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Full Length Article

Wild Plants of Central Kazakhstan with Antibiotic Properties and Effect

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Abstract

This article presents the results of field studies of the biological diversity of wild plants with antibiotic properties growing in the climatic conditions of Central Kazakhstan. As a result of the field studies, 28 plant species with antibiotic properties belonging to 26 families were found. Among them, the most numerous are from *Asteraceae* family – 8 species and the *Lamiaceae* family – 6 species. The rest of the plant species were distributed according to the principle "one species - one family". These plants have enormous potential for health, but mainly grow locally or are scattered in small groups and do not form thickets of commercial value in nature. We also conducted a survey among two age groups – 18 to 25 years old and 35 to 55 years old. The survey showed that the older generation is more aware of plant species with antibiotic properties and is more willing to choose natural herbs. The second group knows only those types of plants that are part of the famous syrups and lozenges for colds. Based on the above data, it can be concluded that a sufficient number of plants with antibiotic properties grow in the territory of Central Kazakhstan. Given their low cost and availability, we believe that they need to be popularized among the younger generation and recommended for commercial use.

Keywords: Antibiotic plants; Biodiversity; Central Kazakhstan; Medicinal plants

Introduction

A global health crisis is currently brewing due to an increase in the number of multidrug-resistant (MDR) microorganisms as it causes antimicrobial resistance (World Health Organization Antimicrobial Resistance 2014). Antibiotics are widely prescribed in the early stages of disease and have recently been used to treat a wide range of infections. The COVID-19 pandemic has increased the consumption of antibiotics and, as a consequence, this has led to an increase in resistance in a large number of people (Rawson *et al.* 2020). Traditionally, medicinal herbs have been used to treat viral and bacterial infections and recently, scientists have been constantly trying to discover new micro-components isolated from medicinal plants. The side effects of available antibiotics and microbial resistance are the main reasons for looking for alternative herbal antibiotics. Plant phytochemicals such as tannins, alkaloids, saponins, flavonoids, polyphenols and glycosides can be considered to act as antibacterial agents (Roca *et al.* 2015).

Currently, the exact composition and mechanisms of action of herbal medicines are still not well understood. However, it is already known that plant components can act as immunomodulators, be a source of antioxidant compounds, prevent the attachment of microbes and the formation of a bacterial film, and also stop the proliferation or reproduction of microorganisms (Akram *et al.* 2020). The antibacterial activity of plants is a subject of interest in the search for new antibiotics and fungicidal preparations. An important area of modern medicine is the search for new substances and strategies for combating infectious diseases, which pose an increasing threat due to the growth of bacterial resistance to antibiotics. The increase in strains of multidrug-resistant pathogens has led to extensive phytochemical and pharmacological research (Tacconelli *et al.* 2018).

Recent events related to the necessary isolation of countries and continents have led to the need not only to search for new sources of plant materials with antibacterial and antiviral effects, but also to use local plants with a similar effect. The purpose of this study is to study the biological diversity of wild plants with an antibiotic effect growing in the territory of Central Kazakhstan, as well as to assess the effectiveness of their use as medicines among the local population.

Materials and Methods

This study was performed as part of the traditional summer practice of biology students in the period of July–August 2019. The main method used in the field studies was route exploration. The route ran in the Karkaraly National Park, the eastern part of the Kazakh Upland. The route coordinates covered the radius of 49°18'7 2''N 75°29'18 24''E and 49°17'41 28''N75°32'19 68''E. (Fig. 1.) This territory has all

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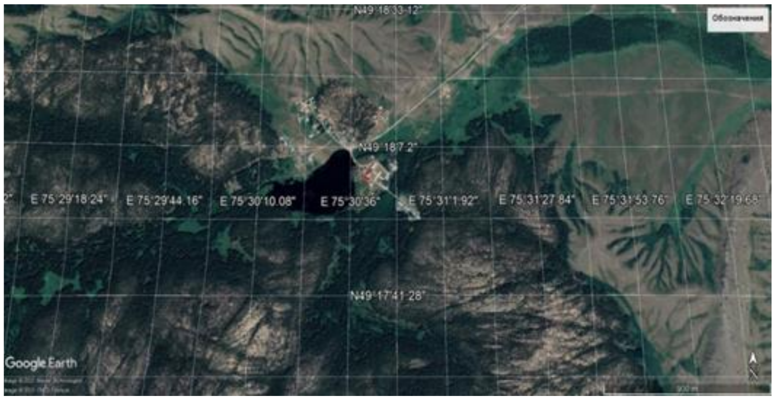
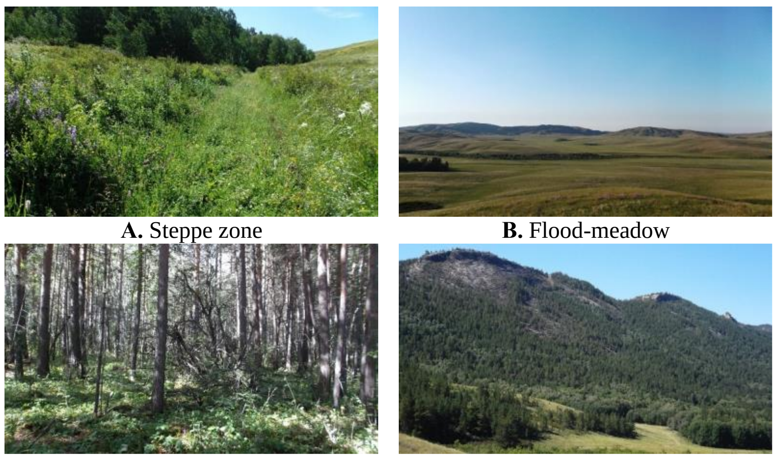


Fig. 1: Territory of the field research route



A. Steppe zone **B.** Flood-meadow

C. Hillside slope **D.** Forest zone

Fig. 2: Natural areas of the territory of the field studies route

the characteristics inherent in the landscape of the entire Central Kazakhstan. There are steppe, forest-steppe and forest zones here (Fig. 2). There are flood-meadows between the hills, where moisture accumulates during the melting of snows, and at the same time there are steppes open to the sun and winds. The soils are brown, saline red-brown and saline. Basically, stony and stony and gravelly soils prevail.

