




Wild food plants gathered by four cultural groups in North Waziristan, Pakistan

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Abstract The foraging of wild food plants (WFPs) is an important sociocultural and human ecological phenomenon, especially in more peripheral rural and mountain areas of the world. Plant-centered local knowledge and practices are an important asset of every human community and their articulation is specific for every cultural group, although sometimes these knowledge systems can extend beyond cultural borders and be shared among diverse linguistic, ethnic, and religious groups. The current study explored the WFPs used among four cultural groups, i.e., Dawar, Mehsood, and Wazir Pathans, and Ormur speakers, living in North Waziristan, NW Pakistan. A total of 47 WFPs were used by the studied groups, most of which were used as snacks (35 species) or cooked vegetables (23 species). Fruits

and aerial parts were frequently consumed. Cross-cultural analysis revealed that only 11 species were commonly used by the four studied groups and a high overlap of plant use was observed between the Mehsood and the Ormur peoples, and the Mehsood and the Wazir communities. More particularly, the WFP use of the Ormur has been completely homogenized with the three different Pathan cultural groups, which indicates a possible cultural assimilation of the Ormur to the dominant Pathan culture, which in turn may have affected their plant use. The study also reports some food and herbal ingredients that are new or rarely used for/in the NW Pakistani ethnobotanical literature, such as *Chenopodium botrys*, *Iris hookeriana*, *Marrubium vulgare*, *Pistacia khinjuk*, *Polygonum verticillatum*, *Tamarix aphylla*, and *Tricholepis furcata*. It is advisable that the recorded food bio-cultural heritage be properly revitalized for improving the food security of the local communities as well as seriously considered in future development programs.

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Introduction

Foraging is a vital socioecological practice among many local communities across the globe. In Pakistan, rural and remote mountain communities are

crucially involved in foraging wild food plants (WFPs). People living in these areas are always vulnerable to food insecurity and as a result foraging is an important human ecological adaptation in times of famine or food shortages (Sulaiman et al. 2022; Guinand et al. 2001; Ocho et al. 2012). Studies have revealed that local communities residing in mountain areas have therefore retained an important store of local knowledge on WFPs, which is an integral part of their culture and is crucially embedded in their daily practices (Söukand and Pieroni 2019; Pieroni et al. 2021). Mountain areas are also an important refuge for biocultural diversity, the subject which thoroughly explains the relationship of culture with biodiversity in a given socio-ecological space (Pieroni and Söukand 2018; Kalle et al. 2020; Pieroni 2017). Thus, every culture has its own viewpoint on the surrounding biological environment which is evolving and revolving on both a spatial and temporal basis, leading cultures to accumulate a body of traditional knowledge on these natural resources (Turner et al. 2011; Gómez-Baggethun et al. 2010; Anderson et al. 2012).

In the current historical time, many local communities have experienced cultural transitions, leading them to reshape their relationships with natural resources and rearticulate the local knowledge attached to plants (Pieroni et al. 2014; Stryamets et al. 2021). Living in multicultural environments, people tend to share knowledge and information, but most often the dominant culture tends to influence and impose its viewpoint on minority groups, which in turn forces the latter to conform to the mainstream way of thinking and behaving (Mattalia et al. 2020; Pieroni et al. 2011; Quave and Pieroni 2015; Ahmad and Pieroni 2016; Aziz et al. 2020a, b; Aziz et al. 2021a, b, c; Abbas et al. 2020). One of the most intriguing questions asked in human ecology is how traditional ecological/environmental knowledge has changed across time and space (Hernández-Morcillo et al. 2014; Ghirardini et al. 2007). More recently, we have seen a number of ethnobiological field studies focusing on the impacts of language and religion on local/traditional environmental knowledge (LEK/TEK) and these studies have observed that both religion and language have played a crucial role in forming social networks with other cultural groups, which have been found to strongly influence the transmission of plant-related cultural knowledge across

groups (Söukand and Pieroni 2019; Aziz et al. 2021a, b, c; Majeed et al. 2021). Therefore, researchers have always shown an interest in more thoroughly understanding the transmission of TEK on WFPs among different ethnic groups or diasporas, in order to assess how food-centered knowledge evolves and is shared in multicultural environments. Among the various groups in the region, the Dawar, the Mehsood, and the Wazir Pathans are linguistically closer and have been living in the Afghan region for centuries (Chodha 2019) while Ormuri speakers represent a cultural diaspora that arrived from the Middle East and settled in the area during the 11th Century (Morgenstierne 1929; Kieffer 1972). The former three groups speak different dialects of the Pashto language and historically they have lived in different geographical locations across the Pakistan-Afghan border (O'Leary 1992). In the tribal belt sharing a border with Afghanistan, local communities are remarkably dependent on wild food resources (Aziz et al. 2021a, b, c; Abdullah et al. 2021), especially those people who rear animals and use mountain pastures to graze their animals, as these areas are more isolated and have very limited access to food markets. Living in remote areas, these tribal communities frequently supplement their local food systems with WFPs. However, social change is affecting this traditional socio-ecological system and a few community members are trying to live in urban environments, where they have easy access to the local food market and grocery shops. The objectives of the current study were:

1. To record the local names and uses of WFPs among Dawar, Mehsood, and Wazir Pathans and Ormuri speakers in North Waziristan, NW Pakistan
2. To compare the WFP uses of the four different considered groups and to possibly interpret differences and commonalities
3. To compare the recorded data with the previous NW Pakistani food ethnobotanical literature.

Materials and methods

Study area and communities

Geographically, Waziristan is considered to be a single unit; however, it is divided into two districts, i.e.,



Fig. 1 Different ecological zones and landscapes of the study area

South Waziristan and North Waziristan, for administrative convenience (Makki and Tahir 2021; Bangash 2018). The area is known for its high elevation and rugged hills (Fig. 1). The geographical location of the study area is presented in Fig. 2. The total area covered by North Waziristan is 4,707 km², extending from 69°22' E to 70°38' E longitude and from 32°35' N to 33°22' N latitude, and with an elevation range of 1,493 to 2,499 m above sea level (Irum et al. 2021). The estimated population is approximately 543 thousand people (Makki and Iftikhar 2021; Irum et al. 2021; Nahyan et al. 2019). During colonial times, Miranshah was the capital city of North Waziristan (Makki et al. 2021). North Waziristan is subdivided into three main divisions: Miran Shah, Razmak, and Mirali. The area is further divided into nine Tehsils (local administrative units), i.e., Datta Khel Tehsil, Gharyum Tehsil, Mir Ali Tehsil, Razmak Tehsil, Spinwam Tehsil, Dossali Tehsil, Ghulam Khan

Tehsil, Miran Shah, and Shewa Tehsil (Rasool and Anwar 2019).

