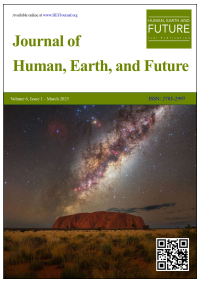
Available online at www.HEFJournal.org

ISSN: 2785-2997

Journal of
Human, Earth, and Future

Vol. 6, No. 1, March, 2025



Assessing Biodiversity, Health Benefits, and Knowledge of Wild Edible Plants in Rural and Urban Areas

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Received 04 November 2024; Revised 09 February 2025; Accepted 14 February 2025; Published 01 March 2025

Abstract

This study examines the diversity of wild fruit trees and shrubs in Central Kazakhstan and the preservation of traditional knowledge about their nutritional and medicinal uses. The objectives included identifying taxonomic composition, analyzing nutritional and medicinal properties, and assessing awareness among rural and urban residents of different age groups. Fieldwork involved route surveys, herbarium collection, and laboratory identification using classical floristic references. A survey (n=240) was conducted among youth (18–25 years) and older adults (35–65 years) in rural (Karkaraly) and urban (Karaganda) areas. A total of 28 species from nine families were identified, with the Rosaceae family having the highest diversity (12 species). Older rural residents demonstrated greater awareness and frequent use of wild plants for nutrition and medicine, while younger and urban populations showed lower awareness and use. Generational and geographic divides were evident, with younger generations less engaged in traditional practices. This study provides a detailed account of wild fruit species biodiversity and uses in a region with limited ethnobotanical data. The findings highlight the need to conserve plant gene pools, preserve cultural heritage, and promote the integration of wild species into modern diets and phytotherapy practices, fostering sustainability.

Keywords: Biodiversity; Central Kazakhstan; Plants; Wild Edible Plants; WEPs; Wild Fruit.

1. Introduction

Throughout human history, mushrooms, wild berries, fruits, nuts, and wild vegetables have played a significant role in human nutrition. Wild fruit-bearing plants can serve as a valuable supplement to the main diet, enhancing its nutritional value and diversity, particularly for rural populations [1, 2]. In recent years, there has been a growing interest in preserving biodiversity worldwide, including the protection of forest ecosystems [3]. Wild fruit trees and shrubs serve not only as an accessible source of food but also as medicinal raw materials. They contain numerous bioactive components, such as flavonoids and anthocyanins. Several studies have demonstrated that wild fruits possess a range of beneficial properties, including antioxidant, anti-inflammatory, antimicrobial, antitumor effects, and the ability to scavenge free radicals [4]. Due to these properties, wild fruits can be utilized in the development of functional foods and pharmaceutical products for the prevention and treatment of various chronic diseases [5].

Moreover, they contribute to food security both during regular periods and in times of crop failure [6]. To address the ongoing population growth and global climate changes, a wide range of edible plants is required to ensure stable and reliable food supplies [7].

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http://dx.doi.org/10. 28991/HEF-2025-06-01-09

In developed countries, there is an increasing loss of knowledge about wild edible plants and their culinary uses. Urbanization, lifestyle changes, and the preference for industrially produced food are gradually displacing awareness of the abundant natural resources available in the wild [8]. This leads to the loss of cultural heritage as well as valuable sources of nutrition and medicinal remedies. However, for ensuring a nation's strategic security, it is critically important to possess comprehensive knowledge about wild edible plants, including fruit-bearing trees and shrubs, growing within its territory. Such information could become essential during crises or emergencies [9].

Many arid regions have highly fragile ecosystems and are particularly vulnerable to the adverse effects of global warming [10]. Among these areas are the arid zones of Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan), which are characterized by unique natural conditions and ecological features. According to recent studies, severe environmental issues have intensified in these regions over the past few years: the glaciers of the Tien Shan are rapidly shrinking [11], the surface area of the Aral Sea continues to decrease [12], and the processes of land degradation and desertification are accelerating [13]. These factors weaken vegetation cover and heighten the risk of desertification [14]. Additionally, human activities, such as changes in land use, urban expansion, and the construction of transportation infrastructure, are contributing to the disappearance of valuable wild plants, including individual economically and ecologically important species (medicinal, fodder, melliferous, and ornamental plants) as well as entire plant communities [9].

The regions of Central Asia have accumulated substantial experience in studying and conserving the biodiversity of fruit trees in various natural and agro-landscape conditions. In Kyrgyzstan, a significant decline in traditional varieties of apple, pear, and apricot has been observed, particularly in the Issyk-Kul region [15]. Similar research has been conducted in the walnut-fruit forests in southern Kyrgyzstan, which harbor unique communities of wild relatives of cultivated plants, remarkable for their area and species diversity [16]. This region is one of the centers of origin for many fruit species, including apple (*Malus*), walnut (*Juglans regia* L.), almond (*Prunus dulcis* (Mill.) D.A.Webb), and apricot (*Prunus armeniaca* L.). Despite the high value of these forests, their genetic diversity is under threat due to the lack of natural seed regeneration and insufficient reforestation efforts [17].

Uzbekistan also has a rich tradition of utilizing wild fruit crops, particularly walnut (*Juglans regia* L.), which forms small populations in the mountainous regions of the Western Tien Shan and Pamir-Alay. Studies of the morphological and biochemical characteristics of its fruits reveal a high level of variability and the presence of promising forms for breeding [16]. Additionally, the local population extensively uses wild plants in both culinary and medicinal practices, with at least 39 species described as being incorporated into traditional dishes [18].

In Kazakhstan, research on the biodiversity of fruit trees is being conducted in several mountainous regions where large populations of wild and semi-cultivated forms are concentrated. For instance, 52 species of wild fruit and berry plants, belonging to 22 genera and 12 families, have been identified in the Kazakh Altai. The highest number of species belongs to the families Rosaceae, Caprifoliaceae, and Grossulariaceae, indicating a rich species composition [19]. In the Kazakh ranges of the Tien Shan, the phytocoenotic diversity of wild relatives of cultivated plants is even more significant, with 289 species recorded, representing 39 families and 145 genera [20].

Central Kazakhstan lies in a region characterized by arid and semi-arid climates, where the scarcity of surface water, low precipitation levels, and highly uneven seasonal rainfall distribution are pronounced challenges. Despite the vast territory of the region hosting a significant number of vascular plant species, a review of the scientific literature reveals that very few studies have been specifically dedicated to the biodiversity of useful plants in Central Kazakhstan [21–24]. This underscores the need for in-depth research in this area. Moreover, there is a complete lack of data on the ethnobotanical knowledge of the local population regarding wild fruit plants found in this region.

The aim of our study was to determine the species diversity of fruit and berry trees and shrubs in Central Kazakhstan and to assess their nutritional and medicinal value. We sought to uncover traditional recipes involving these fruits and, based on scientific literature, identify their medicinal properties. Additionally, we planned to conduct a survey among residents of two settlements – one urban and one rural – to determine the extent to which these plants are used for food and medicinal purposes. This approach would allow us to evaluate the preservation level of traditional knowledge and the potential for utilizing wild fruit plants in modern society.

2. Material and Methods

2.1. Study Area

The study was conducted in the Central Asian region, encompassing Central Kazakhstan. This area includes steppe and semi-desert zones, such as the Turgay Plateau in the west and the Kazakh Uplands (Kazakh Melkosopochnik) in the central and eastern parts. The remoteness of the steppes from oceans creates a sharply continental climate characterized by cold winters, hot summers, and short transitional seasons of spring and autumn. Annual precipitation varies and averages around 300 mm. The winter season is influenced by arctic and temperate air masses, which are low in moisture, resulting in limited precipitation (50–75 mm from November to March) and shallow snow cover (an average of 40 cm),

leading to significant soil freezing. The transition between seasons is rapid: in spring, the soil warms quickly due to warm air masses from the south, raising summer temperatures to 20–24°C in July and occasionally up to 35°C. During the warm season, strong winds contribute to soil erosion and dust storms and exacerbate the dryness of the region. Droughts occur regularly [25].

