Ethnobotanical insights into the use of wild vegetables and food plants as medicinal resources among the indigenous communities in District Bajaur, Pakistan

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Research

Abstract

Background: This study aimed to document and analyze the utilization of wild vegetables and food plants (WVFPs) by the indigenous people of Bajaur District, Pakistan. These plants play a crucial role in the community's subsistence, providing both nutritional and medicinal benefits.

Methods: Data collection was carried out through semi-structured questionnaire surveys conducted in the study area, involving participants from various villages. Informants, including men and women from the indigenous community, were selected to ensure a comprehensive understanding of local knowledge regarding wild vegetables and food plants.

Results: The study documented 29 species of wild vegetable and food plants (WVFPs) from 22 botanical families in the research area. Malvaceae and Rhamnaceae were the most prominent, each with three species, followed by Brassicaceae, Asteraceae, and Polygonaceae. Herbs dominated with 18 species, while shrubs and trees contributed 5 and 6 species, respectively. Fresh leaves and stems (19 species) were the most used parts, followed by fruits (8 species) and whole plants (2 species). These plants were traditionally consumed as saag (leafy greens), salads, and sauces. In addition to their culinary applications, many species had medicinal significance, treating ailments such as aphonia, hoarseness, constipation, inflammation, pain, convulsions, jaundice, dizziness, insomnia, premature aging, and diabetes, highlighting their integral role in the community's nutrition and healthcare.

Conclusion: Wild vegetables and food plants are vital for local nutrition and medicine, especially during economic hardship. Their conservation and sustainable management are crucial to preserving these valuable resources for the health and well-being of future generations.

Keywords: Wild plants, Therapeutic Importance, Rural communities, Hindu Kush range

Background

The earliest evidence of human interaction with plants dates back to the emergence of life on land. Initially, humans relied on plants primarily for food, medicine, and shelter (Birjees *et al.* 2022). Over time, the utility of plants expanded significantly, as they were discovered to serve a wide range of purposes. Wild vegetables and food plants (WVFPs), in particular, have always been vital for human nutrition and have played a significant role in meeting various needs (Ali and Qaiser, 2009; Birjees *et al.* 2022). WVFPs are naturally occurring plants that grow without human intervention and are consumed as food across diverse regions of the world. These plants are found in various ecosystems and are a critical resource for local and rural communities, as emphasized by Pieroni *et al.* (2007).

In rural areas, WVFPs are highly valued, serving not only as food but also for their medicinal properties, offering traditional remedies for various health conditions (Pieroni *et al.* 2017). Globally, around 75,000 plant species are estimated to be edible, with many being nutritionally superior to some cultivated crops (Acharya and Acharya, 2010). Despite advancements in agriculture, research indicates that approximately one-third of rural populations, particularly in mountainous regions, continue to face challenges such as famine and malnutrition (Romeo *et al.* 2020). The growing global population is projected to increase food demand by 70-100% by 2050, further emphasizing the need for sustainable food sources (Ahmad and Pieroni, 2016). In mountainous regions, abundant natural resources, including wild flora, have long been utilized by indigenous communities for food, fuel, timber, and medicinal products (Haq *et al.* 2022).

Ethnobotanical research highlights the extensive use of wild plants, with over 7,000 species utilized for food and medicine worldwide (Dorjey and Maurya, 2021). Pakistan, known for its rich diversity of wild and cultivated plants, is home to many valuable species that are integral to local diets and traditional practices. However, the documentation of WVFPs in regions like Bajaur District remains limited (Aziz *et al.* 2020). Bajaur is home to a wide variety of WVFPs, which not only fulfil dietary needs but also provide economic benefits to local residents. Despite their importance, there has been no focused research on the WVFPs of Bajaur, underscoring the urgent need to document their diversity, historical distribution, commercial value, and medicinal properties for conservation and sustainable utilization.

The connection between food and health has gained prominence in recent years, as consumers increasingly seek nutritious, enjoyable, and naturally functional foods grown in uncontaminated environments (Ercisli, 2007). Traditional knowledge about such foods, often passed down through generations, is a valuable cultural asset (Misra *et al.* 2008; Haq *et al.* 2022). In many parts of Pakistan, wild vegetables and medicinal plants are still gathered throughout the year to meet dietary and therapeutic needs. Consuming wild vegetables not only mitigates risks to food security but also helps individuals meet their daily nutritional requirements (Hadjichambis *et al.* 2008). However, the knowledge and practices associated with using wild plants are at risk of being lost due to modernization and urbanization (Pieroni *et al.* 2005). Since ancient times, humans have used plants for food, medicine, and other essential needs. Ethnobotanical pharmacology, which examines the relationship between humans and plants, has been an integral part of human civilization for millennia. The earliest records of plant-based medicine are found in the *Rig Veda* (4500-1600 BC) and *Ayurveda* (2500-600 BC) from the Indo-Pakistan region (Ahmad, 1999). Ethnobotany continues to hold significant importance in modern fields such as medicine, agriculture, pharmaceuticals, and nutraceuticals.