The climate here, as in all of Central Kazakhstan, is arid, sharply continental. This is reflected in the severity of winter, high summer temperatures, short duration of spring and autumn, dry air and low rainfall. Due to this, the species diversity of plants is quite small. According to the literature, about 850 species of flowering plants belonging to 78 families grow in this territory (Karaganda region Encyclopedia 1986).

While carrying out the research, classical botanical research methods were used. Laboratory processing of the source material was carried out in strict accordance with all requirements, and herbarium samples were stored in the herbarium collection of Karaganda Medical University. To identify the collected materials, the main floristic annotations covering the territory of Kazakhstan (Baitenov 1999, 2001) were followed. The study of the medicinal value of the found plants was carried out using the Google Scholar, Medline and Scopus databases. The search was carried out using various keywords, for example, "medicinal plants", "plants with antibacterial activity", "plants of Central Asia". The search included literature published over a five-year period (to the extent possible) up to May 2021.

We also conducted a survey among two age groups: 1st group 18–25 years old and 2nd group 35–55 years old. The respondents received from us a list of antibiotic plants growing in the territory of Central Kazakhstan and answered two questions Do you know that this plant has antibiotic properties?" and "Do you use this plant as a source of antibiotics for the corresponding diseases? In total, about 120 people participated; 60 for each group.

Results

Biodiversity of antibiotic plants in central kazakhstan

The 28 species of antibiotic plants that we discovered contain a large amount of active substances (Table 1). As a result of

Table 1: Public awareness of local antibiotic herbs

Species	Local name	1st group	2nd group
C. cyanus	Júgeri gúli kók	U(100%)/D (100%)	U(100%)/D(100%)
T. farfara	Ógeıshóp	K(80%)/M(40%)	K(95%)/M(78%)
H. arenarium	Salaýbas	U(100%)/D(100%)	U(100%)/D(100%)
I. helenium	Bıık andyz	U(100%)/D(100%)	K(35%)/M(10%)
C. officinalis	Dárilik qyrmyzygúl	K(90%)/M(40%)	K(100%)/M(80%)
A. absinthium	Ashy jýsan	U(100%)/D(100%)	K(45%)/D(3%)
M. chamomilla	Dárilik túımedaq	K(100%)/M(70%)	K(100%)/M(90%)
G. uliginosum	Aq shaıyr	U(100%)/D(100%)	U(100%)/D(100%)
A. millefolium	Kádimgi myńjapyraq	U(100%)/D(100%)	K(92%)/M(73%)
S. officinālis	Shatyrash	K(90%)/M(87%)	K(100%)/M(93%)
M. piperita	Jalbyz	U(100%)/D(100%)	U(100%)/D(100%)
T. vulgaris	Tasshóp	K(40%)/M(10%)	K(83%)/M(37%)
T. serpyllum	Tasshóp	K(40%)/M(10%)	K(83%)/M(37%)
O. vulgare	Kádimgi jupargúl	U(100%)/D (100%)	U(100%)/D(100%)
H. officinalis	Kók shaıqýraı	U(100%)/D (100%)	U(100%)/D(100%)
A. calamus	Andyz	U(100%)/D(100%)	U(100%)/D(100%)
L. palustre	Saz qazanaq	U(100%)/D(100%)	U(100%)/D(100%)
S. nigra	Qara badam	U(100%)/D(100%)	K (10%) /M (3%)
B. crassifolia	Badan qalyń japyraqty	U(100%)/D(100%)	U(100%)/D(100%)
B. pendula	Qaıyń	U(100%)/D(100%)	U(100%)/D(100%)
P. aviculare	Qus taran	K(30%)/M(15%)	K(87%)/M(70%)
G. lutea	-	U(100%)/D(100%)	U(100%)/D(100%)
D. superbus	Qalampyr	U(100%)/D(100%)	K (7%)/M (1%)
H. perforatum	Shaıqýraı	K(35%)/M(10%)	K(83%)/M(65%)
M. officinalis	Dári túıejońyshqa	U(100%)/D(100%)	K(20%)/M(5%)
C. majus	Súıelshóp	K(85%)/M(3%)	K(100%)/M(30%)
R. confertus	At kýlak / Jylky kymyzdyk	U(100%)/D(100%)	U(100%)/D(100%)
J. communis	Kádimgi arsha	K(30%)/D(100%)	K(68%)/M (20%)

K – known, U – unknown, M – use as medicine, D – do not use as medicine

the conducted field studies, the following plant species with antibiotic effect were found, collected and identified:

***Centaurea cyanus* L.:** An annual, biennial meadow herb of the Asteraceae family. Ethyl acetate extract and aqueous extracts of *C. cyanus* exhibit antibacterial activity against three gram-positive bacteria *Staphylococcus aureus* (food isolate), *S. aureus*, *Listeria monocytogenes* (clinical isolate) in the experiment (Haziri *et al.* 2017).

***Tussilago farfara* L.:** A perennial herb of the family. It has a wide range of pharmacological effects and has an effect on the respiratory, cardiovascular and digestive systems, as well as antioxidant, anti-inflammatory and neuroprotective effects (Liu *et al.* 2020). Its essential oil has antibacterial activity against *E. coli* and *S. Aureus* (Boucher *et al.* 2020).