This study took place as part of the traditional summer practice for biology students from May to August 2022-2023. The primary method employed in the field studies involved route exploration. The route passed around the settlement of Karkaraly, which is part of the Karkaraly National Park area, located in the eastern part of the Kazakh Uplands. The route covered an area between coordinates 49°27′N 75°22′E and 49°21′N 75°34′E (Figure 1).

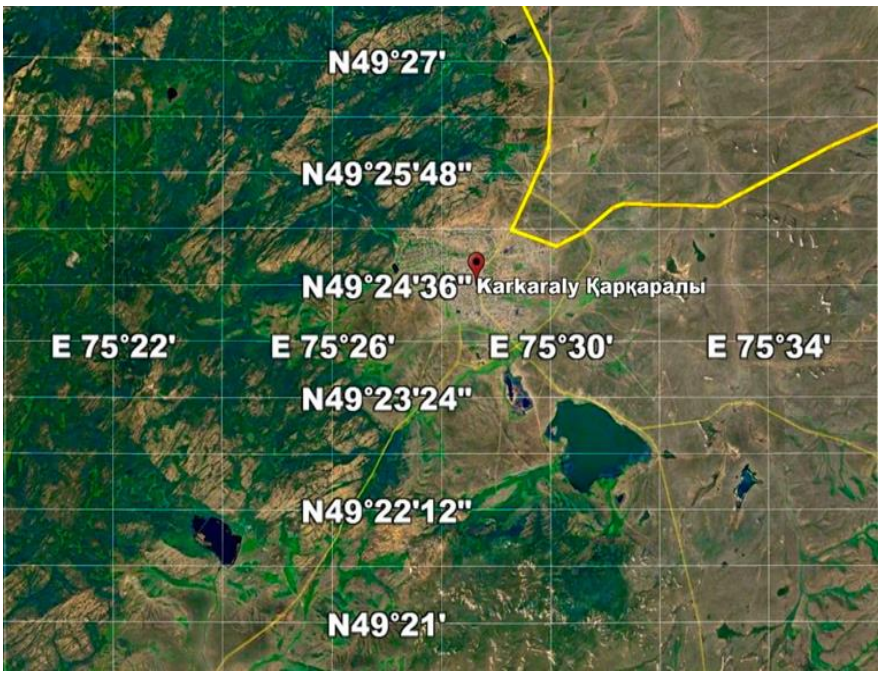

Figure 1. Territory of the field research route

In terms of plant diversity, the primary forest type in this region consists of birch and aspen stands. Their edges form plant associations that include herbaceous species, sagebrush, and shrubs. Among the shrubs, species such as *Lonicera tatarica* L. and *Spiraea hypericifolia* L. dominate, while the understory is characterized by *Artemisia gracilescens* Krasch. et Iljin (syn.: *Seriphidium gracilescens* (Krasch. & Iljin) Poljakov). The steppe zones are covered by herbaceous and feather grass communities, represented by species such as *Ziziphora clinopodioides* Lam., *Achillea millefolium* L., *Calamagrostis epigeios* (L.) Roth, and others. Hilly areas are characterized by sagebrush and feather grass associations, particularly in gravelly zones. On rocky and gravelly areas, lithophytic shrub thickets develop, including species such as *Juniperus sabina* L., *Ziziphora clinopodioides* Lam., *Hypericum scabrum* L., and *Thymus crebrifolius* Klokov. In lower-lying areas and along forest edges, steppe meadows occur, supporting species such as *Inula aspera* Poir. (syn.: *Pentanema asperum* (Poir.) G.V.Boiko and Korniy.), *Thymus marschallianus* Willd. (syn.: *Thymus pulegioides* subsp. *pannonicus* (All.) Kerguélen), *Veronica spicata* L., *Sanguisorba officinalis* L., and *Artemisia absinthium* L. [26].

2.2. Sample Identification

The processing of collected materials in the laboratory was carried out in full compliance with established standards [27, 28]. Herbarium specimens were deposited in the herbarium collection of the Karaganda Medical University, at the Department of Biomedicine. The identification of collected samples was performed using major floristic publications describing the plant world of Kazakhstan, including “Flora of Kazakhstan” [29]. The scientific names of plants were provided in accordance with the international database Plants of the World Online (*http://www.plantsoftheworldonline.org/*).

Additionally, a search for recent studies on the medicinal properties of the identified wild fruit trees and shrubs was conducted. The search was carried out in scientific databases such as Google Scholar, Medline, and Scopus, using keywords that included the Latin names of the identified species.

2.3. Survey

The survey was conducted among rural residents (Karkaraly village) and urban residents (Karaganda city). Karaganda, located in the central part of Kazakhstan, is one of the country’s leading industrial centers, historically renowned as a coal-mining region. The city has a population of approximately 500,000 people, a significant portion of

whom are employed in industrial, commercial, and cultural sectors that drive the region's economic development. Karkaraly, in contrast, is a small settlement situated within the Karkaraly National Park in the Kazakh Uplands, to the east of Karaganda. This village is known for its unique natural landscapes and rich biodiversity. The primary activities of the local population include agriculture, tourism, and conservation work, owing to its proximity to the ecologically significant areas of the national park (Figure 2).

Figure 2. Location of Karaganda and Karkaraly settlements

The survey included 240 respondents, divided into four categories: rural residents aged 18–25, rural residents aged 35–65, urban residents aged 18–25, and urban residents aged 35–65, with 60 participants in each group. The participants were grouped into two age categories: 18–25 years (Group 1) and 35–65 years (Group 2), with gender and ethnicity not taken into account. Each respondent was provided with a list of photographs of edible trees and shrubs native to the region, labeled with their names in Kazakh and Russian. The questionnaire consisted of four main questions: "Do you know that this plant is edible?", "Do you personally consume this plant?", "Are you aware that this plant has medicinal properties?", and "Do you use this plant for treating any illnesses?".

2.4. Statistical Methods

GraphPad Prism software version 8.0.1 was used for statistical analysis. The data were presented as mean values and expressed as percentages. The chi-square test was applied to determine the significance of associations and differences between categorical variables. Results with a p-value of less than 0.05 were considered statistically significant. Heat maps were used to visually represent the data and assess the distribution of knowledge and use of edible plants among different age groups of respondents.

Figure 3 shows the flowchart of the research methodology through which the objectives of this study were achieved.