The diversity of wild plant species contributes to food security and health (Pieroni *et al.* 2007). These plants are also of economic and cultural importance, being used for food, medicine, dyes, fibers, and religious rituals. Both edible and medicinal plants have therapeutic benefits, and their consumption is associated with the prevention of chronic diseases (Haq *et al.* 2023a). Studies have consistently shown that diets rich in fruits, vegetables, and grains can reduce the risk of cardiovascular disease, cancer, and diabetes, as well as Alzheimer's disease, cataracts, and age-related functional decline (Espin *et al.* 2007). Documenting the uses of WVFPs is essential not only to preserve traditional knowledge but also to ensure these plants' sustainable use for future generations. Despite the wealth of ethnobotanical information globally, no prior research has been conducted on the wild vegetable and food plants of District Bajaur. This highlights the urgent need to identify, document, and study these plants and their potential uses in traditional and modern contexts.

Materials and Methods

Collection and identification of wild vegetables and food plants

Data on wild vegetables and food plants in Bajaur were gathered through interviews and semi-structured questionnaires from the local inhabitants of the area (Fig. 1). Fieldwork involved the systematic collection of plant samples, photography, and documentation of relevant data. The collected plant specimens were taxonomically identified using the *Flora of Pakistan*

(Ali and Qaiser, 1993-2023) and verified through the Plants of the World Online (POWO) database for their botanical names and families. The identification process adhered to standard taxonomic practices to ensure accuracy. Each plant sample was carefully pressed, dried, and mounted onto standard herbarium sheets. The prepared voucher specimens were subsequently deposited in the Department of Botany at the Government Girls Degree College, Khar, Bajaur, to serve as a reference for future studies and documentation. This systematic approach ensured the accurate identification and preservation of WVFPs for further research and conservation efforts.

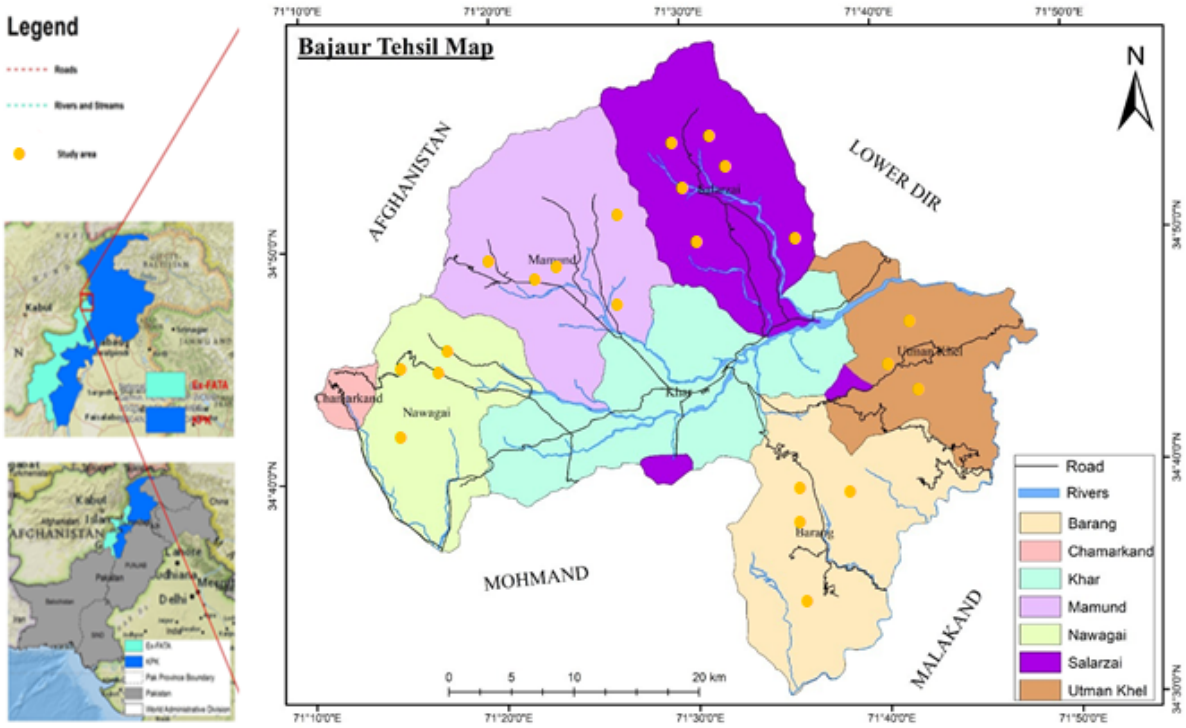

Figure 1. Map of the research area

Ethnomedicinal profile of wild vegetableand food plants

Ethnomedicinal data were collected from local inhabitants of various age groups and genders through the use of questionnaires and interviews. The data collection process followed established standard methods as outlined in previous studies (Hussain *et al.* 2018; Haq *et al.* 2022; Haq *et al.* 2023). This comprehensive approach ensured the inclusion of diverse perspectives and experiences, contributing to a well-rounded understanding of the ethnobotanical knowledge within the community.

Analysis of the collected data

The collected information was analyzed using graphical statistical methods to identify the most prominent plant species. Data were summarized through the application of percentages and bar charts, which were created using Excel® spreadsheet software (2016). To examine variations in the data and to compare the contributions of plant diversity and the indigenous knowledge of wild vegetables and fruits within the local ethnic community, pivot tables were utilized. This analytical approach facilitated a comprehensive understanding of the community's ethnobotanical knowledge and highlighted the significance of specific plant species in their daily lives.