***Helichrysum arenarium* (L.) Moench.:** A herbaceous perennial plant of the Asteraceae family, its flowers have a long tradition of use in European ethnomedicine as a choleretic, hepatoprotective and detoxifying herbal medicine (Pljevljakušić *et al.* 2018). The bacteriostatic and bactericidal activity of the alcoholic extract of dry flowers of *H. arenarium* prepared according to a special method was studied in vitro against *Mycobacterium tuberculosis*. The experiment revealed that Mycobacterium tuberculosis strains resistant to reference drugs were susceptible to *H. arenarium* extract (Skvortsova *et al.* 2015).

***Inula helenium* L.:** Perennial plant species of the Asteraceae family. *I. helenium* has a choleretic, expectorant, fungicidal, bactericidal and antiviral effect. *I. helenium* has antimicrobial activity against three strains of bacteria e.g., *Enterococcus hirae*, *Escherichia coli* and *S. aureus* (Coss *et al.* 2018). The chemical components of *I. helenium* have a strong inhibitory effect on *E. coli*, *S. aureus* and *Bacillus subtilis* (Bai *et al.* 2018). *I. helenium* is a valuable source of active compounds with anti-inflammatory activity and justifies its traditional use in the treatment of inflammatory diseases of the respiratory tract (Gierlikowska *et al.* 2020).

***Calendula officinalis* L.:** An annual plant of the Asteraceae family. Studies of *C. officinalis* show that it has anti-inflammatory and antibacterial activity, as well as angiogenic and fibroplastic properties, positively affecting the inflammatory and proliferative phases of the wound healing process (Parente *et al.* 2012). *C. officinalis* is effective for treating bacterial vaginosis in women of reproductive age without any side effects. This herb is recommended for women of reproductive age who cannot use synthetic drugs due to their potential side effects (Najafi 2019).

***Artemisia absinthium* L.:** A perennial plant of the Asteraceae family. As a result of the study, *A. absinthium* was found to have antiviral effect against the hepatitis B virus in the treatment of chronic hepatitis B (Ansari *et al.* 2018). Extracts of *A. absinthium* exhibit strong larvicidal activity against mosquitoes that transmit malaria, dengue and filariasis (Ali *et al.* 2018). Also, *A. absinthium* extract shows an antioxidant effect, exhibits cytotoxic activity against DLD-1 and ECC-1 cancer cells (Koyuncu 2018).

***Matricaria chamomilla* L.:** An annual plant from the Asteraceae family, it has been used as a source of antimicrobial drugs for a long time (Sharifi-Rad *et al.* 2018).

It is used in dentistry to treat gingivitis (Safiaghdam *et al.* 2018). It also has antioxidant properties (Amraei *et al.* 2018). Phytoisolates of *M. chamomilla* show the ability to produce antifungal agents, its extracts inhibit the growth of important human pathogens: *Candida krusei, C. parapsilosis* and *C. glabrata* (Mojicevic *et al*. 2019). The research results demonstrated that the peptide MCh-AMP1 derived from *M. chamomilla* causes death of *C. albicans* cells by increasing the permeability of the cell membrane and inducing ROS production (Seyedjavadi *et al.* 2019).

***Gnaphalium uliginosum* L.:** An annual plant from the Asteraceae family, widely used in Russian and Bulgarian herbal medicine in the treatment of hypertension, thrombophlebitis, phlebothrombosis and ulcers. It is known that the decoction and infusion of *G. uliginosum* have anti-inflammatory, astringent and antiseptic properties. Oil extracts are used in the treatment of laryngitis, upper respiratory catarrh and tonsillitis (Shikov *et al.* 2010). The ethanol extract of *G. uliginosum* has moderate antimicrobial activity against *S. aureus*, *B. cereus* and *A. solani*. *G. uliginosum* essential oil is considered a weak antioxidant (Leonidovna *et al.* 2019).

***Achillea millefolium* L.:** A perennial plant from the Asteraceae family, *A. millefolium* has anti-inflammatory, wound healing, and antimicrobial effects (Hajisalem *et al.* 2019).

***Sālvia officinālis* L.:** A perennial subshrub of the Lamiaceae family. *S. officinalis* extract showed high antibacterial activity on clinical samples isolated from the oral cavity – *S. aureus, S. epidermidis, Streptococcus mutans, C. albicans, C. tropicalis* and *C. glabrata* (De Oliveira *et al*. 2019). Also, mouthwash with *S. officinalis* solution effectively reduces the amount of *S. mutans* in plaque (Beheshti-Rouy *et al*. 2015).

***Mentha piperita* L.:** A perennial plant of the Lamiaceae family. Its essential oil exhibits significant antibacterial (against *S. aureus, Micrococcus flavus, B. subtilis, S. epidermidis* and *Salmonella enteritides*) and antifungal (against *Alternaria alternata, Fusarium tabacinum, Penicillum spp., F. oxyporum* and *Aspergillus* sp.) activity (Desam *et al.* 2019).

***Thymus vulgaris* L.:** A perennial shrub of the Lamiaceae family is an important source of medicinal substances with antioxidant, antimicrobial, antitumor and cytotoxic properties (Hameed *et al.* 2018). The essential oil obtained from *T. vulgaris* contains a large amount of flavonoids, has antioxidant and antimicrobial activity. Therefore, it can be used as a good source in the development of new natural antioxidants and antibiotics (Almanea *et al.* 2019). The alcoholic extract of *T. vulgaris* has shown excellent antibacterial activity against the gram-positive bacterium *S. aureus* and this extract can be used to target pathogenic bacteria, in particular acne formation (Mohammed *et al.* 2020). Research results support the use of *T. vulgaris* essential oil as an alternative or adjunctive treatment for multidrug-resistant bacteria infections and for preventing biofilm formation and quorum signaling. It can be used as a safe antioxidant (Alibi *et al.* 2020).