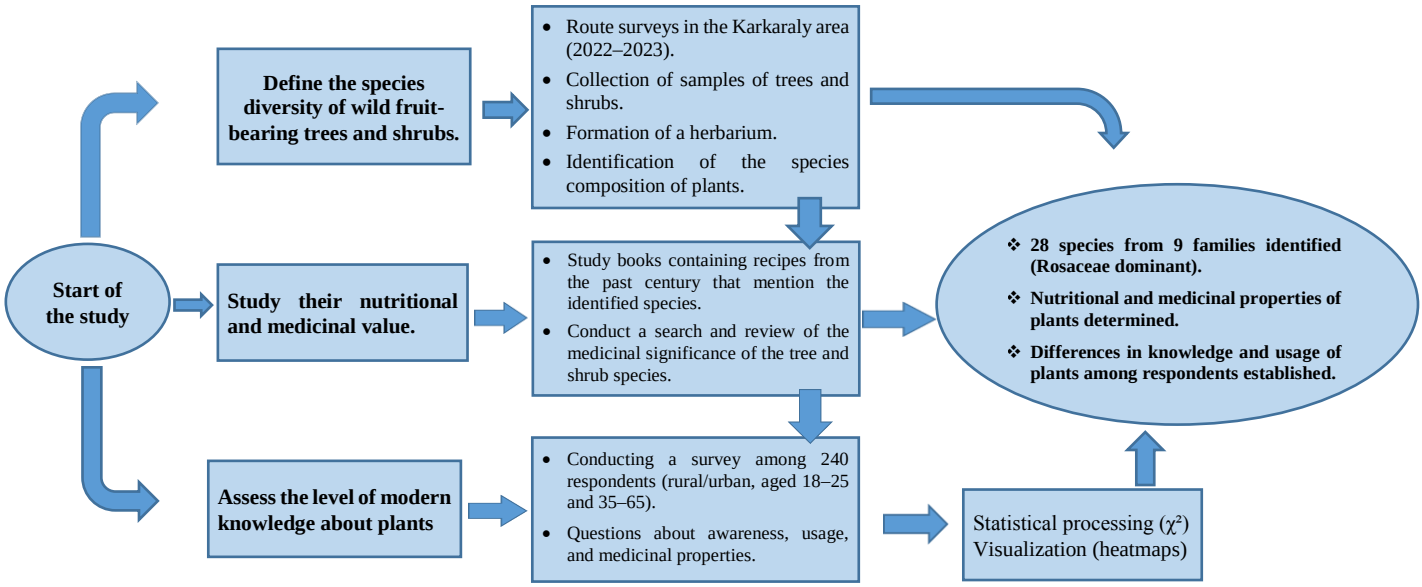

Figure 3. Research Flowchart

3. Results

3.1. Biodiversity, Nutritional and Medicinal Value of Fruit Trees and Shrubs in Central Kazakhstan

As a result of the research, we have discovered and determined the nutritional and biological value for the following tree and shrub species (Figures 4 to 8):

Betulaceae Family

Betula pendula Roth. is a deciduous tree that can grow up to 20 meters in height. It is an important source of sap, rich in glucose, fructose, organic acids, as well as calcium, potassium, and zinc salts [30]. Birch sap is commonly used as a beverage and as an ingredient in dough preparation. Studies have shown that extracts from the buds of *B. pendula* can inhibit quorum sensing, a molecular signaling process by which bacteria coordinate their behavior [31]. Additionally, aqueous extracts from birch leaves suppress the growth and division of inflammatory lymphocytes [32], while dry extracts demonstrate significant antioxidant activity, making them a natural source of antioxidants [33]. In traditional medicine, birch sap is used to strengthen the body in cases of furunculosis, tonsillitis, trauma-induced anemia, and for the treatment of long-lasting wounds and trophic ulcers [34].

Corylus avellana L. is a deciduous shrub that grows to a height of 3 to 8 meters. Its primary edible product is the nut, commonly referred to as hazelnut. Hazelnuts are consumed raw, used in baking (e.g., cakes, cookies, pastries), and incorporated into chocolates and confectionery. They are also utilized in the production of hazelnut oil and pastes, such as commercial spreads like Nutella. In medicine, hazelnuts and other parts of the plant are used to support cardiovascular health [35], act as an astringent, treat varicose veins [36], and improve the condition of skin and hair [37].

Rosaceae Family

Crataegus sanguinea Torr. and A. Gray (Syn: *Crataegus macracantha* Lodd. ex Loudon) is a tall shrub, occasionally a small tree, reaching heights of 1–4 meters. Its edible berries have soft, sweetish, farinaceous pulp and are rich in flavonoids [38]. Hawthorn is recommended for cardiovascular diseases, myocardial infarction, and the early stages of hypertension [39]. Recent studies have demonstrated that *C. sanguinea* extracts exhibit antimutagenic and antitumor effects [40].

Cerasus fruticosa Pall. grows as a dense shrub, ranging from 0.5 to 2 meters in height. The fruits, with a pleasant sweet and sour taste, are utilized in making jams, compotes, kissels, lemonades, and kvass [41]. *C. fruticosa* is a rich source of organic acids, carotenoids, tocopherols, chlorophyll, and phenolic compounds [42]. It is used to treat low hemoglobin [43].

Aronia melanocarpa (Michx.) Elliott is a multibranch shrub, reaching heights of 2.5–3 meters. Its purplish-black berries can be used as pie filling or to make jelly [44]. *A. melanocarpa* berries contain anthocyanins and exhibit high antioxidant activity [45]. The juice helps strengthen blood vessel walls, while the leaves contain substances that improve liver function, bile formation, and outflow [46]. Studies suggest that anthocyanin-rich foods can improve hyperlipidemia and liver steatosis [47].

Cotoneaster uniflorus Bunge. is a deciduous spreading shrub, reaching heights of up to 0.5 meters. Its dryish, farinaceous, sweet berries are edible, although their taste may not be very appealing [48]. The plant's medicinal properties are utilized in treating various ailments, including acute and chronic gastritis, gastroenteritis, and diarrhea [46].

Cotoneaster melanocarpus Fisch. ex A. Blytt is a deciduous shrub with a spreading crown, growing up to 2 meters tall. Its fruits are edible, and modern research suggests that the use of *C. melanocarpus* can be beneficial in treating neonatal jaundice [49].

Figure 4. A – Betula pendula Roth., B – Crataegus sanguinea Torr. and A. Gray, C – Cerasus fruticosa Pall., D – Aronia melanocarpa (Michx.)

Rubus idaeus L. is a deciduous subshrub with a perennial rhizome, from which biennial aerial stems grow, reaching a height of 1.5–2.5 meters. Its edible berries are consumed fresh or dried, often paired with milk or cream, and are used in various culinary preparations, including jams, syrups, jellies, fruit leather, and kissel [41]. *R. idaeus* is widely used as a traditional remedy for colds, with both its fruits and leaves possessing medicinal properties. The leaves, known for their astringent qualities, are used to stop diarrhea and bleeding, while decoctions and infusions are recommended for coughs, sore throats, and as a gargle [50]. The berries of *R. idaeus* exhibit significant antioxidant activity and neuroprotective properties, making them a promising agent in combating oxidative stress associated with diabetes [51, 52].

Rubus fruticosus L. is a deciduous shrub that grows to a height of 1.5 to 3 meters. The primary edible part of the plant is its berries, which are consumed fresh and used in the preparation of various products such as jams, jellies, compotes, juices, syrups, and baked goods [53]. The leaves and roots of the plant are used to prepare infusions and decoctions that are effective in treating diarrhea and inflammatory throat conditions [54]. The berries are rich in vitamins and antioxidants, which contribute to strengthening the immune system [55]. Infusions made from the leaves are often used to improve skin health and possess astringent properties [56].

Rosa spinosissima L. is characterized by sprawling bushes with curved shoots, reaching heights of 2.5 meters and widths of 1.5 meters. Dried leaves and fruits are used as a tea substitute due to their high content of polyphenols, carotenoids, and vitamins B, C, and E [57]. The exceptionally dark color of its fruits, attributed to the high anthocyanin content, distinguishes *R. spinosissima* from other *Rosa species* [58].