Wazir community

In Waziristan, the Wazir community represents the majority of the local population and because of this predominance the region has been given its name (Shakirullah et al. 2020). Different ethnological hypothesis exist about the origin of the Wazir community. The ancestors of the Wazir tribe could be Rajputs because ethnologically they share similarities with the Indians, having a large admixture of Scythian and Tartar blood (Nahyan et al. 2019). The Wazir tribes that inhabit South Waziristan are known as Ahmadzai Wazir, while those that live in North Waziristan are considered Utmanzai (Nichols 2021). Primarily, they lived in Birmal territories, but later on, in the fourteenth century, they defeated the local tribes (Khattak and Dawar) and ousted them from the Shawal and Kohat border

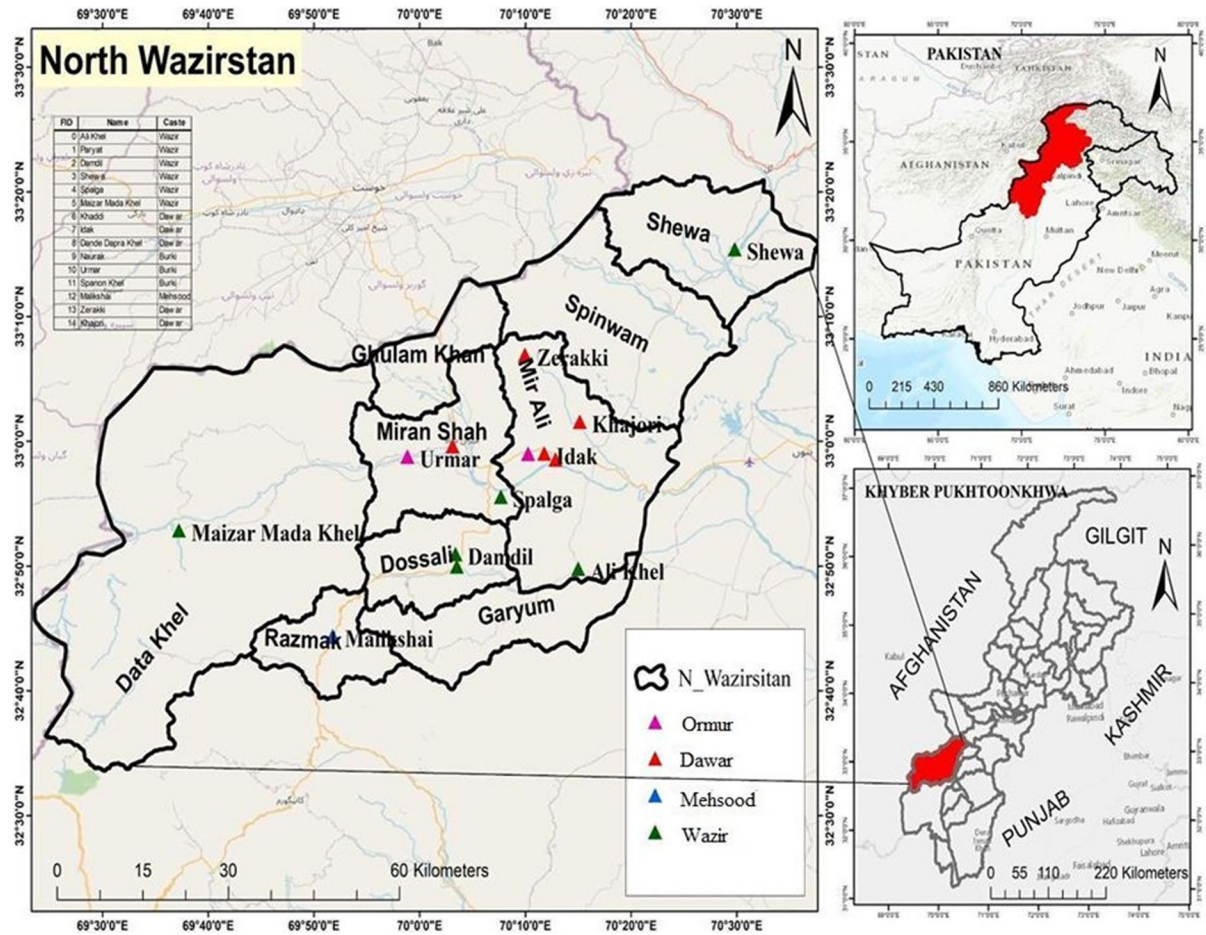


Fig. 2 Map of the study area and villages

near Tochi. Nowadays, they are spread over most parts of North Waziristan. They reside in both lower elevation (in winter) and higher elevation (in summer) areas. In North Waziristan, most of them are shepherds, heavy transport vehicle drivers, and potato and maize farmers, while a small number of them hold government jobs or run forest businesses (Table 1).