***Thymus serpyllum* L.:** A perennial subshrub of the Lamiaceae family. *T. serpyllum* oil has antirheumatic, antiseptic, antispasmodic, antimicrobial, cardiac, carminative, diuretic and expectorant properties. The oil is also good for strengthening the immune system and helps fight colds, flu, infections, and chills. It has been proven to be a urinary antiseptic, very useful in the treatment of cystitis and urethritis (Nikolić *et al.* 2014). The essential oil obtained from *T. serpyllum* has antimicrobial activity against the *E. coli* strain and against the yeast *C. albicans* (Wesolowska *et al*. 2015).

***Origanum vulgare* L.:** A perennial plant of the Lamiaceae family. Research results indicate a high antioxidant and antibacterial activity of *O. vulgare* against ampicillin-resistant *E. coli.* (Moghrovyan *et al.* 2019). Hydroalcoholic extract from *O. vulgare* stimulates antimycobacterial innate immunity and limits the inflammatory response in vitro (De Santis *et al.* 2019).

***Hyssopus officinalis* L.:** A subshrub of the Lamiaceae family, *H. officinalis* is on the list of herbs with potential to fight HIV/AIDS, but more research is needed (Laila *et al.* 2019).

***Acorus calamus* L.:** A perennial plant of the Araceae family. It has an insecticidal, antifungal, antibacterial, tranquilizing, antidiarrheal, antidyslipidemic, neuroprotective, antioxidant, anticholinesterase, antispasmodic, vascular modulator effect (Mohammed and Hameed 2018). It is currently being investigated as a new antiviral candidate for dengue fever (Rosmalena *et al.* 2019). Studies have been carried out to prove the effectiveness of plant rhizome extracts against nosocomial strains of *B. subtilis, E. coli, Pseudomonas aeruginosa* and *Vibrio cholerae* (Nayak *et al.* 2017).

***Ledum palustre* L.:** An evergreen shrub from the Ericaceae family, found in peatlands in Northern Europe, Asia and North America. For about 200 years, it has been used in ethnomedicine to treat various diseases such as rheumatism, coughs, and colds (Dampc and Luczkiewicz 2013).

***Sambucus nigra* L.** A deciduous shrub of the Adoxaceae family, traditionally used to treat flu and colds. Oral administration of high molecular weight fractions of *S. nigra* to mice infected with human influenza A virus (IFV) inhibits viral replication and increases serum IFV-specific neutralizing antibodies (Kinoshita *et al.* 2012). New experimental data also confirm that *S. nigra* extracts block viral effects (Torabian *et al.* 2019). *S. nigra* flavonoids bind and prevent H1N1 infection in vitro by binding to H1N1 virions, blocking host cell entry and/or recognition (Roschek *et al*. 2009). *S. nigra* (as an extract or lozenge) can reduce flu symptoms, including fever, headache, nasal congestion, and nasal discharge in adults when taken within the first 48 h of symptom onset (Przybylska-Balcerek *et al.* 2021).

***Bergenia crassifolia* (L.) Fritsch.:** A perennial herb of the Saxifragaceae family, it has hemostatic, anti-inflammatory and antimicrobial properties (Żbikowska *et al.* 2017). *B. crassifolia* leaf extract exhibits antibacterial, antiviral, antitumor, antidiabetic, diuretic and immunostimulating activity (Tumova *et al.* 2018).

Betula pendula **Roth.:** A species of woody plants of the Betulaceae family. Studies have shown that *B. pendula* bud extract has activity against Quorum Sensing – the ability of some bacteria to communicate and coordinate their behavior through the secretion of molecular signals (Tolmacheva *et al.* 2014). An aqueous extract of *B. pendula* birch leaves inhibits the growth and division of inflammatory lymphocyte cells (Gründemann *et al.* 2011). Dried birch leaf extract has a relatively high antioxidant potential and can be used as a natural source of antioxidants (Penkov *et al.* 2018).

Polygonum aviculare **L.:** An annual plant of the Polygonaceae family. Its extracts show significant antimicrobial properties against gram-negative and gram-positive bacteria, as well as mycobacteria (tuberculous and non-tuberculous mycobacteria) (Millar *et al.* 2021). *P. aviculare* extracts also have wound healing and antioxidant properties (Seo *et al.* 2016).

Gentiana lutea **L.:** A perennial plant of the Gentianaceae family. Methanol extracts of its flowers and leaves have shown antimicrobial activity against a variety of gram-positive and gram-negative bacteria, as well as the yeast *C. albicans* (Savikin *et al.* 2009). *G. lutea* has antioxidant, anti-inflammatory, antimitogenic, antiproliferative and hypolipidemic effects, as well as cardioprotective, hypotensive, vasodilatory and antiplatelet effects (Jiang *et al.* 2021).

Dianthus superbus **L.:** A species of perennial herbs of the Caryophyllaceae family. Molecular studies have shown that quercetin 3-rutinoside and isorhamnetin 3-glucoside, abundant in *D. superbus*, have shown strong antiviral activity against influenza A and B viruses, providing a new line of research to develop possible natural anti-influenza drugs (Nile *et al.* 2020).

Hypericum perforatum **L.** A perennial herb from the Hypericaceae family that has long been used as a traditional treatment for skin wounds, burns, cuts and stomach ailments, including abdominal pain and ulcers. Recent studies have shown its properties to inhibit antiquorum sensitivity (anti-QS) and antibiofilm activity (Doğan *et al.* 2019). Its active components hypericin naphthodianthrone and hyperforin phloroglucinol are effective antibacterial compounds against various gram-positive bacteria (Lyles *et al.* 2017). The results of in vitro experiments confirmed that the antiviral component of *H. perforatum* significantly reduces the relative expression of ribonucleic acid (mRNA) and infectious bronchitis virus (IBV) titer (Chen *et al.* 2019).