Results and Discussion

Demographic Data about the wild vegetable and food plants (WVFPs)

The demographic analysis of respondents utilizing wild vegetable and food plants revealed that the majority were from rural areas, where traditional foraging practices remain an essential part of the local diet. The age distribution indicated that older individuals (above 50 years) possessed the most extensive knowledge (60.87%) of WVFPs, followed by middle-aged respondents (30-50 years, 28.26%) and younger individuals (below 30 years, 10.87%). Women played a dominant role (86.96%) in the collection and preparation of wild vegetables, emphasizing their vital contribution to household food security and ethnobotanical traditions (Table 1). Educational attainment was generally low, with most respondents having only primary-level education or none, suggesting that knowledge of WVFPs is primarily traditional and passed down orally. These

demographic trends highlight the critical importance of documenting and preserving such indigenous knowledge to ensure its sustainable utilization and intergenerational transmission.

Table 1. Demographic data of the respondents in the area

Factor	Categories	Respondents	%age
Gender	Male	6	13.04
	Female	40	86.96
Occupation	Govt. employees	2	4.35
	Unemployed	44	95.65
Profession	Teachers	2	4.35
	Farmers	5	10.86
	Housewives	39	84.78
Age (yrs)	<30	5	10.87
	30-50	13	28.26
	>50	28	60.87

Utilization and preference of wild vegetable and food plants (WVFPs)

Information about WVFPs was systematically collected, encompassing various aspects such as their botanical names, local names, plant families, the utilized parts of the plants, and the methods by which they are consumed. The analysis revealed that the dominant plant families were Malvaceae and Rhamnaceae, each represented by three species, followed by Brassicaceae, Asteraceae, and Polygonaceae, each with two species, and Amaranthaceae and Fabaceae, each with one species (Table 2 and Fig. 2). The majority of plants used for food preparation were herbs (18 species), followed by trees (6 species) and shrubs (5 species) as shown in Figure 3. Native communities in District Bajaur commonly utilize nearly all parts of WVFPs; however, unprocessed or raw fruit, either dried or fresh, is consumed most frequently. Leaves and young stems accounted for the highest utilization (79%), followed by fruits (20%) and the entire plant (1%). Many of these plants are considered weeds, locally known as Gayyah, which grow in or near crop fields. Traditional communities collect these species not only for their own consumption but also for animal feed. Previous studies, such as those by Assefa and Abebe (2014), reported significant utilization of fruits and leaves in the region, consistent with the findings of this study.

The preference for leaves and fruits highlights their continual usage during food scarcity, as these parts are easy to collect and prepare. This aligns with research by Sina and Degu (2015), which demonstrated the reliance on easily accessible plant parts during periods of food shortage. The results further emphasized that local communities rely heavily on natural food sources within their immediate environment. The proximity and convenience of natural habitats greatly influence the utilization of WVFPs, a trend supported by Weckerle *et al.* (2006), who suggested that local habitats serve as preferred collection sites due to familiarity and ease of access. Numerous ethnopharmacological studies on wild medicinal plants highlighted leaves as the most commonly used part in local herbal remedies (Hosseini *et al.* 2017; Kamatenesi *et al.* 2011; Maroyi, 2011). The current findings show that fruits are the most frequently consumed part of WVFPs. This preference may be attributed to their palatability, accessibility, and the fact that fruits often do not require cooking. These findings are consistent with the work of Abbasi *et al.* (2013), who also noted the high consumption of fruits in traditional diets.

Table 2. Diversity and Consumption of Wild Vegetables and Food Plants of District Bajaur, Pakistan

Botanical name/ Voucher number	Family	Vernacular name / local name	Habit	Condition	Method for food preparation	Part Used	Therapeutic uses
Amaranthus viridis L. HAH. BOT. 01	Amaranthaceae	Chlwae	Herb	Fresh	Fresh leaves and young shoots are boiled in water. Once boiled, they are drained and then cooked in oil or ghee. Then seasoned with a variety of aromatic spices and flavorful condiments, which infuse the dish with rich taste and enticing aromas.	Leaves and young stem	It is used as a blood purifier, diuretic, sedative, hepatoprotective agent, antiscorbutic, laxative, and anthelmintic, effective against roundworms and hookworms.
Anagalis arvensis L. HAH. BOT. 02	Primulaceae	Ghmy Gul	Herb	Fresh	Fresh plant parts are collected, washed, boiled and cooked in oil or ghee. Spices are added for better taste and aroma.	Leaves and young stem	It is used for its wide range of medicinal properties, including anti-mycotic, antimicrobial, antioxidant, anti-inflammatory, anti-leishmanial, antiviral, and cytotoxic effects, and its ability to support spermatogenesis.
Astragalus anisacanthus Boiss HAH. BOT. 03	Fabaceae	Mamol	Herb	Fresh	Fresh leaves and young shoots are boiled in water and then cooked in oil or ghee. Then seasoned with a variety of aromatic spices and flavorful condiments, which impart rich taste and enticing aromas to the dish.	Leaves and young stem	Used to treat upper respiratory infections, allergic rhinitis (hay fever), asthma, chronic fatigue syndrome and chronic kidney disease
Berberis lycium Royle HAH. BOT. 04	Berberidaceae	Tor Kwaray	Shrub	Fresh and dry	Fruits can be consumed directly, either in their fresh or dried form. The roots can be dried and ground into a fine powder, which can be consumed by mixing it with water or incorporating it into green tea.	Fruit and roots	It is used to treat a variety of conditions, including diabetes, arthritis, joint pain, and stomach ulcers.
Broussonetia papyrifera L. HAH. BOT. 05	Moraceae	Gul toot	Tree	Fresh and dry	Fruits can be consumed directly in either their fresh or dried form.	Fruit	It has diuretic and laxative properties and is also used in the treatment of dysentery.