Dawar community

The Dawar group belongs to the Karlani Pathan tribe, it is closely related to the Banuchis and considered descendant of the Shitaks (branch of Karlani Pathans). However, they are traditionally considered to be descended from Shah Husain (Ghor Sultanate). The Dawar peoples are subdivided into two groups,

i.e., Spin Gwand (Milizad) and Tor Gwand (Patizad), while geographically they are divided into upper and lower Dawar. Before the 14th Century, Dawar Pathans settled in Shawal, but they were then ousted by the Wazirs and driven towards the Tochi Valley, where they settled and spread (Dawar et al. 2021). Nowadays, the Dawars are considered educationally and economically more advantaged than the other communities in North Waziristan. The main economic and business centers of Waziristan are found in the territories of the Dawars, i.e., Mirali Bazaar, Idak Bazaar, and Miranshah Bazaar. The Dawars have plenty of fertile agricultural land, where the primary crops cultivated include maize, wheat, and *Trifolium* spp. (used as fodder). All the fields are irrigated via a single source, i.e., the Tochi River. The majority of

Table 1 Characteristics of the visited villages (plains and mountains) and studied linguistic communities

Languages	Average age	Studied villages	Elevation (meters above the sea level)	Religious faith	Ecology of the area	Number of interviewees	Endogamic/Exogamic rules	Main occupation
Wazir community								
Waziri Pashto (Iranic)	42	Ali Khel	868	Sunni Islam	Both plain and mountain areas	4 male/2 female	Rarely exogamic towards the Mehsood and other Pathan communities	Horticulturists, farmers, drivers (heavy transport vehicles), and laborers
		Paryat	1226	Sunni Islam		2 male/0 female		
		Damdil	1306	Sunni Islam		6 male/0 female		
		Shewa	652	Sunni Islam		4 male/0 female		
		Spalga	920	Sunni Islam		2 male/0 female		
		Maizar Mada Khel	1500	Sunni Islam		8 male/2 female		
Dawar community								
Dawar Pashto (Iranic)	53	Khajori	644	Sunni Islam	Plain areas	4 male/0 female	They are mostly endogamic, but sometimes exogamous towards the Wazir community	Shopkeepers, local sellers, farmers, and businessmen
		Zerakki	707	Sunni Islam		6 male/2 female		
		Khaddi	721	Sunni Islam		6 male/2 female		
		Idak	732	Sunni Islam		6 male/0 female		
		Dande Darpa Khel	949	Sunni Islam		2 male/2 female		
Ormuri community								
Ormuri (Iranic)	51	Naurak	758	Sunni Islam	Mountain areas	10 male/4 female	Endoamic in the past, mostly exogamic nowadays	Government officers, horticulturists, and farmers
		Urmar	1022	Sunni Islam		4 male/2 female		
		Spanon Khel	2114	Sunni Islam		8 male/2 female		
Mehsood community								
Mehsood Pashto (Iranic)	47	Malakshai	2297	Sunni Islam	Mountain area	22 male/8 female	Exogamic towards all the Pathan communities	Shepherds, farmers, laborers, and employed in government offices

the population are businessmen, farmers, or have government jobs (Table 1).

Mehsood community

The Mehsood peoples are a Karlani Pathan tribe (the last ruler of Bengal Sultanate), mostly settled in South Waziristan, with a small number of individuals living in North Waziristan and in the Logar Province, Afghanistan. The Mehsood Pathans were first called “Mehsood Wazir” or just “Wazir” by British travelers because their ancestry was sufficiently close to other Wazir groups; however, they have had a distinct identity since the 19th Century. The Mehsood tribe is now divided into three main sub-tribes locally referred to as “D’ray Maseed” (i.e., Alizais, Shaman Khels, and Bahlolzais). The main business and population centers of the Mehsood tribe are Makin and Kaniguram in South Waziristan, which also share boundaries with North Waziristan (Razmak) (Beattie 2019). In North Waziristan, the Mehsood Pathans first settled only in Razmak town and Malikshai village (Razmak Tehsil), but because of military conflicts the population moved back to South Waziristan from Razmak town while they remained in Malikshai village (Table 1). The main subsistence activities of the Mehsood tribe are keeping domestic animals, horticulture, and working in governmental jobs. As compared to other tribes, they have a limited amount of cultivable land and irrigation water, and so they have constructed a proper irrigation system (irrigation channels and strong stone walls around fields) to fully utilize the local available resources.

Ormur community

Different ideas and hypotheses exist about the ancestry and the arrival of the Ormuri speakers in Waziristan. The literature on the progenitors of the Ormuri group is quite limited. The local people use another name for the term “Ormuri”, which is “Barki”. The Ormuri tribe also belongs to the Karlani Pathan tribe. They have their own distinct Eastern Iranian language, called Ormuri, but due to being part of the Pathan tribal system for a long time, they have started speaking the local Pashto language, while their own Ormuri language is only used in the home (Aziz et al. 2021c). In the past, the Ormuri speakers were only settled in Logar Province, Afghanistan

and Kaniguram, South Waziristan, Pakistan (Efimov 2011). According to Khattak (2011), the population of Ormuri speakers in Kaniguram counts approximately 10,000 members. According to the traditional orientalist history of the studies, diverse populations (Persians, Kurds, Afghans, and Arabs) have been thought to be the ancestors of the Ormuri community (Grierson 1918; Morgenstierne 1926, 1929). According to one Russian linguist instead, Ormuri speakers migrated from the southern shores of the Caspian Sea to the south-eastern part of Iran (Efimov 2011), while other hypotheses suggest that for a long time they were living as indigenous communities in southern areas of the Hindu Kush. Other scholars believe that the ancestors of today’s Ormuri people were taken to Egypt by Darius Hystaspes, Persian Emperor Governor of Egypt, after conquering the Greek colonies of Kyrene and Barke in Libya, and then later resettled in Bark’e village of Central Asia (Bactrian area) (Bellew 1891). Today’s Ormuri tribes living in the villages of Baraki Rajan and Baraki Barak in the Logar district of Afghanistan would represent the former Barkaian colony (Bellew 1891). According to Captain Leech (1838), the Ormuri speakers were probably linked with Tajaks and Parsiwans and could have been brought from Yemen by Sultan Mahmud of Ghazni in the eleventh century during his invasion of India (Morgenstierne 1929; Kieffer 1972, 1979; Bellew 1891; Leech 1838). Later in the 11th Century, some of the Ormur soldiers would have settled in Kaniguram, after the return of Sultan Mehmud to Afghanistan, because they could have found a suitable valley in which to dwell. From the very start, the Ormur tribes were active in various fields of life, such as horticulturalism, pastoralism, and education. Nowadays they are spread across different parts of the world, while in North Waziristan they are reported to be settled in three villages, i.e., Naurak, Urmar, and Spanon Khel (Table 1).