Melilotus officinalis **(L.) Lam.:** A biennial herb of the *Fabaceae* family. In a study of *M. officinalis* extracts for antimicrobial, antioxidant and antibiofilm activity, the results show a greater effect on gram-positive bacteria than on gram-negative bacteria. Acetone extract of *M. officinalis* inhibits the formation of biofilms of bacteria *Proteus mirabilis* and *P. aeruginosa*. *M. officinalis* aqueous extract has high antioxidant activity. The flavonoid compounds in *M. officinalis* have antioxidant and anti-inflammatory properties (Khosroyar and Arastehnodeh 2018).

Chelidonium majus **L.:** A perennial plant of the Papaveraceae family. The latex of the herb *C. majus* has been used in folk medicine for many years to treat viral warts. It has been experimentally shown that *C. majus* may be a potential remedy for skin warts, especially in younger patients where conventional therapy can be difficult to apply (Nawrot *et al.* 2020).

Rumex confertus **Willd.:** A perennial plant of the Polygonaceae family. Studies have shown that *R. confertus* extracts have a differential inhibitory effect on the growth of gram-positive bacteria – staphylococci – and gram-negative bacteria – *E. coli, P. mirabilis, P. aeruginosa* (Wegiera *et al.* 2011). *R. confertus* fruit extracts showed moderate activity against *Candida spp.* and *Trichophyton mentagrophytes*. The data obtained indicate that the fruit of *R. confertus* can be considered as an alternative or adjuvant in the treatment of superficial mycoses (Kosikowska *et al.* 2011).

Juniperus communis **L.:** An evergreen coniferous shrub of the Cupressaceae family. It is used in several traditional medicinal systems for the treatment of various diseases, including rheumatism, arthritis and gout (Fernandez and Cock 2016). The hydroalcoholic extract obtained from *J. communis* has genoprotective, antioxidant, antifungal and anti-inflammatory properties (Fierascu *et al.* 2018). As a result of resource studies of the study area, it was found that most species of antibiotic plants grow near roads, in meadows and forest zones and have the status of weeds. The greatest floristic diversity was noted in flood-meadows and areas where the soils are sufficiently moist. The quantitative distribution of the plants found by us by families is extremely uneven. Of the 28 found and identified plant species, 8 species belong to the Asteraceae family, and 6 species belong to the Lamiaceae family. The rest of the plant species were distributed according to the principle “one species – one family”.

Some of the antibiotic plants we found, according to the pharmacopoeial publications (State Register of Medicines of the Republic of Kazakhstan 2001), are used in Kazakhstan as part of preparations for the treatment of cholecystitis, gastritis, insomnia, diseases of the stomach, liver, intestines, and brain function. Also, they are used as analgesics, for the treatment of helminthiasis, stomatitis, tonsillitis, wounds, ulcers, hemorrhoids and other diseases. But the majority of species of antibiotic plants, as our research has shown, do not form thickets of commercial value in nature. Some species are found locally or scattered. Some species grow in hard-to-reach, swampy places and in alpine conditions, some, like ruderal plants, grow near roads, in settlements, on fallow lands, etc. Therefore, many of them are cultivated and this covers the need for raw materials.

Public awareness of local antibiotic herbs

As a result of the analysis of the survey of the two age groups, the results were obtained, and the prevailing answer options are presented in Table 2. Based on the survey analysis results, it was evident that the population is poorly aware of local