Calendula arvensis L. HAH. BOT. 06	Asteraceae	Zyer gulley	Herb	Fresh	Fresh plant materials are boiled and cooked in oil or ghee and different spices and condiments are added for special taste and aroma.	Leaves and young stem	It is used to treat a variety of conditions, including varicose veins, sore eyes, wounds, sprains, stings, bites, and skin issues.
Caltha alba Jacb. HAH. BOT. 07	Ranunculaceae	Makhanpath	Shrub	Fresh and dry	Fresh or dried leaves and shoots are boiled and cooked in oil or ghee. Various spices and condiments are added for taste and aroma.	Leaves and stem	It possesses diuretic, anti-inflammatory, pain-relieving, and anticonvulsant properties.
Capsella bursa-pastoris L. HAH. BOT. 08	Brassicaceae	Barmbaisa	Herb	Fresh and dry	Dried or fresh plant materials are boiled in water, drained and cooked in ghee or oil. Then seasoned with a variety of aromatic spices and flavorful condiments, which infuse the dish with rich taste and enticing aromas.	Leaves and stem	It is used as a stimulant and diuretic.
Caralluma tuberculata N.E.Brown. HAH. BOT. 09	Apocynaceae	Pamunkay	Herb	Fresh	Fresh plant parts are boiled in water and cooked in ghee or oil. Various spices and condiments are added, which increase its taste and aroma.	Leaves and young stem	It is used to treat conditions such as hypertension, Alzheimer's disease, rheumatism, and gastric issues.
Chenopodium album L. HAH. BOT. 10	Chenopodiaceae	Chalwaye	Herb	Fresh	Fresh leaves and shoots are boiled in water. Once boiled, they are drained and then cooked in oil or ghee. Then seasoned with a variety of aromatic spices and flavorful condiments, which infuse the dish with rich taste and enticing aromas.	Leaves and young stem	It is used as a blood purifier, diuretic, sedative, hepatoprotective agent, antiscorbutic, laxative, and anthelmintic, effective against roundworms and hookworms.
Convolvulus arvensis L. HAH. BOT. 11	Convolvulaceae	Perwatye	Herb	Fresh	Fresh plant materials are boiled in water, drained and then cooked in oil or ghee. Then seasoned with a variety of aromatic spices and flavorful condiments, which provide a rich taste and enticing aroma to the dish.	Leaves and young stem	It is used in the treatment of conditions such as hepatitis and also acts as a diuretic, laxative, and purgative.

Debregeasia saeneb (Forssk) Hepper and Wood HAH. BOT. 12	Urticaceae	Ajlai	Shrub	Fresh and dry	Fresh or dried fruits are added to other vegetable foods as a flavoring agent.	Fruits	It is used as a flavoring agent, as well as an antifungal, and is effective in treating skin problems.
Galium aparine L. HAH. BOT. 13	Rubiaceae	Ghanam Jalaky	Herb	Fresh	Fresh leaves and shoots are boiled in water and then cooked in oil or ghee. A variety of aromatic spices and flavorful condiments are added, which infuse the dish with rich taste and enticing aromas.	Leaves and young stem	It is used to treat a variety of conditions, including scurvy, scrofula, psoriasis, eczema, seborrhea, sunburn, freckles, as well as sores, blisters, wounds, and burns.
Malva neglecta Waller. HAH. BOT. 14	Malvaceae	Peshtary	Herb	Fresh	Fresh leaves and shoots are boiled in water, drained and then cooked in oil or ghee. Then seasoned with different aromatic spices and flavorful condiments, which gives a rich taste and enticing aroma to the dish.	Leaves and young stem	It is used in the treatment of pain, inflammation, hemorrhoids, kidney stones, constipation, and infertility.
Monothecea buxifolia Falc. HAH. BOT. 15	Sapotaceae	Gurgura	Tree	Fresh and dry	Fresh or sun-dried fruits are eaten directly as a nutritious food source.	Fruit	It is used as a hematinic, laxative, purgative, vermicidal, and antipyretic, as well as for managing gastro-urinary disorders.
Morus alba L. HAH. BOT. 16	Moraceae	Spin toot	Tree	Fresh and dry	Fresh or sun-dried fruits can be enjoyed directly as a nutritious food source or used to make juice.	Fruit	It is used to treat conditions such as dizziness, insomnia, and premature aging.
Morus nigra L. HAH. BOT. 17	Moraceae	Toor Toot	Tree	Fresh and dry	Fresh or sun-dried fruits can be enjoyed directly as a nutritious food source or used to make juice.	Fruit	It is used to treat conditions related to pain relief, inflammation, infections, skin pigmentation, diabetes, obesity, and high cholesterol.
Nasturtium officinale L. HAH. BOT. 18	Brassicaceae	Tara Mira	Herb	Fresh	Fresh leaves and shoots are boiled in water. Once boiled, they are drained and then cooked in oil or ghee. Then seasoned with a variety of aromatic spices and flavorful condiments,	Leaves and stem	It is used to treat respiratory diseases, diabetes, oxidative stress, asthma, and immune deficiency.