Field study

A field ethnobotanical study was carried out from October to December 2021 in 15 different villages in North Waziristan. We employed the emic concept of “wild”, e.g., recorded the uses of plants that were thought to be wild/non-cultivated by the local community, without considering the etic concept of “being wild” in plant biology. We interacted with 120

randomly selected informants (30 from each linguistic group), including both males and females, via focus group discussions, interviews, and a semi-structured questionnaire. All the interviews were conducted in the local Pashto (Pathan) language, which all the groups were able to speak and understand as it was and still is the *lingua franca* in the study area. The majority of participants were middle-aged and elderly individuals (range: 36 to 80 years old) who worked as local food sellers, plant collectors, shepherds, housewives, and farmers, as they were considered possible knowledge holders who have had continuous contact with the local environment in the study area. The main characteristics of the study area and study participants presented in Table 1 were obtained through interviewing study participants. The interviewees were informed about the objectives of the survey. Prior to each interview, verbal consent was obtained from each of the participants, and the Code of Ethics adopted by the International Society of Ethnobiology (ISE 2008) <http://www.ethnobiology.net/whatwe-do/coreprograms/ise-ethics-program/code-of-ethics/> was strictly followed. It is important to note that in most cases women were not directly interviewed by the first author due to cultural restrictions and respect

for the practice of *Pardah* (veil). Therefore, for interviewing women we used two approaches: a) male family members mediated our questions and answers, or the women were interviewed covered with a *Burka* (*Hijab*). The women in particular were interviewed to learn about the basic culinary processing of WFPs. In the semi-structured interviews, we focused on locally used WFPs: wild vegetables, wild fruits, seasoning wild plants, as well as commonly used home-made wild teas. Study participants were asked local names, perceived availability, part used, habitat, availability period, gathering areas, collectors, market price (for those species which are traded in local markets for commercial purposes), use modality, gastronomic use, medicinal properties of all quoted wild food plants (Fig. 3). The map of the study area was designed with the help of ArcGIS software and Google Earth. We also took some photos of the study participants who gave consent to publish them. With the help of a taxonomist and the available literature related to the flora of Pakistan, all the documented species were identified (Nasir and Ali 1970–1979; Nasir and Ali 1980–1989; Nasir and Ali 1989–1992; Ali and Qaiser 1993–2009). Voucher specimens were subsequently deposited at the Herbarium of the



Fig. 3 Interviewing local inhabitants during the field survey

Department of Botany, University of Peshawar, Khyber Pakhtunkhwa, Pakistan. Nomenclature followed the Plants of the World Online (<https://powo.science.kew.org/>).

Data analysis

The data were processed by creating two datasets in MS Excel for each studied group: one comprising the overall plants used and the other containing the most frequently quoted plants (those reported by more than 50% of the informants). For each of the datasets, proportional Venn diagrams were built simply in MS Word without the use of any specialized software to compare the data among the different linguistic groups. The frequency of citation from each linguistic group was recorded for each taxon by counting the number of informants mentioning the plant's uses. Additionally, the data were compared for each pair of datasets using the Jaccard similarity index (JI) to assess the similarities and differences among the considered linguistic groups (González-Tejero et al. 2008). The similarity in data among the two sets was determined using the following formula (Jaccard 1901):

$$J[A, B] = \frac{A \cap B}{A \cup B}$$

A = individual set of plant uses reported among group A ; B = individual set of plant uses reported among group B .

Moreover, to identify possible novelties in use, the reported data were compared with the previously documented food ethnobotanical literature of Pakistan (Majeed et al. 2021; Ahmad and Pieroni 2016; Aziz et al. 2020a, b; Aziz et al. 2021a, b; Abbas et al. 2020; Abbasi et al. 2013; Khan et al. 2015, 2021; Tareen et al. 2016; Abdullah et al. 2021; Manduzai et al. 2021; Abdullah et al. 2021).

Results and discussion

WFPs and their uses

The survey recorded a total of 47 wild food species, including one mushroom species, belonging to 29 botanical families which were quoted by the four studied groups (Table 2, Fig. 4). The frequently

reported species included *Amaranthus viridis*, *Mentha longifolia*, *Apteranthes tuberculata*, *Convolvulus arvensis*, *Malva neglecta*, *Nasturtium officinale*, *Oxalis corniculata*, *Portulaca oleracea*, *Quercus baloot*, *Quercus incana*, *Teucrium stocksianum*, and *Withania coagulans*, which have also been frequently quoted in the food ethnobotanical literature of Pakistan (Aziz et al. 2020a, b; Aziz et al. 2021a, b, c). Lamiaceae was the dominant plant family represented by five species, followed by Amaranthaceae and Moraceae (four species each) and Rosaceae (three species). The greater number of WFPs and wider cultural acceptance of the Lamiaceae family can probably be related to the fact that the species belonging to this family are highly aromatic in nature, offering distinctive flavors and making them favorable for consumption as food or medicine (Aziz et al. 2021a, b, c). Most of the quoted WFPs were used as a raw snack (35 species: 74%) or cooked as a vegetable (23 species: 49%) (Table 2). The consumption of raw snacks is an interesting phenomenon in food anthropology and predominantly emerged during the development of mobile pastoralism. Our results are in line with the work of our research group in South Waziristan, Pakistan (Aziz et al. 2021c). The WFPs were collected from different habitats including mountains, fields, stream banks, and near houses. Most of the wild vegetables, apart from *Mentha longifolia* and *Nasturtium officinale* which were reported to be present only on the bank of streams, were reported from mountain regions (18 species) and fields (13 species) near houses (Table 2). The generation gap and changes in lifestyle have led to a decrease in the transmission of ethnobotanical knowledge from elderly individuals to the younger generation (Bussmann et al. 2018; Hedges et al. 2020; Ludwinsky et al. 2020; Aswani et al. 2018). Our results are in agreement with the previously published literature that reported a great erosion of LEK of WFPs in the younger generation (Odhav et al. 2007; Modi et al. 2006), but contrary to the results of Shava (2000) for the Eastern Cape region where an extensive LEK of wild vegetables was found in the younger generation. Vorster et al. (2007) mentioned that traditional vegetables are considered poverty foods and used by the uneducated, which is the reason the younger generation is not interested in learning about these vegetables (Fig. 5).