Table 2: Phytochemical components of antibiotic plants of Central Kazakhstan

Species	Phytochemical Constituents
C. cyanus	**Flowers:** anthocyanin glycosides (cyanidin and pelargonidin diglucosides), flavones glycosides (apigenin and luteolin derivatives), flavonols (quercetin glucoside, 3-methyl-kaempferol, rutin, cicornin), vitamin C, carotene, tannins, essential oil, mucus, polyacetylene compounds (Lockowandt *et al.* 2019).
T. farfara	**Leaves** saponins, inulin, bitter glucoside tussilagin, tannins, ascorbic acid, carotenoid, gallic, malic and tartaric acids, sitosterol, dextrins, essential oil, flavonoids (Uysal *et al.* 2019).
H. arenarium	**Inflorescences and leaves**: flavonoid glycosides (salipurposide, kaempferol and isosalipurposide), flavonoids (naringenin and apigenin) (Morikawa *et al.* 2009). **Inflorescences**: phthalides, steroid compounds, dyes, essential oil, inositol, tannins, fatty acids, mineral salts (Czinner *et al.* 2000).
I. helenium	**Rhizome:** inulin, bitter substances, essential oil, saponins, resins, gum, a small amount of alkaloids, gelenin (Lunz and Stappen, 2021). **Essential oil:** allantolactone (proazulene, gelenin), resins, dihydroalantolactone, fridelin, stigmastern, phytomelan, pectins, wax, gum, vitamin E. **Leaves:** flavonoids, vitamins (ascorbic acid, tocopherol), bitter substances, tannins, lactones, fumaric, acetic, propionic acids (Bai *et al.* 2018).
C. officinalis	**Flowers:** carotenoids and flavonoids (carotene, lycopene, violaxanthin, citraxanthin, rubixanthin, flavoxanthin, flavochrome). **Inflorescences**: polysaccharides, polyphenols, resins, organic acids (malic, ascorbic and traces of salicylic acid) (Mlcek *et al.* 2021). **Herb:** up to 10% bitter substance calendene, triterpene saponin. In seeds: fatty oil (lauric and palmitic acids). **In roots**: inulin and a number of triterpene glycosides (derivatives of oleanolic acid) (Ak *et al.* 2021).
A. absinthium	**Herb:** sesquiterpene lactones, bitter glycosides (absinthine, anabsinthine, artabsin and artemisetin), saponins, flavonoids, phytoncides, ascorbic acid, resinous and tanning substances, potassium salts, artemisetin, carotene, organic acids (malic, succinic) (Szopa *et al.* 2020). **Essential oil:** thuyl alcohol (up to 10-25%), thujone (up to 10%), pinene, cadinene, phellandrene, β-caryophyllene, γ-selinene, β-bisabolene, curcumene and chamazulenogen (Ickovski *et al.* 2021).
M. chamomilla	**Inflorescences:** chamazulene, sequiterpene carbohydrates – farnesene and cadinene, sequiterpene alcohols – bisabolol, caprylic acid, sequiterpene lactones matricin and matricarin (Aćimović *et al.* 2021a). In addition, the inflorescences contain: carbohydrates and related compounds (pectic acid, xylose, arabinose, galactose, rhamnose, glucuronic acid), choline, polyacetylenic compounds, phenolcarboxylic acids and their derivatives (anisic, vanillic, syringic, chlorogenic, salicylic, caffeic acids), tannins, coumarins (umbelliferone, herniarin), flavonoids (apigenin, luteolin, quercetin, isorhamnetin, chrysoeriol, patuletin, cynaroside) (Bhukta *et al.* 2021).
G. uliginosum	**Herb:** flavonoids (gnafalosides A and B, luteolin, scutellarein, scutellarein glycoside, rutin, tricine, eupafolin, quercetin), chlorogenic and caffeic acids, carotenoids, as well as vitamin C, thiamine, resins, tannins, coumarins, alkaloids (gnafalin), essential oil, phytosterols, ascorbic acid (Olennikov *et al.* 2015).
A. millefolium	**Herb:** flavones, achillein alkaloid, coumarins, aconitic acid, bitter substances and tannins, resins, organic acids, inulin, asparagine, mineral salts, ascorbic acid, phylloquinone, carotene, choline (Benedek *et al.* 2007). **Leaves and inflorescences**: essential oil (cineole, camphor, thujol), sesquiterpenoids – achillin, acetylbalquinolide, caryophyllene, azulenes, esters, L-borneol, β-pinene, L-limonene, thujone, bornylacetate, cineole, camphor (Dias *et al.* 2013).
S. officinālis	**Leaves:** cineol, linalool, α- and β-pinene, borneol, thujone, linalyl acetate and other terpene compounds, tannins, vitamins P and PP; flavonoids: hispidulin, genquanin, 6-methoxygenquinine, salvitin, luteolin, 6-hydroxyluteolin, cirziliol, cynaroside, nepetine; alkaloids, resinous substances; triterpenoids: ursolic and oleanolic acids; diterpene salvin; phenolcarboxylic acids: chlorogenic, noochlorogenic, cryptochlorogenic, caffeic, rosmarinic; bitter principles, phytoncides (Turkmen 2021)
M. piperita	**Essential oil:** menthol (40–70%) and its esters, β-pinene, limonene, cineole, dipentene, pulegone and other terpenoids. Inflorescence oil also contains menthol, α-pinene, β-pinene, menthofuran, pulegone, sabinene hydrate, pereric acid (Motiee 2021). **Leaves**: organic acids, tannins, flavonoids, carotene, betaine, hesperidin, ursolic and oleanolic acids (Wu *et al.* 2019).
T. vulgaris	**Herb:** thymol and liquid carvacrol, cymol, borneol, pinene, terpinene, terpineol, tannins, ursolic, caffeic, chlorogenic and oleanolic acids, flavonoids, bitter principles and mineral salts (Popa *et al.* 2021).
T. serpyllum	**Herb:** thymol, carvacol, n-cymol, a-terpineol, borneol, tannins, bitter principles, gum, triterpene compounds (ursolic and oleanoic acids), flavonoids (Malankina *et al.* 2019)
O. vulgare	**Herb:** thymol (up to 40%), cymol, carvacrol, sesquiterpenes, geranyl acetate, selinene, α-thujone, α-, flavonoids: apigenin, luteolin, 7-glucuronide, luteolin-7-glucoside, isoroifolin, cosmosiin; ascorbic acid and tannins (Zhao *et al.* 2021).
H. officinalis	**Herb**: triterpenic acids (oleanolic and ursolic), tannins and bitter substances, resins, gums, pigments. **Essential oil:** 1-pinocamphone, α-pinene (1%), β-pinene (5%), cineole, camphene, 1-pinocampheol and its acetic ester, sesquiterpenes (Aćimović *et al.* 2021b).
A. calamus	**Rhizomes**: monoterpenes (camphene, camphor, borneol) and sesquiterpenes (acorone, isoacorone, acoroxide, etc.), aromatic compounds (azaron, eugenol), bitter glycoside acorin, bitter principle acoretin, tannins, ascorbic and palmitic acids, starch, choline, vitamins, iodine. The smell of rhizomes is due to azarylaldehyde (Chellakannu and Paneerselvam 2020).
L. palustre	**Herb:** ledol, palustrol, η-cymol, geranyl acetate, glucosides (ericolin, arbutin); andromedotoxin; coumarins (esculin, esculetin, scopoletin, umbelliferon etc.), flavonoids (quercetin, hyperoside); tannins; phytoncides; vitamin C; dyes; micro and macro elements (Zhao *et al.* 2017).
S. nigra	**Flowers**: flavonoids, organic acids (malic, acetic, valeric, chlorogenic), terpenes, sambunigrin glucoside, sambucin, rutin; essential oil, vitamin C, antiseptics – benzaldehyde and cynates. **Fruits**: ascorbic acid, glucose, fructose, malic acid, vitamin C, tannins, carotene, anthocyanin. Unripe fruits contain the poisonous glycoside sambunigrin (breaks down into hydrocyanic acid and benzaldehyde) (Radojković *et al.* 2021).
B. crassifolia	**Rhizomes:** tannins, phenolic compounds, phenolcarboxylic acids, a coumarin derivative – bergenin, isocoumarins, catechins, starch, sugars, mineral salts. **Leaves**: gallic acid, coumarins, flavonoids, vitamin C, carotene and arbutin, plus 2-4% free hydroquinone (Akzhigitova *et al.* 2020).
B. pendula	**Buds essential oil**: betulin, betulol, betulenolic acid. **Leaves:** betuloretinic acid, ascorbic acid, carotene, triterpene alcohols, flavonoids, leucoanthocyanides, sterols, hyperoside, tannins, saponins (Rastogi *et al.* 2015).
P. aviculare	**Herb**: tannins; flavonoids (avicularin, hyperin, isorhamnetin, myricetin, quercetin, kaempferol), vitamins C, E, carotene; coumarins (scopoletin, umbelliferon), phenolcarboxylic acids (gallic, caffeic, β-coumaric, chlorogenic), anthraquinones, silicic acid compounds (up to 4.5%), resins, mucus, fats, sugars, macronutrients: potassium, calcium, magnesium, iron; trace elements (Seo *et al.* 2016).
G. lutea	**Roots and herb:** monoterpene glycosides – bitter principles (gentiopicrin and amarogencin, gentin, gentisin, gentiamarin, gentiacaumol, gentianose), flavonoids, gentianin alkaloids and iridoids, catechins, polysaccharides, pectin substances, ascorbic acid, fatty oils, essential oil, tannins, mucus and resin (Citová *et al.* 2008).
D. superbus	**Herb**: triterpene saponins (diantosides) and heterocyclic oxygen compounds (3,4-dihydroxy-2-methylhydropyran and barbapyroside); flavonoids (orientin, homoorientin), tannins (pyrocatechol derivatives), traces of alkaloids (Yang *et al.* 2017)
H. perforatum	**Herb**: tannins; flavonoids (hyperoside, rutin, quercetin, quercitrin and isoquercitrin), carotene, antibiotic hyperforin; leukoanthocyanides and anthocyanins; cineole; resins, nicotinic and ascorbic acids, vitamins P and PP, choline, anthocyanins, saponins, alcohols (Belwal *et al.* 2019).
M. officinalis	**Herb**: coumarins and their derivatives (coumarin, dicoumarol, dihydrocoumarin, melitoside glycoside), flavonoids (robinin, flovin, kaempferol and its derivatives), melilotin, polysaccharides (mucus), saponins, purine derivatives (allantoin), phenolcarboxylic acids (hydroxycinnamic, coumaric, melilotic), phenolic triterpene compounds. The pleasant smell of the plant is given by coumarin and melilotin (Sisay *et al.* 2021).
C. majus	The plant is poisonous, contains isoquinoline alkaloids, benzophenanthridine derivatives: homochelidonine, chelerythrine, chelidonine, sanguinarine, protopine and others (over 20 alkaloids) (Arora and Sharma 2013).
R. confertus	**Roots:** anthraquinones (chrysophanein, glucofrangulaemodin, rheochrysin, glucoaloe-emodin and glucorein), tannins, flavonols (quercetin and its glycosides – hyperoside, rutin, as well as quercetin flavone bioside – rumarin) and leukoanthocyanidins (leukoanthocyanidin, leukodelphinidin, leukopelargonidin), phenolcarboxylic acids (caffeic, chlorogenic), citric and lactic acid, traces of essential oil, oxycoumarins, iridoids, steroids, resins. **Leaves**: anthracene glycosides, flavonoids (hyperin, rutin), tannins, ascorbic acid, carotene, hydroxycinnamic acids (caffeic and chlorogenic acids), oxalic acid (Tynybekov *et al.* 2013).
J. communis	**Fruits**: terpenoids (α-pinene, cadinene, camphene, α-terpinene, dipentene, sabinene, borneol, isoborneol, α-phellandrene, juniper camphor, etc.), as well as sugars (up to 40%), resins (up to 10%), organic acids (formic, acetic and malic), flavonoids, pectins (pentosans), vitamin C, dyes (juniperin), fatty oil, wax and trace elements (manganese, iron, copper and aluminum) **(**Orav *et al.* 2010).