Sorbus sibirica Hedl. is a small tree or shrub reaching a height of 3 to 10 meters. Its orange-red berries, with an astringent and sweet-bitter taste, are typically consumed after the first frost. These berries are widely used in culinary applications, including the preparation of jams, fruit pastes, jellies, vinegar, and kvass. Additionally, they are dried and ground into flour, which is used for baking pies and confectionery products [48]. The fruits of *S. sibirica* are renowned for their preventive and medicinal properties, helping to address conditions such as hypovitaminosis, anemia, asthenia, atherosclerosis, hypertension, rheumatism, gout, kidney and bladder diseases, urolithiasis, and subacid gastritis [59, 60]. Ethanol extracts of the berries have demonstrated the ability to reduce the viability of human lung adenocarcinoma cells, indicating their potential anticancer properties [61].

Prunus padus L. is a deciduous tree or large shrub reaching a height of 5 to 15 meters. The primary edible part of the plant is the berries. The berries are consumed fresh and used to make jams, jellies, compotes, tinctures, and baked goods. [59] The leaves and berries are used to prepare infusions and decoctions for treating bronchitis, inflammatory throat diseases, antiseptic treatments, and as an astringent [62, 63]. The berries are rich in vitamins and antioxidants, which help strengthen the immune system [64].

Figure 5. A – Rubus idaeus L., B – Rubus fruticosus L., C – Rosa spinosissima L., D – Sorbus sibirica Hedl

Amelanchier alnifolia Nutt. is a deciduous shrub or small tree, reaching heights of 1–8 meters. Its fruits are consumed fresh or processed into various culinary products such as jam, marshmallow, jelly, and wine. Juice from the fruits is used for gargling and treating sore throats, while decoctions of bark and leaves serve as astringents and enveloping agents [65-67].

Prunus spinosa L. is a highly branched shrub that can grow up to 3 meters in height. Its sweet and sour fruits are widely used in culinary applications, such as in the preparation of compotes, jams, and as a flavor enhancer in soups [44]. In traditional medicine, the fruits of *P. spinosa* are valued for their beneficial properties in treating gastrointestinal disorders, blood purification, and as a dietary and anti-inflammatory remedy. The plant's flowers are used for their diuretic, diaphoretic, laxative, detoxifying, and blood-cleansing effects, while the leaves are applied in the treatment of kidney diseases [50]. *P. spinosa* is rich in phenolic and flavonoid compounds, anthocyanins, and also contains dichloromethane and ethyl acetate [68].

Caprifoliaceae family

Lonicera altaica Pall. (Syn: Lonicera caerulea subsp. altaica (Pall.) Gladkova) is a densely branched shrub that grows up to 2 meters in height. Its berries, with a slight bitterness, are suitable for fresh consumption and are also used to prepare jams, kissels, jellies, and various beverages [41]. In traditional medicine, the fruits and other parts of the plant are used to stop bleeding and to treat gallbladder diseases, hypertension, and gastrointestinal disorders [50]. Extracts of *L. altaica* exhibit strong antioxidant, antiviral, antibacterial, and antifungal properties. Scientific studies confirm that *L. altaica* contains significant amounts of flavonoids, phenolic compounds, terpenoids, sugars, alkaloids, tannins, saponins, and cardiac glycosides, which contribute to the high antioxidant activity of the plant's extracts [69].

Viburnum opulus L. is a shrub or small tree reaching a height of 1.5 to 4 meters. Its fruits have a distinctive aroma and a bitter taste, which becomes milder after exposure to frost. The fruits are used to prepare juices, wines, and kissels with a characteristic tartness. They are also suitable as pie fillings and as a seasoning for meat dishes. Due to their high pectin content, the fruits are used to make fruit jelly, while the seeds, known for their tonic properties, are occasionally used as a coffee substitute [59]. In medicine, the bark of *V. opulus* is used as a hemostatic agent, particularly in gynecological and obstetric practice. It is effective in alleviating painful menstruation and uterine bleeding. Bark-based preparations also exhibit anticonvulsant and sedative effects [70, 71]. Extracts of viburnum berries demonstrate protective effects against oxidative stress, attributed to their high antioxidant activity and ability to neutralize free radicals [72].

Fabaceae family

Caragana arborescens Lam. is a tall shrub or small tree, reaching a height of 2 to 7 meters. Roasted seeds of *C. arborescens* are used as a coffee substitute, while its fresh leaves, with their spicy taste and aroma, are added to vegetable salads and used as a seasoning for soups, vegetable dishes, meat, and poultry [73]. In traditional medicine, the plant is employed for treating inflammatory conditions. Infusions and decoctions made from its aerial parts are used to address gastrointestinal disorders and inflammation of the mucous membranes of the mouth and throat. Aqueous infusions of the leaves and bark are recommended for the treatment of atherosclerosis, headaches, heartburn, and diathesis [46]. Recent studies confirm that extracts of *C. arborescens*, particularly those rich in flavonoids, can reduce hypoxia-induced damage in human brain microvascular endothelial cells and stimulate angiogenesis [74].

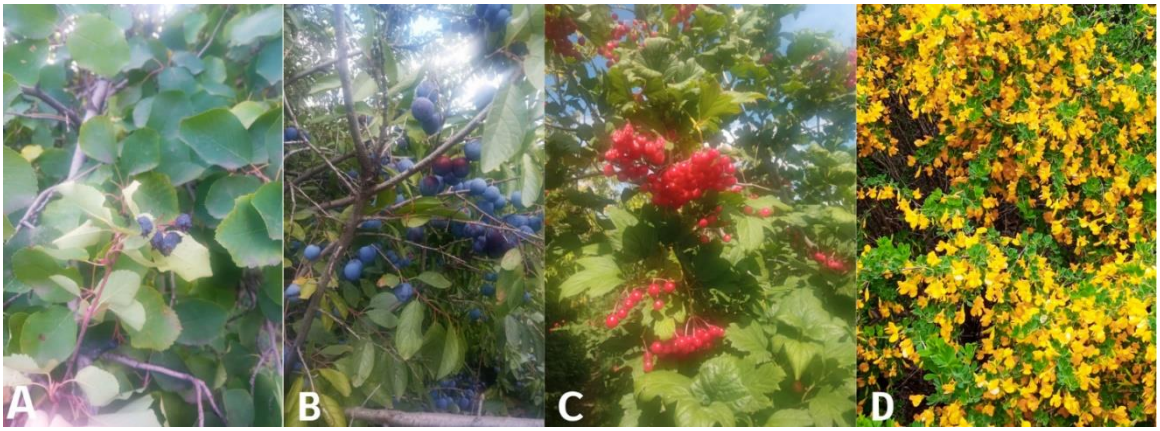

Figure 6. A – Amelanchier alnifolia Nutt., B – Prunus spinosa L., C – Viburnum opulus L., D – Caragana arborescens Lam

Grossulariaceae family

Grossularia acicularis (Smith) Spach is a densely branched shrub reaching heights of up to 2 meters. The berries are consumed raw or used for cooking jams, compotes, syrups, and kissels. They are also utilized in preparing jelly, candy fillings, and preserved in dried, boiled, and candied forms [44]. The fruits of *G. acicularis* are recommended for metabolic disorders and obesity, and in folk medicine, they are used as a laxative, as well as a diuretic and choleretic agent [75].

Ribes nigrum L. *Ribes nigrum* is a shrub reaching a height of 1 to 2 meters, bearing berries with a sweet and slightly tart flavor and a distinctive aroma. The berries are consumed fresh or processed into jams, jellies, syrups, fruit leather, and fillings for confectionery, as well as dried for long-term storage. To accelerate drying, they can be briefly treated with acidified boiling water. The leaves of *R. nigrum* are used to flavor kvass and during the pickling and marinating of cucumbers, tomatoes, cabbage, and mushrooms [76]. Extracts of *R. nigrum* have been shown to positively influence glucose metabolism, aid in correcting dyslipidemia in animals on high-fat diets, and support cardiovascular health in humans [77].