The analysis revealed that more than 50% of the quoted species were reported by less than 50% of

Table 2 Local uses of WFPs gathered and consumed in the study area

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
01	<i>Amaranthus viridis</i> L., Amaranthaceae, UOP NK 01	Sakaak ^O , Ranzaka ^{W,D,M}	Reduced availability due to the shortage of water in an area	Leaves	Herb	June–October	Fields	Male, female	0.49 \$ ^W	Cooked	Young fresh leaves are cut into small pieces and boiled in water for one hour. The extra water is poured out after boiling. Tomatoes are added to another pot containing fried onion and red chilies and then cooked for 10 min. Finally, the boiled leaves are mixed with the tomato and onion mixture. Kept on fire until the water evaporates and oil appears on the side and top. This is now ready to be eaten with bread	Carminative, stimulant, and diuretic	W (16) D (4) M (12) O (8)	Yes
02	<i>Allium carolinianum</i> DC., Amaryllidaceae, UOP NK 02	Ghra yazza ^M , Wozza ^O Ghra pyoz ^{W,D}	Reported decrease in availability due to a decrease in the rate of precipitation over the last few years	Leaves	Herb	May–June	Mountains and fields	Male, female	–	Fresh	–	Used against fever and as a stimulant	W (4) D (2) M (4) O (2)	Yes
03	<i>Berberis lycium</i> Royle, Berberidaceae, UOP NK 03	Keral ^{W,M,O}	Reported increase in availability due to less grazing and utilization	Fruits, leaves, barks	Shrub	July–August	Mountains and fields	Children, male, female	–	Fresh	–	Roots are used against hepatitis, skin disorders	W (6) D (0) M (8) O (2)	Yes

Table 2 (continued)

S.	Plant species, family, NO and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
04	<i>Apteranthes tuberculata</i> (N.E.Br.) Meve & Liede., Apocynaceae, UOP/NK 04	Pawanal ^{W.D.M.O}	No pronounced decrease or increase reported in availability	Aerial parts	Herb	August–October	Moumtains	Male, female	1.03 \$ ^{MD}	Fresh, cooked	The whole stem is washed with water and cut into small pieces. To avoid bitterness the fresh stem is boiled in salty water for 15 to 20 min. After boiling, the water is poured out and the boiled stem pieces are put into another container containing onion, red chilies, and tomato paste. Keep it on fire until an oil appears on its top and sides. Now, this is ready for eating with bread	Antidiabetic and carminative	W (10) D (6) M (4) O (2)	Yes
05	<i>Celtis australis</i> L., Cannabaceae, UOP/NK 05	Terawan ^{WM} Taagh ^O	Significant decrease in availability reported due to deforestation and the Waziristan war	Fruits	Tree	September–October	Moumtains	Male, female	–	Fresh	–	None	W (2) D (0) M (6) O (6)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
06	<i>Chenopodium album</i> Bosc ex Moq., Amaranthaceae, UOP NK 06	Sormai ^W , Speen sormai ^M , Kharrsaak ^O , Sherakeey ^D	Decrease in the availability of the species due to the shortage of water	Aerial parts, leaves	Herb	April–June	Fields	Male, female	0.57 \$ ^{DM}	Cooked	The species is cooked by itself or with other wild vegetables. When cooked by itself, the fresh young leaves and stem are washed with water and boiled for half an hour. The boiled stem and leaves are then mixed with fried onion. To complete the full cooking process and make it completely edible, the mixture is kept on the fire for nearly 20 to 25 min. In the second case, the leaves 07 and young stems of different wild vegetables are collected randomly in small quantities and boiled together. All the boiled food plants are then fried in oil for 15 to 20 min to perfectly cook	Used against constipation and kidney problems	W (6) D (2) M (6) O (2)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
07	<i>Chenopodium botrys</i> L., Amaranthaceae, UOP NK 07	Marghai teeth ^M	Decrease in the availability of the species due to the Waziristan war	Fruits	Herb	August – October	Fields	Male, Female	–	Fresh	–	None	W (0) D (0) M (8) O (0)	Yes
08	<i>Chenopodium foliosum</i> Asch., Amaranthaceae, UOP NK 08	Khorrach ^{M,O}	–	Fruits	Herb	August – October	Fields	Male, female	–	Fresh	–	None	W (0) D (0) M (6) O (4)	Yes
09	<i>Convolvulus arvensis</i> L., Convolvulaceae, UOP NK 09	Parwatiay ^{W,D,M,O}	Decreased availability due to less crop cultivation as it is found as a weed species in cropland	Leaves	Herb	March–June	Fields	Male, female	–	Cooked	The fresh young leaves are put in a container containing water for boiling. The leaves are boiled for nearly 10 min. A fried onion, green chili, and tomato mixture is prepared in another container. When the leaves become soft, the extra water is poured out and they are added to the container containing the onion, green chili, and tomato mixture. This is cooked together for 5 to 10 min until all the water evaporates. It is then ready to eat	Leaves are especially used for skin disorders	W (0) D (16) M (2) O (6)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
10	<i>Cotoneaster nummularius</i> Fish. and C.A.Meyer, Rosaceae, UOP NK 10	Sherawa ^{W,M,O}	Increased availability due to less grazing, as the majority of families have not moved back into their territory after the Waziristan war	Fruits	Shrub	April–June	Moun-tains	Childers, male, female	–	Fresh	–	None	W (10) D (0) M (6) O (4)	Yes
11	<i>Ficus palmata</i> L., Moraceae, UOP NK 11	Toghta ^{W,M,D} Inzeer ^O	Availability remains the nearly same, no pronounced decrease or increase reported	Fruits	Tree	June–July	Moun-tains	Male, Female	–	Fresh	–	None	W (6) D (6) M (2) O (4)	Yes
12	<i>Fragaria nubicola</i> Lindl., Rosaceae, UOP NK 12	Ghra strawberry ^M	Increasing availability due to less grazing and smaller population size in the area	Fruits	Herb	May–August	Moun-tains	Male, Female	–	Fresh	–	None	W (0) D (0) M (12) O (0)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
13	<i>Iris hookeriana</i> Foster., Iridaceae, UOP NK 13	Sheezai ^{W,DM}	Availability remains the nearly same, no pronounced decrease or increase reported	Leaves	Herb	May–June	Mountain	Male	0.42 \$ ^M	Fresh and cooked	First, the leaves are boiled in water for an hour. After boiling, the water is poured into another container. Tomatoes are reduced to a paste in oil in another container. The boiled leaves are mixed with the tomatoes. The container is kept on the fire until oil comes to the top	None	W (4) D (4) M (6) O (0)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
14	<i>Lepidium draba</i> L., Brassicaceae, UOP NK 14	Bashka ^{D,M} Ghughwast ^O	Decreased availability due to the increase in uncultivated land as it was found associated with cultivated crops	Leaves	Herb	March–May	Moun-tains and fields	Male, female	–	Cooked	The leaves are cut into pieces, washed with water, and boiled for half an hour. In another pot some onions are fried in oil or ghee; when the onions turn brown, the cut pieces of the plant and the tomatoes are added. This is kept on medium heat for 15 to 20 min. When the tomatoes dissolve, and the leaves change color from light green to dark green and ghee appears on the surface, it is now ready to eat with bread made from wheat or maize	Leaves are used against facial skin infections and as a carminative	W (0) D (18) M (12) O (16)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
15	<i>Mahva neglecta</i> Wallr., Malvaceae, UOP NK 15	Tikal ^{W,M,D} -Tech ¹⁰	Decreased availability due to high consumption	Leaves, fruits	Herb	March–April	Fields	Male, female	0.57 \$ ^w	Fresh, cooked	The fruits are used fresh while the leaves are cooked. Leaves are washed with water, then put in a container for boiling. Onions are fried in oil in another container. When the onions turn brown, the tomatoes are added. The container is kept closed for some time so that the tomatoes become a paste. Once this happens, the boiled leaves are added. The container is kept on the fire until oil appears on the top	Used against constipation, and as an antitussive and an antidiuretic	W (16) D (6) M (8) O (4)	Yes
16	<i>Marrubium vulgare</i> L., Lamiales, UOP NK 16	Khwrashka ^{W,O,M}	Increased availability due to less grazing as animals do not like to eat it because of its bitter taste	Leaves	Herb	June–August	Mountains and fields	Male	–	Cooked	The leaves are boiled in water and drunk as a tea	Antitussive	W (4) D (0) M (8) O (4)	No