					which infuse the dish with rich taste and enticing aromas.		
Oxalis corniculata L. HAH. BOT. 19	Oxalidaceae	Trwakay	Herb	Fresh and dry	They are consumed as a salad or mixed and cooked with other conventional and wild vegetables.	Leaves and stem	It is used as a flavoring agent, as well as a diuretic, laxative, and purgative.
Plantago major L. HAH. BOT. 20	Plantaginaceae	Isphagol	Herb	Fresh and Dry	Fresh leaves are first boiled in water to soften them, then sautéed in oil or ghee. A blend of aromatic spices and flavorful condiments is added, enriching the dish with a deep, salty taste and pleasing aromas. While the seeds are soaking in water.	Leaves and seeds	It is effective in treating upper and lower gastrointestinal bleeding, hematemesis, dysentery, hemorrhoids, and stomachaches.
Rumex dentatus L. HAH. BOT. 21	Polygonaceae	Shalkhy	Herb	Fresh	Fresh leaves and stems are boiled in water and then cooked in oil or ghee. A blend of aromatic spices and flavorful condiments is added, enriching the dish with a deep, salty taste and pleasing aromas.	Leaves and young stem	It is used as a diuretic, refrigerant, and cooling agent.
Rumex hastatus D. Don HAH. BOT. 22	Polygonaceae	Tarookay	Herb	Fresh and dry	Fresh leaves and stems are boiled in water and then cooked in oil or ghee. A blend of aromatic spices and flavorful condiments is added, enriching the dish with a deep, salty taste and pleasing aromas.	Leaves and stem	It is used to treat conditions related to its antioxidant, anti-nociceptive, anti-diarrheal, and cytotoxic properties.
Sisymbrium officinale L. HAH. BOT. 23	Brassicaceae	Sharshum	Herb	Fresh and dry	The leaves are consumed both as a salad and incorporated into other vegetable dishes.	Leaves and stem	It is used to treat throat diseases such as aphonia and hoarseness.
Solanum nigrum L. HAH. BOT. 24	Solanaceae	Khachmacho	Herb	Fresh	Fresh leaves and stems are boiled in water and then cooked in oil or ghee. A blend of aromatic spices and flavorful condiments is added, enriching the dish with a deep, salty taste and pleasing aromas. While the fruits are eaten directly.	Leaves, young stem and fruit	It is used to treat conditions such as pneumonia, toothaches, stomach aches, tonsillitis, ringworm, pain, inflammation, fever, and tumors.

Taraxacum officinale Webber. HAH. BOT. 25	Asteraceae	Ziar guly	Herb	Fresh	Fresh leaves and stems are boiled in water and then cooked in oil or ghee. A blend of aromatic spices and flavorful condiments is added, enriching the dish with a deep, salty taste and pleasing aromas.	Leaves and young stem	It is used to treat dyspepsia, heartburn, as well as disorders of the spleen and liver.
Zanthoxylum armatum DC. HAH. BOT. 26	Rutaceae	Dambara	Shrub	Dry	Dried fruits or their powdered form are commonly used as condiments and flavoring agents.	Fruit	It is used to treat ailments like diabetes, indigestion, dyspepsia and stomach issues.
Zizyphus jujuba Mill. HAH. BOT. 27	Rhamnaceae	Baira	Tree	Fresh and dry	Fresh and dry fruits can be consumed directly as food.	Fruit	It is used to treat various conditions, including asthma, cough, constipation, and diseases of the genitourinary system.
Zizypus nummularia (Burm. f.) Wight and Arn HAH. BOT. 28	Rhamnaceae	Kurkanda	Shrub	Fresh and dry	Fresh and dry fruits can be consumed directly as food.	Fruit	It is used to treat conditions such as colds, abdominal pain, dyspepsia, and diarrhea.
Zizyphus oxyphylla Edgew. HAH. BOT. 29	Rhamnaceae	Elanai	Shrub	Fresh and dry	Fresh root extracts or their dried powder can be consumed.	Root	It is used to treat a range of conditions, including liver-related issues, jaundice, and diabetes.