Ribes rubrum L. is a deciduous shrub reaching a height of 1 to 1.5 meters. The primary edible part of the plant is the berries. The berries are consumed fresh and used to make jams, jellies, compotes, juices, syrups, and baked goods. The

leaves and berries are used to treat colds, anemia, inflammatory throat diseases, improve gastrointestinal function, and strengthen the immune system [78]. The berries are rich in vitamins and antioxidants, which help promote health and increase the body's resistance [79].

Pinaceae family

Larix sibirica Ledeb. is a tree that grows up to 25–30 meters tall. Its needles are rich in vitamin C [80]. A decoction made from the young branches of *L. sibirica*, collected in early spring, is known to alleviate coughing, particularly in cases involving purulent discharge, chronic bronchitis, urolithiasis, and flatulence. It is also used as a vermifuge and laxative. For scurvy, an infusion of the needles is recommended, while turpentine is applied externally for neuralgia, myositis, rheumatism, and as an antimicrobial and deodorizing agent in the treatment of bronchopulmonary diseases [81].

Pinus sylvestris L. is a tree that can reach heights of 25–40 meters. Its needles are a rich source of ascorbic acid (ranging from 150 to 300 mg% or more), along with vitamin K and carotene, making them suitable for producing vitamin C concentrates [82]. The unopened male inflorescences (anthers), which are yellow or pinkish-red, can be consumed raw [83].

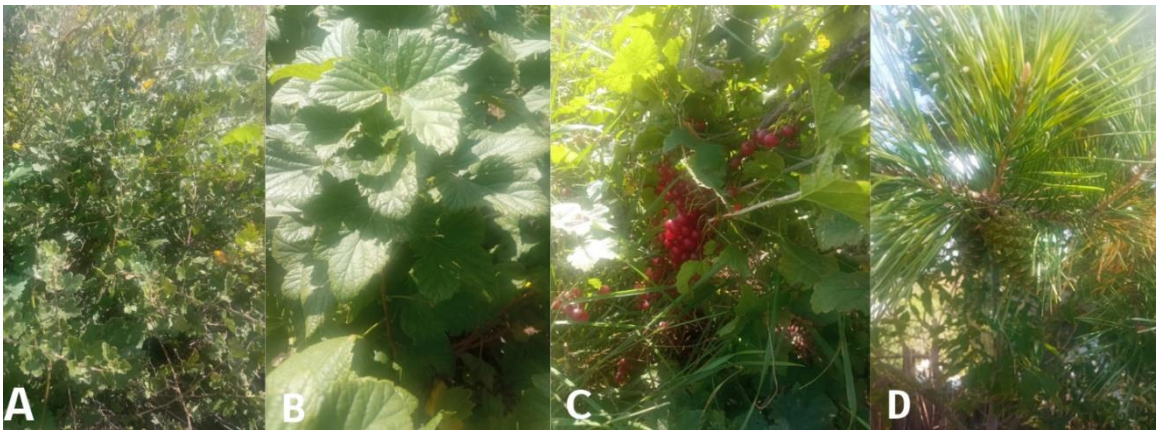

Figure 7. A – Grossularia acicularis (Smith), B – Ribes nigrum L., C – Ribes rubrum L., D – Pinus sylvestris L

Elaeagnaceae family

Hippophae rhamnoides L. is a shrub or small tree, typically reaching a height of 1–3 meters, though it can grow up to 6 meters. The sea buckthorn berries are edible and consumed fresh, as well as used to prepare jams, jellies, juices, and other products that retain their vitamin content. Due to its pineapple-like aroma, the plant is often referred to as the "Siberian pineapple." The harvest is collected after the first frosts, which reduce the bitterness and astringency of the berries, giving them a sweet-tart flavor with a hint of pineapple. Frozen berries can retain their freshness for extended periods [44]. The fruits, leaves, bark, and branches of the plant are used for medicinal purposes. The berries, rich in vitamins (A, B1, B3, E, P, and C) and other beneficial compounds, contribute to overall health improvement [84]. Sea buckthorn oil, extracted from various parts of the plant, exhibits antihyperglycemic and antidiabetic activity [85, 86]. Studies confirm that sea buckthorn oil effectively inhibits the growth of *Staphylococcus aureus* [87]. Additionally, the consumption of *Hippophae rhamnoides* has been shown to positively influence metabolism and alleviate symptoms of type 2 diabetes in diabetic rats [88].

Elaeagnus angustifolia L. is a shrub or small tree that typically grows to a height of 3 to 7 meters. Its fruits are consumed as food, either fresh or ground into flour, which can be added to bread, soups, and other dishes. The fruits are also used to produce wine with a distinctive spicy aroma [59]. In traditional medicine, the flowers are used to treat edema, scurvy, as an antihelminthic, and for colitis, bronchitis, and heart disease. The leaves are employed to alleviate symptoms of rheumatism and gout and are also applied for wound healing [89].

Berberidaceae family

Berberis vulgaris L. is a tall, densely branched, thorny shrub that can reach up to 2.5 meters in height, characterized by creeping woody rhizomes. The ripe fruits of *B. vulgaris* are edible and are typically dried, crushed, or ground into powder to be used as a seasoning for meat dishes and soups. Additionally, the young leaves of this plant can serve as a substitute for sorrel (*Rumex*) in the preparation of green soups [41]. A tincture made from the leaves of *B. vulgaris* is well-known for its hemostatic and choleretic properties, making it particularly beneficial in the treatment of gallbladder disorders [90]. Furthermore, scientific studies have demonstrated that berberine, an alkaloid found in barberry, exhibits notable neuroprotective effects, primarily by suppressing oxidative stress processes [90].

Fagaceae family

Quercus robur L. is a deciduous tree that grows to a height of 20 to 40 meters. The primary edible part of this plant is its acorns. After appropriate processing, acorns can be consumed and used to produce flour, which is added to bread and various other dishes [91]. The leaves and bark of *Q. robur* are traditionally employed in the treatment of diarrhea, skin disorders, and inflammatory conditions [92]. Infusions made from its bark and leaves exhibit astringent, anti-inflammatory, and antiseptic properties [93].

Figure 8. A – Hippophae rhamnoides L., B – Elaeagnus angustifolia L., C – Berberis vulgaris L., D – Quercus robur L

3.2. Awareness of Rural and Urban Residents about the Edibility and Medicinal Properties of Local Fruit Trees and Shrubs

The heatmap effectively illustrates the levels of awareness and usage of local edible plants among rural and urban populations in Central Kazakhstan, divided into two age groups: 18–25 years (Group 1) and 35–65 years (Group 2). The color scheme of the heatmap – where red represents a low level of awareness and usage (0–49%), yellow indicates a moderate level (50–79%), and green denotes a high level (80–100%) – clearly highlights the differences in knowledge and application of these plants across various demographic groups (Figure 9).