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
17	<i>Medicago polymorpha</i> L., Fabaceae, UOP NK 17	Speshitara ^M Speshitai ^w	Reported increase in availability due to a decrease in the human population as the majority of families have migrated	Leaves	Herb	March–June	Moun-tains and fields	Male, female	–	Fresh, cooked	The leaves are fried with salt on a teghna (metal plate used for cooking purposes)	Antihypertensive	W (8) D (0) M (12) O (0)	Yes
18	<i>Mentha longifolia</i> (L.) L., Lamiaceae, UOP NK 18	Valana ^{W,D,M} Ghwan ^O	Decrease in availability due to a disturbance that occurred in the irrigation system as it is found on the banks of water bodies	Leaves	Herb	April–September	Bank of stream	Male, female	–	Fresh, cooked	Leaves are used as a salad with bread. Some people also cooked them. Leaves are boiled and then fried in oil. Some people used the leaves as a tea	Used against diarrhea and abdominal pain	W (6) D (12) M (20) O (16)	Yes
19	<i>Morus alba</i> L., Moraceae, UOP NK 19	Speenteet ^{W,M,D}	–	Fruits	Tree	April–May	Moun-tains and fields	Male, female	–	Fresh, cooked	The young fruit is fried in oil for 10 to 15 min and eaten with bread	Used against constipation and abdominal disorders	W (4) D (12) M (4) O (0)	Yes
20	<i>Morus nigra</i> L., Moraceae, UOP NK 20	Turteet ^{W,M,D,O}	Decreased availability due to high consumption for timber purposes	Fruits	Tree	April–May	Moun-tains and fields	Male, female	–	Fresh, cooked	The young fruit is fried in oil for 10 to 15 min and eaten with the breed	Used to strengthen the nervous system and for sleeping	W (4) D (8) M (4) O (4)	Yes
21	<i>Morus</i> sp., Moraceae	Abedani ^D	Decreased availability due to high consumption for timber purposes	Fruits	Tree	May–June	Moun-tains and fields	Male, female	0.85 \$ ^D	Fresh	–	Appetite stimulant	W (0) D (16) M (0) O (0)	No

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
22	<i>Nannorrhops ritchiana</i> (Griff.) Aitch., Araceae, UOP NK 21	Mazaral ^M	Increasing availability due to human migration from the area	Root bulbs	Tree	Whole year	Fields	Male, female	–	Fresh	–	Used for oral and stomach infections	W (0) D (0) M (12) O (0)	Yes
23	<i>Nasturtium officinale</i> R.Br., Brassicaceae, UOP NK 22	Tarmira ^{P,O} Dalamira ^M	Decreased availability due to less precipitation and a poor irrigation system	Leaves	Herb	Whole year	Bank of stream	Male, female	–	Fresh, cooked	The leaves and young shoots are crushed with a mortar and pestle and then added to another container containing oil or ghee, it is then fried for 5 to 10 min, when there is a pleasant smell, it is ready to eat	Used as a carminative and an antidiuretic	W (0) D (8) M (12) O (20)	Yes
24	<i>Oxalis corniculata</i> L., Oxalidaceae, UOP NK 23	Tarwekal ^{W,M,D} Tuftufak ^O	Increased availability due to less grazing	Leaves	Herb	March–May	Moun-tains and fields	Male, female, Childers	–	Fresh	–	Treat diarrhea	W (0) D (4) M (20) O (8)	Yes
25	<i>Olea ferruginea</i> Royle., Oleaceae, UOP NK 24	Shaavan ^{W,M} Showan ^O	Decreased availability due to deforestation	Fruits	Tree	September–October	Moun-tains	Male, Female	–	Fresh	–	Used to purify the blood	W (8) D (0) M (4) O (12)	Yes
26	<i>Periploca aphylla</i> Decne., Apocynaceae, UOP NK 25	Barara ^{W,M}	Increasing availability due to human migration from the area because it is used as fuelwood by local inhabitants	Fruits	Shrub	March–April	Moun-tains	Female	–	Dried	The young stem is cut into pieces with a sharp blade or pebble. The gum that comes out is dried for one day, after which it can be used as gum	None	W (8) D (0) M (4) O (0)	Yes