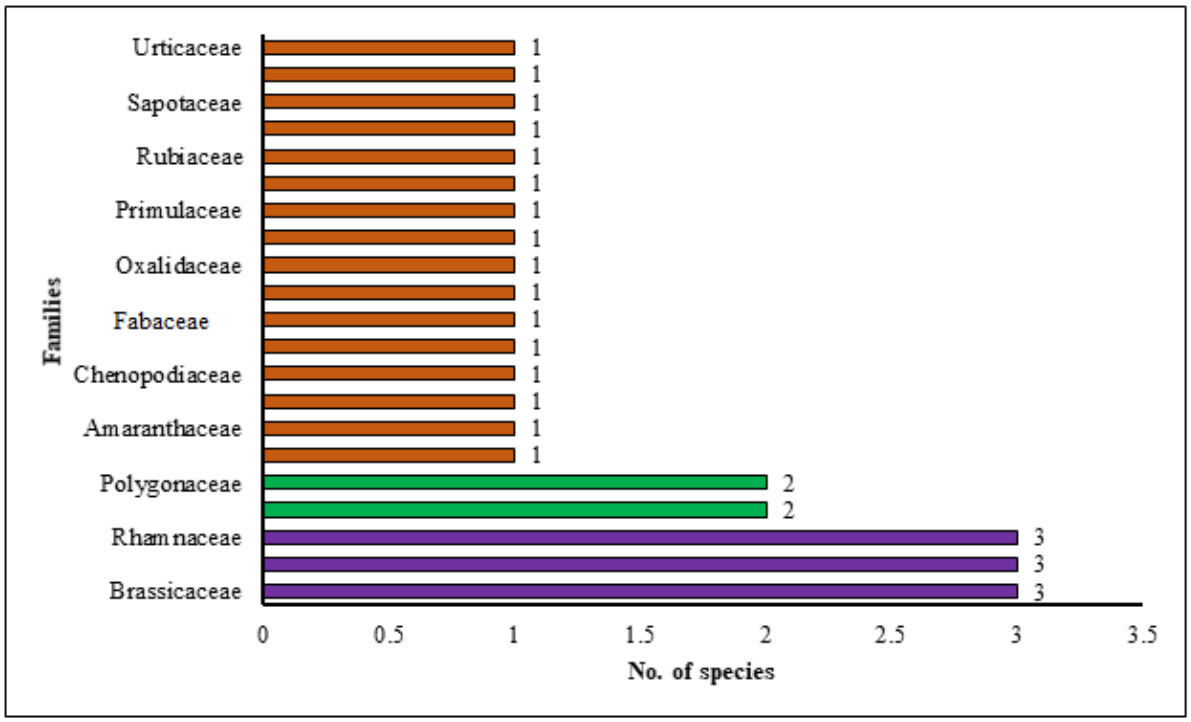

Figure 2. Family-wise distribution of WVFPs

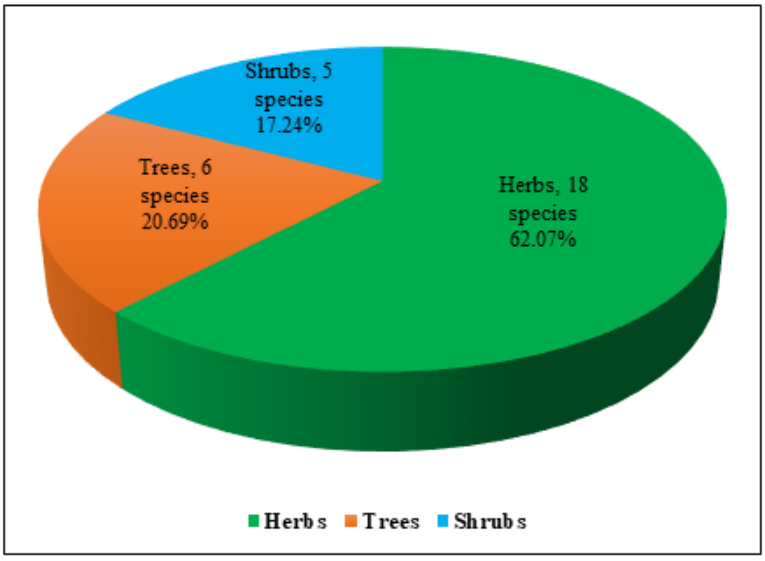

Figure 3. Habit of WVFPs

Traditional culinary practices involving wild vegetables and food plants (WVFPs)

Several traditional recipes prepared from WVFPs were documented, reflecting the diverse culinary practices of local communities. The knowledge of these species and their preparation methods has been passed down through generations. Various approaches to preparing wild foods were employed, depending on the type of plant and its characteristics. Typically, small pieces of wild vegetable plants were sliced and boiled in water as a preliminary step. For cooking dishes, the boiled vegetables were then fried in oil or butter, often with added ingredients such as onion, garlic, ginger, and green chili to enhance flavor. Plants that were used in wild vegetables foods preparation are *Caralluma tuberculata*, *Taraxacum officinale*, *Calendula arvensis*, *Chenopodium album*, *Convolvulus arvensis*, *Malva neglecta*, *Broussonetia papyrifera*, *Morus alba*, *Morus nigra*, *Rumex dentatus*, *Anagalis arvensis*, *Zizyphus jujuba*, *Galium aparine*, *Monothecea buxifolia*, *Solanum nigrum*, *Amaranthus viridis*, *Astragalus anisacanthus*, *Berberis lycium*, *Caltha alba*, *Capsella bursa-pastoris*, *Debregeasia saeneb*, *Oxalis corniculata*, *Nasturtium officinale*, *Plantago major*, *Rumex hastatus*, *Sisymbrium officinale*, *Zanthoxylum armatum*, *Zizyphus oxyphylla*, and *Zizypus nummularia* (Table 2).

Among the most popular traditional dishes was **Saag,** a preparation of green leafy vegetables. The primary ingredients for Saag were typically *Brassica campestris* and *Spinacia oleracea*, which were boiled with other wild vegetables. Once cooked, the vegetables were ground into a paste and fried in oil or butter with spices, onion, garlic, ginger, and green chili, following a traditional method of frying. Saag was often served with *roti* (flatbread) made from corn flour and accompanied by *lassi* (a yogurt-based drink) on special occasions, highlighting its cultural significance. Other unique preparations included sweet dishes made from *Peganum harmala*, which was boiled in milk with sugar, and jams (*Marba*) prepared using *Capparis decidua* and *Citrullus colocynthis*. The findings of this study align with earlier research by Hadjichambis *et al.* (2008), which documented the consumption of cooked wild plants in various Mediterranean regions. Similarly, Misra *et al.* (2008) reported that most WVFPs are traditionally cooked before consumption, a practice echoed in the culinary traditions of the Bajaur District. These results underscore the enduring importance of WVFPs in traditional diets and their role in preserving culinary heritage.