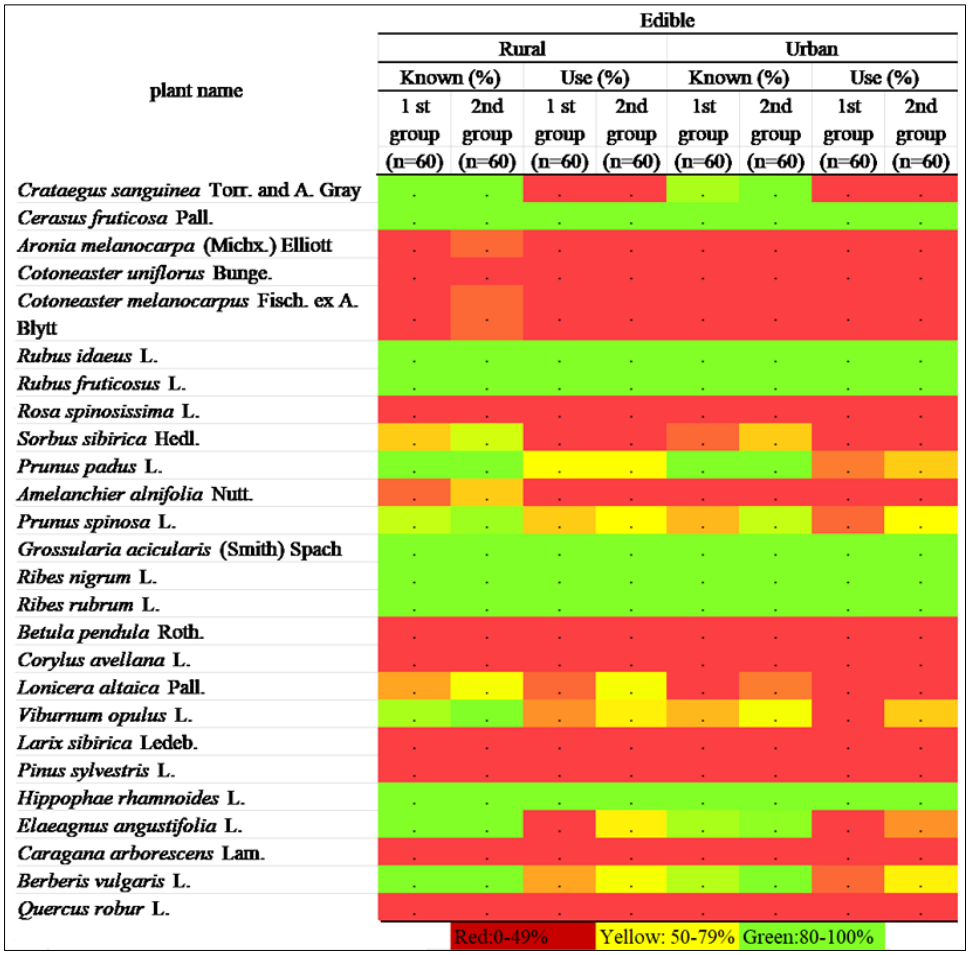

Figure 9. Awareness of rural and urban residents about the edibility of local fruit trees and shrubs

At the same time, this visualization highlights the overall dominance of red and yellow markers for the younger generation and urban residents, indicating that traditional knowledge about local plants is likely being transmitted less effectively.

In rural areas, the younger age group (18–25 years) generally demonstrates low awareness of most plant species, as reflected by the red markers for plants such as Crataegus *sanguinea*, *Cerasus fruticosa*, and *Aronia melanocarpa*. This suggests a decline in the intergenerational transfer of traditional knowledge about local flora. However, among the older rural group (35–65 years), there is a noticeably higher level of awareness of plants such as *Rosa spinosissima* and *Prunus spinosa*, as indicated by the yellow and green markers. This implies that the older generation retains more knowledge about these plants, likely due to their prolonged interaction with rural environments and traditional practices involving wild plants.

A similar trend is observed in actual plant usage. Young rural residents rarely use plants such as *Sorbus sibirica* and *Prunus spinosa*, whereas the older group uses them much more frequently. This is evidenced by the moderate and high usage levels of plants such as *Rosa spinosissima* and *Rubus idaeus*. The higher awareness and usage of plant resources among the older rural population underscore the significant role of age in preserving traditional knowledge.

In urban areas, particularly among the younger generation (18–25 years), the level of awareness and usage of edible plants is even lower. The dominance of red markers on the heatmap for young urban residents reflects their limited knowledge of local edible plants. Even relatively well-known species such as *Cerasus fruticosa* and *Aronia melanocarpa* show low awareness levels among urban respondents. The older urban group (35–65 years) exhibits a slight improvement in awareness and usage of some species, such as *Ribes nigrum* and *Corylus avellana*, which are better known and utilized in both rural and urban settings. However, even among the older urban population, the use of local edible plants remains limited.

A detailed analysis of individual plant species reveals notable patterns. For instance, *Ribes nigrum* (blackcurrant) and *Ribes rubrum* (redcurrant) are better known and more widely used in both rural and urban areas, particularly among the older generation. These species are likely more integrated into daily life due to their availability in markets and their extensive use in culinary traditions. In rural areas, the older generation demonstrates a high level of awareness of these species, as indicated by the green and yellow markers on the heatmap. In urban areas, although awareness of these species is slightly higher, their usage remains relatively low.

Regarding the medicinal properties of these plants, the younger rural group (18–25 years) shows low awareness of the therapeutic value of most species, as evidenced by the prevalence of red markers on the heatmap. Plants such as *Crataegus sanguinea*, *Aronia melanocarpa*, and *Cerasus fruticosa* are particularly poorly known among rural youth. However, the older rural group (35–65 years) demonstrates greater awareness of the medicinal properties of several species, including *Rosa spinosissima*, *Rubus fruticosus*, and *Rubus idaeus*, as indicated by the yellow and green markers. This suggests that the older generation retains more traditional knowledge about the medicinal uses of these plants, likely due to their longer experience in rural areas and their involvement in traditional medicine practices (Figure 10).

Young rural residents demonstrate a highly limited use of medicinal plants, as reflected by the predominance of red markers on the heatmap. In contrast, older rural residents actively utilize several plants for medicinal purposes, including *Sorbus sibirica* and *Rosa spinosissima*, as indicated by the yellow and green zones. These plants are well-known for their health benefits, and the older rural population appears to preserve these practices to a greater extent.

In urban areas, the heatmap reveals an even lower level of awareness and use of the medicinal properties of edible plants. Both younger (18–25 years) and older (35–65 years) urban groups exhibit limited knowledge, with most plants marked in red in the columns for awareness and use. However, a few exceptions stand out. For instance, the medicinal properties of *Ribes nigrum* and *Ribes rubrum* are relatively well-known among both young and older urban residents, as indicated by the yellow and green zones. These species are likely more familiar to urban populations due to their commercial availability and recognized health benefits, such as their high antioxidant content.

A comparison of rural and urban populations reveals that rural residents, particularly those in the older age group, have a deeper understanding and more frequent use of the medicinal properties of local edible plants. The preservation of traditional knowledge and practices in rural areas contributes to this trend, whereas urban populations exhibit a significant disconnect from this aspect of local flora. The younger generation in both rural and urban settings is particularly affected by a lack of knowledge, which may reflect a generational shift away from the use of plants for medicinal purposes, potentially driven by modernization and an increased reliance on pharmaceutical solutions.

The heatmap underscores the disparities in awareness and use of medicinal plants across different age groups and regions. While older rural residents exhibit a higher level of engagement with these plants, younger individuals and urban dwellers show a decline in traditional knowledge and practices related to the medicinal use of local edible plants.