Table 2 (continued)

S.	Plant species, family, NO and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
27	<i>Pistacia khinjuk</i> Sapotaceae, UOP NK 26	Sherawani ^{W,M}	–	Fruits	Tree	–	Moun-tains	Male, female	–	Fresh	–	None	W (4) D (0) M (4) O (0)	Yes
28	<i>Plantago ovata</i> Forsk., Plantaginaceae, UOP NK 27	Sath ^O Ispaghul ^{M,D}	Increased availability due to less grazing as animals do not like to eat it	Fruit and seeds	Herb	June-October	Moun-tains and fields	Male	2.28 \$ ^{O,D,M}	Fresh	–	Keep the gastrointestinal tract healthy	W (0) D (16) M (8) O (18)	Yes
29	<i>Peroyskia atriplicifolia</i> Benth., Lamiaceae, UOP NK 28	Sansubai ^{M,O,W}	Decrease in availability not reported as animals do not like to eat it due to its aromatic nature	Flowers	Shrub	June-October	Moun-tains	Male, female	–	Fresh	–	Used for respiratory problems; it is also used for cooling	W (4) D (0) M (6) O (4)	Yes
30	<i>Polygonum verticillatum</i> Birlot ex Colla, Polygonaceae, UOP NK 29	Miralam ^{M,O}	No pronounced change detected	Roots	Herb	April-October	Moun-tains	Female	–	Fresh, cooked	The fresh leaves and young stem are cut into pieces and boiled for 20 min; after boiling this is mixed with fried onion and cooked for 10 to 15 min, when ghee appears on all sides, it is ready to eat	Sexual stimulant	W (0) D (0) M (12) O (8)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
31	<i>Portulaca oleracea</i> L., Portulacaceae, UOP NK 30	Ghwarghostai ^W Sormai ^M Ghanghas ^O Parkhorai ^D	Decreased availability due to high consumption for food purposes	Aerial parts	Herb	June–July	Fields	Male, female	0.85 \$ ^W	Fresh, cooked	All the aerial parts are cut into small pieces and boiled in water. Onions are fried in oil in another container. When the onions turn brown, tomatoes and chillies are added. The top of the container is kept closed so that the tomatoes reduce to a paste. The boiled aerial parts are mixed with tomato and onion mixture. The container kept on the fire until oil appears on the top	Keep the knees healthy, against dysentery, and plays a good role in treating gastrointestinal problems	W (16) D (8) M (8) O (16)	Yes
32	<i>Quercus baloot</i> Griff. Fagaceae UOP NK 31	Spera serray ^{M,W} Sat ^O	Varied decrease in availability detected due to deforestation by local inhabitants and the timber mafia	Fruits	Tree	July–October	Moun-tains	Male, female	–	Cooked	The fruits called pargai are roasted on coals	Keeps the stomach healthy	W (20) D (0) M (8) O (8)	Yes
33	<i>Quercus incana</i> Roxb., Fagaceae, UOP NK 32	Ghora serray ^{W,M} sat ^O	Varied decrease in availability detected due to deforestation by local inhabitants and the timber mafia	Fruits	Tree	July–October	Moun-tains	Male, female	–	Cooked	The fruits called pargai are roasted on coals	Antidiabetic	W (18) D (0) M (16) O (8)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
34	<i>Rubus fruticosus</i> L., Rosaceae, UOP NK 33	Thway ^M Karwara ^W	–	Fruits	Shrub	July–October	Moun-tains	Male	–	Fresh	–	Stimulant	W (4) D (0) M (8) O (0)	Yes
35	<i>Rumex vesicarius</i> L., Polygonaceae, UOP NK 34	Tarweekal ^W	Decreased availability due to high consumption for food purposes	Leaves, fruits	Herb	June–August	Moun-tains and fields	Male, female	–	Fresh	–	None	W (16) D (0) M (0) O (0)	Yes
36	<i>Solanum nigrum</i> Acerbi ex Dunal, Solanaceae, UOP NK 35	Khwezabai ^{W,D} Malgebai ^M Cheekhrut ^O	No change detected	Fruits	Herb	April–September	Fields	Childers	–	Fresh	–	Laxative, inflammation, and fever	W (4) D (8) M (16) O (4)	Yes
37	<i>Silene conoidea</i> L., Caryophyllaceae, UOP NK 36	Gara ^{M,O}	–	Fruits	Herb	May–June	Fields	Male	–	Fresh	–	None	W (0) D (0) M (4) O (8)	Yes
38	<i>Tamarix aphylla</i> (L.) Waib, Tamaricaceae, UOP NK 37	Ghaaz ^{W,M} Ghazga ^O	Decreased availability due to deforestation, fuelwood use, and timer purposes	Fruits	Tree	August–October	Fields	Male, female	–	Pasted	The fruits are ground with the help of a grinder and then mixed with coconut bark	Used against leucorrhoea and cancer; it is also used for back pain	W (0) D (0) M (16) O (0)	No
39	<i>Teucrium stockianum</i> Boiss, Lamiaceae, UOP NK 38	Kastoral ^{W,M,D}	Although consumption is high for food purposes, availability is increasing as the population is smaller due to human migration because of the Waziristan war	Fruits	Herb	March to April	Moun-tains	Male	0.57 \$ ^{M,W}	Fresh, cooked	The fruit is first shade dried, then fresh and cooked form; the fruit is fried in desi ghee	Stimulant	W (16) D (8) M (28) O (0)	Yes

Table 2 (continued)