plants with antibiotic effects. Thus, the respondents of the first group (18–25 years old) recognized only banal plant species that are part of the well-known syrups and lozenges for colds- *T. farfara, C. officinalis, S. officinālis, T. vulgaris L., H. perforatum* and *C. majus.* But 70% of native plants with antibiotic effect are unknown to them and they prefer pharmacological preparations, the use of which does not take time to prepare or brew.

The second group (35–55 years old) showed greater awareness and desire to use natural herbs as a source of antibiotics. 50% of the plants on the list were familiar to many respondents, and they used them systematically in the treatment of colds and viral infections (with the exception of *A. absinthium* because of its bitter taste).

Discussion

Since their discovery, antimicrobial drugs have become an integral part of modern healthcare, allowing the treatment of previously life-threatening bacterial infections. However, the massive and irresponsible use of antibiotics has contributed to the emergence of resistant strains. Rapid emergence of antimicrobial resistance is now a global public health crisis and has been named one of the most significant global public health problems by the World Health Organization (Bianco *et al.* 2020). In addition, the World Health Organization (WHO) recently updated its priority list of 12 bacterial pathogens for which there is a need to develop new antibiotics (WHO 2017). Multidrug resistant pathogens such as ESKAPE (e.g., *E. faecium*, *S. aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *P. aeruginosa*, and *Enterobacter*) are considered to be virtually resistant to most antibiotics available and play a critical role in the rise in nosocomial infections (Ghosh and Saha 2020). The emergence of multidrug-resistant pathogens is of great concern to the global health community. Our ability to treat diseases effectively is based on the discovery of powerful drugs to treat these complex diseases. Traditional medicines are one of the main sources of search for safe, effective and cost-effective drug candidates (Ayaz *et al.* 2016). In addition to the need to find new drugs due to bacterial resistance, there has been a shortage of drugs as a result of disruptions in the supply chain and reduced exports during the 21st century pandemic (Rusen 2020).