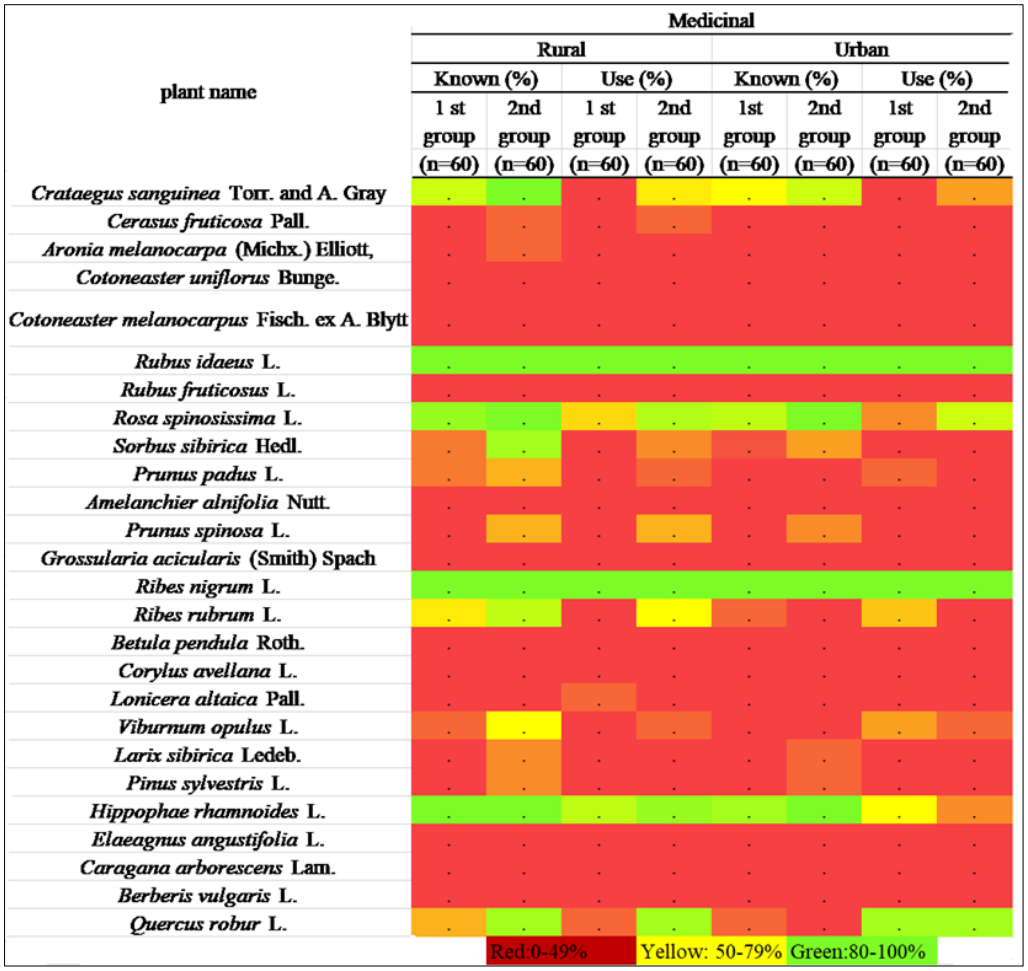

Figure 10. Awareness of rural and urban residents about the medicinal properties of local fruit trees and shrubs

4. Discussion

Collecting and consuming wild edible plants (WEPs) are essential components of livelihood strategies worldwide [94]. WEPs not only alleviate food shortages during periods of drought or resource scarcity but also play a critical role in supporting the livelihoods of many people in developing countries. These plants can supplement or enhance the nutritional quality of daily diets [95]. Rich in nutrients, WEPs have significant nutritional value and can serve as primary food sources or dietary supplements, contributing to food security in impoverished communities [96]. Furthermore, they offer valuable genetic resources for the development of new crop varieties through hybrid screening [97].

Ethnobotanical research from various countries underscores the significance and multifunctional use of wild edible plants (WEPs). For instance, in eastern Ethiopia (Mieso district), 41 species of wild plants were identified, with a primary emphasis on their fruits and shrub forms [98]. Similarly, in Pakistan, 64 species from 45 botanical families, including trees, shrubs, and herbs, were documented [99]. A study in Indonesia recorded 73 species of wild fruit-bearing plants, predominantly trees, found mainly in forested areas [100]. In the Metema district (Amhara region, Ethiopia) and the northwestern province of Cagayan (Philippines), the abundance of fruit-bearing trees, primarily consumed fresh, was also noted [101, 102]. In the Himalayas, a list of 662 species highlights the diversity of forms and uses, ranging from vegetables and fruits to medicinal applications [103].

Comparable findings were reported in northern Guizhou province (China), where 151 species were documented, with fruits and leaves being widely utilized [104], and in Inner Mongolia, where 53 species were primarily harvested for their young stems, leaves, and fruits [105]. Studies in Morocco (64 species) and the Bukit Rimbang-Bukit Baling Reserve in Indonesia (67 species) emphasize the broad culinary and pharmacological applications of WEPs [106, 107]. In Chile, 330 species of edible plants, mainly perennial herbs, shrubs, and trees, were recorded [108]. Similarly, in Manipur (India), 108 species, many of which are integral to culinary practices, were identified [109].

In southern Yemen, local communities traditionally collect and consume 58 species, favoring stems, leaves, and fruits, which are mostly eaten raw [110]. On Borneo Island (Kota Belud), leaves, fruits, and young shoots are commonly consumed with minimal culinary processing [111]. In Cameroon, a study documented 91 species from 43 families, highlighting the vital role of trees and lianas in providing food resources [112].

Our research identified 28 species across 9 families. The families with the most species are Rosaceae with 12 species, Grossulariaceae with 3 species, Betulaceae, Caprifoliaceae, Pinaceae, and Elaeagnaceae, each with 2 species, and Fabaceae, Berberidaceae, and Fagaceae, each with 1 species. These species are categorized into 9 tree species, 16 shrub species, and 3 subshrub species.

Various parts of these plants are utilized for food. Birch sap from *Betula pendula* Roth. is used as a beverage and in baking; hazelnuts from *Corylus avellana* L. are consumed raw, in baked goods, chocolate, and confectionery, and for making hazelnut oil and paste. The berries from species such as *Crataegus sanguinea* Torr. & A. Gray, *Cerasus fruticosa* Pall., *Aronia melanocarpa* (Michx.) Elliott, *Cotoneaster uniflorus* Bunge, *Cotoneaster melanocarpus* Fisch. ex A. Blytt, *Rubus idaeus* L., *Rubus fruticosus* L., *Rosa spinosissima* L., *Sorbus sibirica* Hedl., *Prunus padus* L., *Amelanchier alnifolia* Nutt., *Prunus spinosa* L., *Viburnum opulus* L., *Hippophae rhamnoides* L., *Elaeagnus angustifolia* L., *Ribes nigrum* L., and *Ribes rubrum* L. are widely used in various culinary preparations. Leaves and other parts of *Caragana arborescens* Lam. are added to salads and used as seasoning in soups and vegetable dishes.

Recently, with the rise in living standards, the requirements for dietary balance and food diversity have been gradually increasing, and wild edible plants present great opportunities, especially in their domestication and use of their genes to develop new cultivars. Wild edible plants have both nutritional and medicinal potential; many plants are both edible and medicinal [113]. From a medicinal perspective, all identified plants possess therapeutic properties. *Corylus avellana* L. and *Crataegus sanguinea* Torr. & A. Gray are known for cardiovascular benefits. *Rubus idaeus* L. and *Prunus padus* L. are traditional remedies for colds and respiratory infections. Anti-inflammatory properties are found in *Betula pendula* Roth., *Cotoneaster uniflorus* Bunge, and *Caragana arborescens* Lam. *Aronia melanocarpa* (Michx.) Elliott and *Elaeagnus angustifolia* L. are beneficial for liver and gallbladder health. *Rubus idaeus* L., *Viburnum opulus* L., and *Hippophae rhamnoides* L. have significant antioxidant properties. *Betula pendula* Roth. is used for treating anemia and wound infections. *Sorbus sibirica* Hedl. and *Viburnum opulus* L. demonstrate anti-tumor activities.