Traditional use of medicinal plants is a rich heritage and evolving practice

District Bajaur, located in the tribal belt of Pakistan, possesses rich biodiversity that contributes to the country's recorded flora of approximately 6,000 species (Abbasi *et al.* 2010; Haq *et al.* 2023b). Over 4,000 of these species are native to the mountainous regions of the Hindukush and Himalayas. In Pakistan, traditional medicine plays a crucial role, treating over 75% of the population, with more than 50,000 herbal practitioners who continue to pass down this knowledge through generations (Shinwari *et al.* 2009; Haq *et al.* 2022). However, a recent survey has shown a decline in the use of traditional plant-based therapies, especially among younger generations, who view them as superstitions or less effective compared to modern medicine. The most commonly used plant parts for vegetable consumption were the leaves, harvested from 19 species, making them the primary choice. This was followed by stems from 18 species, fruits from 11 species, roots from 2 species, and seeds from just 1 species, as shown in Figure 4.

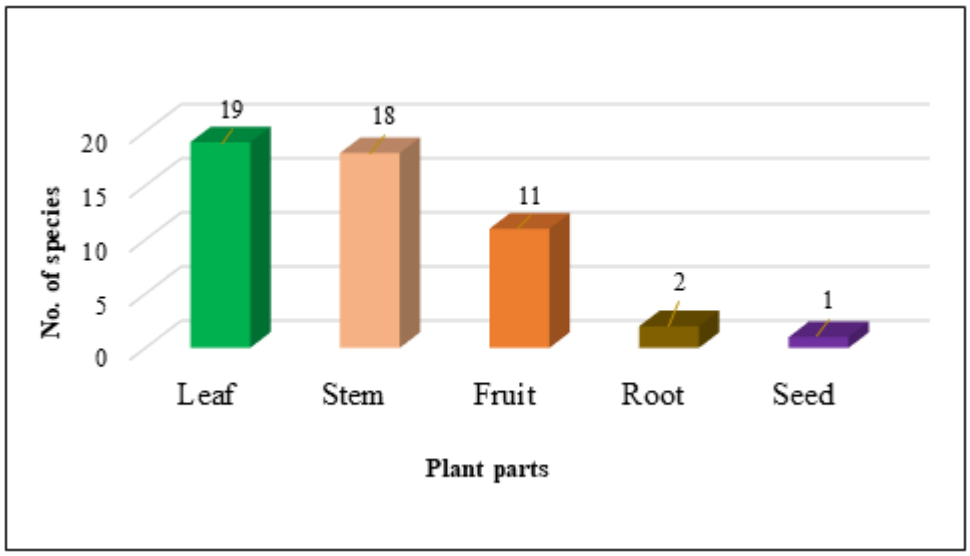

Figure 4. Plant parts used as food

Traditionally, vegetable dishes were prepared by combining fresh leaves and tender stems. These were first boiled in water to soften their texture and bring out their natural flavours. Afterward, the boiled vegetables were sautéed or cooked in oil or ghee, enhancing their richness and imparting a satisfying, savoury taste. To further elevate the dish, a carefully curated mixture of aromatic spices and flavourful condiments was added. This infusion of spices not only enriched the dish with a deep, salty flavour but also imbued it with enticing aromas, making the preparation both flavourful and aromatic, a true delight for the senses. These remedies were primarily administered orally or topically. Oral treatments, taken with water, milk, or black tea, were typically consumed multiple times daily, depending on the severity of the illness. The various parts of plants are rich in bioactive compounds, including both primary and secondary metabolites. These naturally occurring substances possess significant therapeutic properties, making them valuable for the treatment and management of various human ailments (Mustafa *et al.* 2017; Haq and Badshah, 2024). These treatments addressed a wide variety of health issues, including gastrointestinal problems (abdominal pain, bloating, gastric ulcers, intestinal worms, constipation, vomiting, diarrhea, dysentery), respiratory conditions (asthma, flu, sore throat and cough), skin infections (measles, rashes, wound healing), bone fractures, rheumatism, diabetes, earaches, toothaches, eye infections, fever, and heart problems (Table 2). A comparison of the ethnobotanical data with existing literature revealed that the medicinal uses listed in Table 2 align with

the findings of Afzal *et al*. (2009) and Ali and Qaiser (2009), who noted that a traditional remedy for improving vision involved using a seed powder made from *Amaranthus hybridus, A. spinosus,* and *A. viridis*. These findings highlight the importance of traditional knowledge regarding medicinal plants, which continues to play a vital role in rural communities despite the evolving perceptions of plant-based treatments.

Saag is a traditional leafy vegetable dish commonly prepared in many local communities using a variety of wild plant species. In particular, species such as *Amaranthus viridis* (Chalwaye), *Solanum nigrum* (Kachmacho), *Malva neglecta* (Pindirak), and *Rumex dentatus* (Shalkhy) are frequently used due to their rich nutritional value and availability (Fig. 5). The young, tender leaves of these plants are carefully harvested, thoroughly washed, and finely chopped. They are then slow-cooked with a small amount of water until they become soft and tender. After cooking, the greens are mashed and sautéed with aromatic ingredients such as garlic, green chilies, onions, and a small quantity of ghee or oil to enhance their flavour (Fig. 6). This mixed saag is not only a flavorful dish but also a rich source of essential vitamins, minerals, and antioxidants. It is typically served with maize (Jawar) or wheat (Ghanum) flatbread and holds cultural and nutritional significance in the traditional diets of many regions of Pakistan (Ahmad *et al.* 2016; Abbas *et al*. 2020; Abdullah *et al*. 2021; Waheed *et al.* 2023). Out of 46 respondents, *Amaranthus viridis* was cited by 41 individuals as a commonly used wild food, particularly for preparing saag. This was followed by *Solanum nigrum*, cited by 25 informants, and *Rumex dentatus*, mentioned by 11 participants. Other species, such as *Malva neglecta*, *Nasturtium officinale*, *Caralluma tuberculata*, *Chenopodium album*, and *Plantago major,* were cited by fewer than 10 informants each. The high citation frequency of certain species as food reflects their broad acceptance, accessibility, and continued significance in traditional food systems. It also underscores their ethnopharmacological relevance in the local healthcare context.