Mankind has used plants as medicines to treat dangerous diseases, and they are still popular for developing new drug candidates. Plants contain a combination of phytochemicals, also known as secondary metabolites, that occur naturally and provide various therapeutic benefits (Sener 2020).

Studies of the biodiversity of plants with antibiotic properties in the territory of Central Kazakhstan were carried out for the first time. As a result of the work done, the following data were obtained: 28 plant species with antibiotic properties belonging to 26 families grow in the territory of Central Kazakhstan. Among them, the most numerous are the *Compositae* family – 8 species and the *Labiatae* family – 6 species. The rest of the plant species were distributed according to the principle "one species – one family".

Also, these plants are candidates in experiments to find new drugs for diseases such as obesity, diabetes, oncology. For example, in experiments with induced neuroinflammation, aqueous fraction of *Acorus calamus L.* caused the prevention of memory deficits and a decrease in anxiety levels by controlling oxidative stress and inflammatory processes (Esfandiari *et al.* 2018). *L. palustre* extract reduced serum uric acid levels in patients with gouty arthritis and hyperuricemia (Singh *et al.* 2021). *S. nigra* flavonoids prevented H1N1 infection in vitro by binding to H1N1 virions, blocking host cell entry (Roschek *et al.* 2009). Fermented leaf extracts of *B. crassifolia* significantly improved glucose tolerance and reduced serum triglyceride levels in rats (Shikov *et al.* 2012). Antioxidant and antitumor activity of *C. cyanus* extract was studied on a colon cancer cell line (HT29). The results of the experiment showed that the extract has a significant antibacterial and anticancer effect (Escher *et al.* 2018). The results of an experiment in a mouse model of restraint stress showed that treatment with *P. aviculare* reduced fatigue, suppressed neuroinflammation and expression of hormones associated with fatigue (Park *et al.* 2018). Hypericin contained in *H. perforatum* improved the viability of liver cells by reducing apoptosis and attenuated lipid accumulation in hepatocytes (Liang *et al.* 2020). *M. officinalis* improved brain tissue health in rats with cerebral ischemia by reducing cerebral thrombosis, oxidative stress, and inflammatory mediators (Zhao *et al.* 2017) Aqueous extracts of *I. helenium* exhibited antiproliferative and cytotoxic activity, and it can be considered as a potential antitumor agent for brain cancer (Koc *et al.* 2018). The research results indicate that the hydroalcoholic extract of *C. officinalis* flowers in the study of diabetes mellitus reduced the concentration of insulin and restored the functions of beta cells (Ebrahimi *et al.* 2019). Methanol extracts of *A. millefolium* had a high antioxidant activity and reduced the strong inhibition of lipid peroxidation. This suggests potential use as a therapy for neurodegenerative conditions such as Alzheimer's disease (Barut *et al.* 2017). There is an assumption that *T. serpyllum* has antihyperlipidemic and hepatoprotective effects (Mushtaq 2017). The extract of *C. majus* altered the expression of genes associated with apoptosis and induced apoptosis in hematopoietic cells (Och *et al.* 2019). An *in vivo* evaluation study of *S. officinālis* in mice with induced Alzheimer's disease found that this extract at 300 mg/kg significantly reduced elevated levels of lipid peroxidation enzymes and also significantly increased levels of antioxidants in brain tissue, making it effective against Alzheimer's disease (Datta and Patil 2020).

A critical assessment of the literature on the medicinal properties of the found plants irrefutably shows that they have a huge therapeutic potential. But, due to natural habitat conditions – growing in hard-to-reach, swampy places and in alpine conditions, as well as local or scattered growth – they do not form thickets of commercial value in nature.

Plant sources have a long history of medicinal use. Herbs have been invariable sources of both protective and therapeutic traditional medicine preparations for people since ancient times. The World Health Organization forecasted that about 60% of the worlds inhabitants in developing countries trust herbs for curing a variety of illnesses, owing to the lack of modern healthcare resources. The use of traditional medicines is usually influenced by the availability and acceptability of medical services. Medicinal plants, especially in remote regions of developing countries, may be the only source of health available (Karakaya *et al.* 2020). Therefore, many developing countries are studying the biodiversity of local plants, searching for new sources of phytoactive substances. Research on the public knowledge of local medicinal plants is also being conducted (Aworinde and Erinoso 2015).

The analysis of our survey of two age groups showed that the older generation (35–55 years old) is more aware of plant species with antibiotic properties and is more willing to choose natural herbs as medicines. The other group (18–25 years old) recognizes only banal plant species that are part of well-known syrups and lozenges for colds, and prefers pharmacological preparations, the use of which does not take time to prepare. This indicates the incomplete formation of survival knowledge among the younger generation living in Central Kazakhstan. Fundamental survival knowledge includes knowledge of medicinal plants, food plants and hunting strategies. This requires considerable social research.

Conclusion

Based on the above data, it can be concluded that a sufficient number of plants with antibiotic properties grow in the territory of Central Kazakhstan. Reportedly, these plants hold great promise for further study of their medicinal properties and their use as medicines. Given their low cost and availability, we believe that they need to be popularized among the younger generation and recommended for commercial use.

Author Contributions

Pozdnyakova Yelena participated in an expedition to collect and identify plants, wrote a manuscript. Omarova Gulnara participated in an expedition to collect and identify plants, did a literature search. Murzatayeva Aigul participated in an expedition to collect and identify plants, translated the manuscript.

Conflicts of Interest

All authors declare no conflict of interest.

Data Availability

Data presented in this study will be available on a fair request to the corresponding author.

Ethics Approval

Not applicable in this paper

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