The analysis of respondent surveys using a heatmap revealed significant differences in awareness and actual use of wild edible plants (WEPs) between rural and urban populations, as well as across age groups (18–25 and 35–65 years). The older generation in rural areas exhibits a noticeably higher level of knowledge (represented by yellow and green segments) about wild fruits and berries. This is likely due to prolonged interaction with the natural environment and strong family traditions of harvesting and utilizing wild plants. In contrast, young rural respondents more frequently display red segments on the heatmap, indicating low awareness and minimal practice in using local plants. This suggests that a substantial portion of traditional knowledge is being lost due to insufficient intergenerational communication and the younger generation's preference for store-bought products and pharmaceutical solutions.

The depopulation of rural areas and the migration of youth to cities appear to further exacerbate this trend. In urban environments, opportunities to engage with wild resources are virtually nonexistent, while globalized markets dominated by imported products overshadow local species. The results indicate that in cities, particularly among the younger group (18–25 years), red dominates the heatmap, even for relatively well-known plants (e.g., *Cerasus fruticosa*, *Aronia melanocarpa*), signifying extremely low awareness and almost no usage. Although the older urban group (35–65 years) demonstrates slightly greater familiarity with certain species (e.g., *Ribes nigrum*, *Corylus avellana*), potentially due to past rural experiences or the commercial availability of berries and nuts, their overall interest in wild plants remains limited.

At the same time, internal heterogeneity exists within the older rural population: some species, such as *Rosa spinosissima*, are significantly more commonly used in everyday life than others, like *Sorbus sibirica*. This selectivity may reflect the more pronounced medicinal or culinary properties of specific plants, or it may suggest that certain families actively preserve traditions while others gradually lose them. In some cases, economic factors also influence this trend: harvesting wild species requires time and specific skills, and younger individuals often neglect this activity, opting instead to purchase ready-made products from stores. The general underestimation of the taste and health benefits of local species is further compounded by the lack of systematic education and promotion.

A similar pattern is observed in the realm of herbal medicine. Many older rural respondents continue to use decoctions and infusions made from *Sorbus sibirica*, *Rosa spinosissima*, and *Rubus fruticosus*, recognizing their preventive and therapeutic potential. In contrast, younger generations tend to perceive these methods as outdated, favoring readily available pharmaceutical options. In urban settings, this gap becomes even more pronounced: the absence of direct contact with nature and the dominance of mass culture focused on commercial products diminish interest in traditional medicine. The limited presence of yellow and green zones on the heatmap for some urban respondents aged 35–65 can be attributed to personal experience or early exposure to specific plants (e.g., blackcurrants), as well as their market availability, which enhances recognition.

It is noteworthy that blackcurrants and redcurrants (*Ribes nigrum* and *Ribes rubrum*) maintain their status as "familiar berries" due to their diverse applications, ranging from making jams and compotes to adding leaves to tea and pickling. Such versatility often aids in preserving traditional knowledge, even as other local species lose their popularity.

Furthermore, the demand for currants in urban markets and the practice of suburban gardening help sustain their prominence even in urban areas. However, for plants such as hawthorn (*Crataegus sanguinea*), traditionally used for cardiovascular conditions, younger generations exhibit markedly less interest, preferring official pharmaceuticals. A similar trend is evident with *Sorbus sibirica*, widely utilized by older rural residents as a vitamin-rich remedy but largely unfamiliar to the youth.

Thus, the heatmap vividly illustrates the influence of geographic (urban vs. rural), generational (youth vs. older adults), and cultural-economic factors on the preservation and transmission of ethnobotanical knowledge. The survey and data analysis highlight a significant decline in the awareness and use of local edible and medicinal plants, particularly among younger generations and urban populations. This underscores the urgent need for targeted initiatives to safeguard and transfer traditional knowledge about local flora. Such efforts could play a vital role in promoting more sustainable practices in nutrition and healthcare in the future.

5. Conclusions

The consumption of wild edible plants (WEPs) is a tradition with deep historical roots that continues to play a vital role in food security and nutrition, particularly in regions like Central Kazakhstan. This study identified 28 species of wild fruit trees and shrubs from nine botanical families, with the Rosaceae family exhibiting the highest diversity, comprising 12 species. Among the identified species, 9 were trees, 16 were shrubs, and 3 were subshrubs.

These plants possess significant nutritional and medicinal properties. Various parts, including fruits, leaves, nuts, and roots, are utilized for food. Fruits are consumed fresh or processed into juices, jams, and preserves. Leaves are added to salads or used as seasonings in soups and vegetable dishes. Nuts are eaten raw, incorporated into baked goods, or processed into oils and pastes.

Medicinally, different parts of these plants are used to treat a variety of ailments. For example, certain leaves and roots exhibit anti-inflammatory properties effective against respiratory infections, colds, and arthritis. Specific berries and fruits are valued for their antioxidant properties, contributing to cardiovascular health, liver and gallbladder support, and immune system enhancement. Additionally, the sap and bark of some trees possess detoxifying and wound-healing effects.

Survey results indicate that only a few species are widely recognized and utilized for both culinary and medicinal purposes across both age groups (18–25 and 35–65 years), regardless of residence—rural or urban. While partially known species are used selectively, their application is more prevalent among rural residents due to their higher level of awareness. Conversely, little-known or unknown plants are rarely used by any age group, irrespective of location.

The analysis revealed a gradual decline in knowledge about edible and medicinal plants among younger generations. Younger individuals are less familiar with these plants and rarely use them, in contrast to older generations. This trend is particularly pronounced in urban areas, where traditional knowledge is less prevalent than in rural regions. Urbanization exacerbates this decline, as younger people increasingly rely on commercially available products and pharmaceuticals, neglecting natural resources.

Addressing this issue requires proactive measures. Educational programs that integrate ethnobotanical knowledge into school curricula can raise awareness among younger generations about the value of wild plants. Community-led initiatives focused on the collection, cultivation, and use of wild plants can further preserve traditional practices. Additionally, scientific research is essential to document and disseminate knowledge about these plants. Conservation efforts aimed at protecting wild plants and their habitats are also critical.

Such measures are vital to preserving ethnobotanical knowledge and ensuring these natural resources continue to benefit future generations. Given their importance for food security, health, and biodiversity conservation, wild plants play an indispensable role. Collaborative efforts to safeguard and revive traditional practices associated with their use are crucial for fostering a sustainable future.

6. Declarations

6.1. Author Contributions

Conceptualization, Y.P. and A.M.; methodology, Y.P.; software, Y.P.; validation, Y.P., A.M., and G.O.; formal analysis, Y.P.; investigation, A.M. and G.O.; resources, Y.P.; data curation, Y.P.; writing—original draft preparation, Y.P.; writing—review and editing, Y.P., A.M., and G.O; visualization, Y.P.; supervision, Y.P.; project administration, Y.P. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6.4. Acknowledgments

The authors sincerely thank the informants for their voluntary and spontaneous participation in this study.

6.5. Institutional Review Board Statement

Not applicable.

6.6. Informed Consent Statement

Oral Prior consent was obtained from each participant. This study does not contain any experiment(s) on humans and animals.

6.7. Declaration of Competing Interest

The authors declare that there are no conflicts of interest concerning the publication of this manuscript. Furthermore, all ethical considerations, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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