen, W. Schliemann, D. Strack, Isolation and identification of arctiin and arctigenin in leaves of burdock (*Arctium lappa* L.) by polyamide column chromatography in combination with HPLC-ESI[Sol]MS, *Phytochemical Analysis*, 2005, **16**, 86-89, doi: 10.1002/pca.816.
[111] R. Jaiswal, N. Kuhnert, Identification and characterization of five new classes of chlorogenic acids in burdock (*Arctium lappa* L.) roots by liquid chromatography/tandem mass spectrometry, *Food & Functions*, 2011, **2**, 63-71, doi: 10.1039/c0fo00125b.
[112] K. Abdiyev, M. Marić, B. Orynbaev, M. Zhursumbaeva, N. Seitkaliyeva, Z. Toktarbay, A novel cationic polymer surfactant for regulation of the rheological and biocidal properties of the water-based drilling muds, *Polymers*, 2023, **15**, 330, doi: 10.3390/polym15020330.
[113] Y. Dauletov, N. Nuraje, K. Abdiyev, Z. Toktarbay, M. Zhursumbaeva, Copolymers of diallyldimethylammonium chloride and vinyl ether of monoethanolamine: synthesis, flocculating, and antimicrobial properties, *Journal of Surfactants and Detergents*, 2019, **22**, 1129-1137, doi: 10.1002/jsde.12283.
[114] U. M. Khan, A. Sameen, R. M. Aadil, M. Shahid, S. Sezen, A. Zarrabi, B. Ozdemir, M. Sevindik, D. N. Kaplan, Z. Selamoglu, A. Ydyrys, T. Anitha, M. Kumar, J. Sharifi-Rad, M. Butnariu, Citrus genus and its waste utilization: a review on health-promoting activities and industrial application, *Evidence-Based Complementary and Alternative Medicine*, 2021, **2021**, 1-17, doi: 10.1155/2021/2488804.
[115] P. Asgharian, A. P. Tazehkand, S. R. Soofiyani, K. Hosseini, M. Martorell, V. Tarhriz, H. Ahangari, N. Cruz-Martins, J. Sharifi-Rad, Z. M. Almarhoon, A. Ydyrys, A. Nurzhanyat, A. Yessenbekova, W. C. Cho, Quercetin impact in pancreatic cancer: an overview on its therapeutic effects, *Oxidative Medicine and Cellular Longevity*, 2021, **2021**, 1-13, doi: 10.1155/2021/4393266.
[116] S. Ijaz, J. Iqbal, B. A. Abbasi, Z. Ullah, T. Yaseen, S. Kanwal, T. Mahmood, S. Sydykbayeva, A. Ydyrys, Z. M. Almarhoon, J. Sharifi-Rad, C. Hano, D. Calina, W. C. Cho, Rosmarinic acid and its derivatives: current insights on anticancer potential and other biomedical applications, *Biomedicine & Pharmacotherapy*, 2023, **162**, 114687, doi: 10.1016/j.biopha.2023.114687.
[117] P. Prasher, M. Sharma, S. K. Singh, M. Gulati, D. K. Chellappan, R. Rajput, G. Gupta, A. Ydyrys, M. Kulbayeva, A. F. Abdull Razis, B. Modu, J. Sharifi-Rad, K. Dua, Spermidine as a promising anticancer agent: recent advances and newer insights on its molecular mechanisms, *Frontiers in Chemistry*, 2023, **11**, 1164477, doi: 10.3389/fchem.2023.1164477.
[118] N. Zahra, J. Iqbal, M. Arif, B. A. Abbasi, H. Sher, A. F. Nawaz, T. Yaseen, A. Ydyrys, J. Sharifi-Rad, D. Calina, A comprehensive review on traditional uses, phytochemistry and pharmacological properties of Paeonia emodi Wall. ex-Royle: current landscape and future perspectives, *Chinese Medicine*, 2023, **18**, 1-21, doi: 10.1186/s13020-023-00727-7.
[119] Y. Taheri, C. Quispe, J. Herrera-Bravo, J. Sharifi-Rad, S. M. Ezzat, R. M. Merghany, S. Shaheen, L. Azmi, A. Prakash Mishra, B. Sener, M. Kılıç, S. Sen, K. Acharya, A. Nasiri, N. Cruz-Martins, P. V. Tsouh Fokou, A. Ydyrys, Z. Bassygarayev, S. D. Daştan, M. M. Alshehri, D. Calina, W. C. Cho, Urtica dioica-derived phytochemicals for pharmacological and therapeutic applications, *Evidence-Based Complementary and Alternative Medicine*, 2022, **2022**, 1-30, doi: 10.1155/2022/4024331.
[120] B. E. Van Wyk, M. Wink, Medicinal plants of the world, Cabi, 2018.