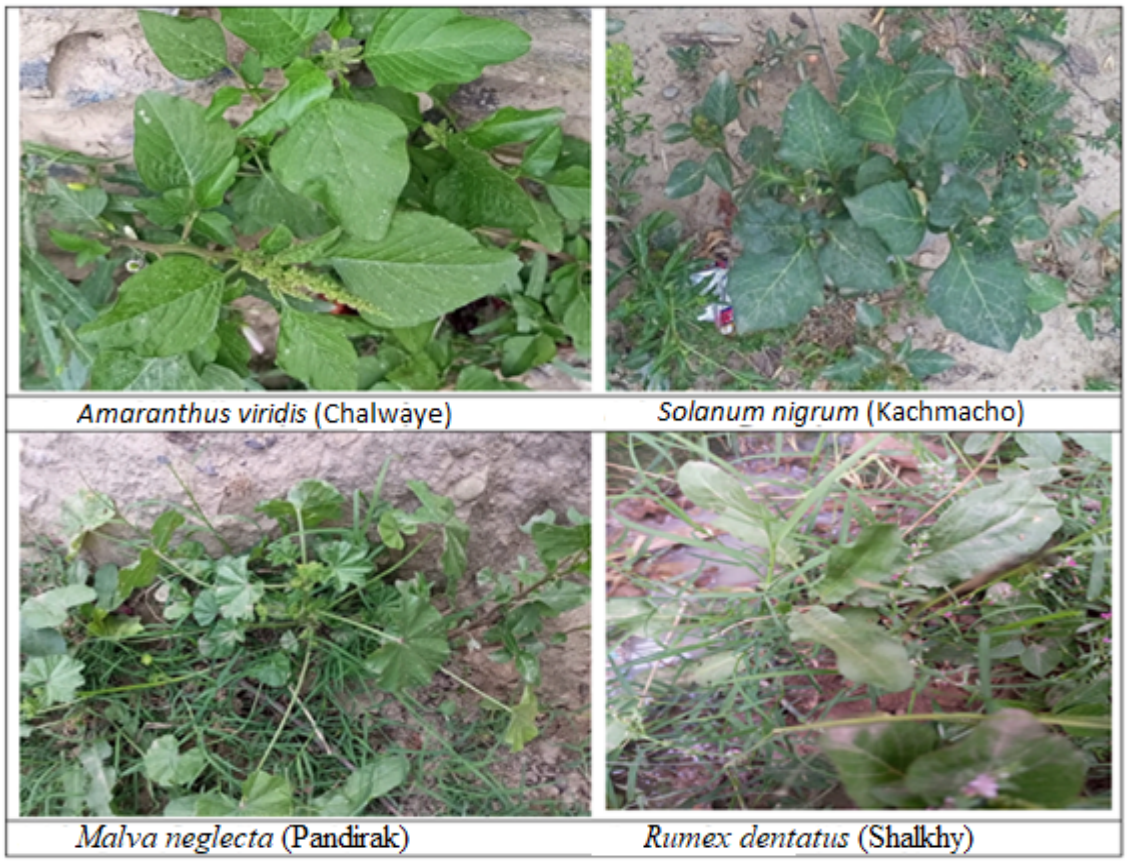

Figure 5. Pictorial view of wild vegetable plants

WVFPs became an important resource for lowering the cost of food and providing a source of income, especially in areas where nearly half of the population lives below the poverty line. Many people rely on selling WVFPs in local markets rather than purchasing expensive cultivated products. Traditional knowledge of WVFPs is passed down primarily from older generations, and the majority of these plants are collected from local habitats for both commercial and domestic use. However, the conservation of these species is essential, as many are currently at risk of biodiversity loss. The local markets, including Khar, Inayat Killi, Pashat, Raghagan, Sadiq Abad Phatak and Nawagai, play a crucial role in the trade of WVFPs, with

several species holding significant economic value. These plants offer a vital resource during crises such as food shortages and extreme weather, and their use has the potential to improve the livelihoods of low-income families. Despite this, conservation efforts are urgently needed to protect these species from further decline due to overuse and environmental changes.

Figure 6. Pictorial view of traditional foods (Saag) prepared from wild vegetable plants

Conclusion

This research marks the first comprehensive study on the contribution of WVFPs to the food system of Bajaur District. It highlighted that the majority of plants used for food preparation are herbs, followed by shrubs and trees, with fresh leaves and stems being the most commonly utilized plant parts. Traditional foods like saag, salad, and chutney are prepared from these plants, demonstrating the deep-rooted cultural reliance on WVFPs for nutrition and health. The study further emphasized the critical importance of conserving these wild plants, as they continue to be a source of sustenance and medicinal relief for local communities. Given their significant role in the local economy and daily life, conservation strategies are urgently needed to ensure the long-term sustainability and biodiversity of WVFPs in the region. This will not only preserve the ecological balance but also help future generations benefit from these valuable plant resources, ensuring they remain a central part of the community's food and medicinal practices.

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