S. No	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
40	<i>Thymus linearis</i> Benth., Lamiales, UOP NK 39	Marvezay ^{W,M} Izbuq ^O	Increasing availability due to less consumption	Leaves	Herb	June–October	Moun-tains and fields	Male, female	–	Fresh, cooked	The leaves are boiled in water and used as a tea	Fresh leaves are used against tobacco addiction. Tea is used to eliminate kidney and bladder stones. Tea is also used for stomach problems	W (16) D (0) M (8) O (8)	Yes
41	<i>Trachyspermum ammi</i> (L.) Sprague, Apiaceae, UOP NK 40	Sperkay ^{W,M}	Decreasing availability due to high consumption	Leaves, seeds	Herb	June–July	Moun-tains and fields	Male	–	Cooked	The leaves are boiled in water and used as a tea	It is used as a carminative and against kidney stones	W (4) D (0) M (12) O (0)	Yes
42	<i>Tragopogon gracilis</i> D. Don., Compositae, UOP NK 41	Shabiay ^{M,O}	No pronounced change detected in availability	Aerial parts	Herb	March–August	Fields	Male, female	–	Fresh	–	None	W (0) D (0) M (8) O (16)	Yes
43	<i>Tricholepis furcata</i> DC., Compositae, UOP NK 42	Makhlak ^M Makhilak ^O	Decreasing availability due to the limited availability of water for cultivated land	Leaves	Herb	March–April	Fields	Male	–	Cooked	Leaves are washed with water and fried in oil or ghee for a short time	None	W (0) D (0) M (8) O (12)	Yes
44	<i>Tulipa clusiana</i> DC., Liliaceae, UOP NK 43	Shamdat ^{M,O}	No pronounced change recorded	Bulbs	Herb	March–May	Moun-tains	Childers, male, female	–	Fresh	–	None	W (0) D (0) M (16) O (12)	Yes

Table 2 (continued)

S. NO	Plant species, family, and voucher code	Local names	Perceived availability	Used parts	Habit	Gathering period	Gathering area(s)	Collectors	Price/kg in local markets (USD)	Use modality	Culinary processing	Medicinal uses	Frequency of citation	Previously reported in Pakistan as food plants
45	<i>Viburnum cotinifolium</i> D. Don., Adoxaceae, UOP NK 44	Mangharawa ^{W,M,O}	Increasing availability due to reduced consumption rate because of government restrictions to controlled areas in the mountains	Fruits	Shrub	June–August	Mountains	Male, female	–	Fresh	–	Used to purify the blood	W (18) D (0) M (12) O (4)	Yes
46	<i>Withania coagulans</i> (Stocks) Dunal., Solanaceae, UOP NK 45	Shapyanga ^{W,M,D}	Decreased availability due to high consumption for medical purposes	Fruits	Herb	September–October	Mountains and fields	Male, female	1.42 \$ ^D	Fresh	–	Carminative, treat diarrhoea	W (16) D (18) M (22) O (0)	Yes
47	<i>Morchella esculenta</i> Fr., Morchellaceae, UOP NK 46	Gurgeecho ^O Kurkeecho ^M	Decreased availability due to the very high consumption of the species	Aerial parts	Mushroom	March–April	Mountains	Male	(Fresh) 114.17 \$ ^B (Dried) 399.59 \$ ^M	Cooked	All the aerial parts are washed with water and then fried in oil with chilies	Sexual stimulant	W (0) D (0) M (16) O (20)	Yes

Local name recorded among Dawar (D), Mehsood (M), Ormur (O), and Wazir (W) communities



Fig. 4 Some of the specimens we collected from fields and deposited at the herbarium: **(a)** *Berberis lycium*, **(b)** *Olea ferruginea*, **(c)** *Rubus fruticosus* **(d)** *Nasturtium officinale*, **(e)** *Celtis australis*, **(f)** *Quercus baloot*

Fig. 5 Some plants, i.e., *Apteranthes tuberculata*, *Withania coagulans*, and *Malva neglecta*, sold by vendors in a local market



the participants which indicates that the biocultural heritage linked to WFPs is gradually eroding, as in many parts of the world, due to ongoing major social changes. As traditional ecological knowledge is crucially embedded in the daily practices of local communities, social changes have influenced daily practices, which in turn have affected the core body of LEK. In Chitral and Gilgit-Baltistan, Aziz et al. (2020a, b) also found that both climate and social changes have driven local communities to rely more on commercialized food ingredients or cultivated vegetables, which ultimately has weakened the effective transmission of practical knowledge to younger generations in the region. Participants confirmed that the growth of WFPs has also decreased over the last few decades, and they described that in the past many of the plant species were readily available in the surrounding environment, indicating that climate change or unhealthy local ecological practices have had a negative impact on the area. It is important to note that for the last two decades the area has been hit by the “War”, and thus in most of the places we have seen, the local people have abandoned their houses and migrated to other areas as refugees, which has

possibly influenced the growth of many WFPs in the area. Some of the participants also perceived that in the area a lot of explosive materials have been used during the conflict which has also negatively affected the growth of some WFPs, such as *Chenopodium botrys*, and *Celtis australis*. In addition, people mentioned that foraging practices have decreased due to the availability and dependency on cultivated vegetables, the inability of younger generations to identify wild vegetables, the destruction of natural habitats due to anthropogenic activities and natural disasters, overgrazing, the conversion of land for residential purposes (as a result of the rapid increase in the population), increasing demand for meat, the limited availability of time (government and private jobs), and government restrictions (for security reasons) to high elevation areas where the availability of WFPs are thought to be greatest. Khan et al. (2021) affirmed that the local people of West Pakistan still engage in foraging practices to support their subsistence economies by selling wild vegetables in local markets, even though the availability of WFPs has significantly decreased due to an increase in anthropogenic or environmental factors. Participants mentioned that most

of the WFPs are available for foraging from April to August (Table 2). Study participants mentioned that the most frequent gathering of WFPs takes place in the month of June. All the species were reported for specific months of the year, apart from *Nannorrhops ritchieana* and *Nasturtium officinale*, which are found throughout the whole year.

Foraging and gender roles

The interviewees confirmed that both men and women, as well as children, equally take part in plant foraging. We were able to interview fewer women than men, but at some locations we were told that women have more knowledge of WFPs as they have continuously been engaged in cooking, and thus they have retained more knowledge compared to men, who are only involved in the gathering of wild food ingredients. This was also observed by Aziz et al. (2021 b, c) in Mastuj, Chitral, where the research team found similar trends. However, our results are in contrast to those of Iqbal et al. (2019) for Sargodha, Pakistan, as women in their study area possess much less knowledge due to their involvement in domestic activities, which allows for less interaction with the surrounding plants and related traditional practices. Manduzai et al. (2021) reported that women are crucially involved in foraging anthropogenic weeds that grow near their houses or in cultivated fields or gardens. Although both genders are involved in foraging, it is important to mention that some of the WFPs, i.e., *Iris hookeriana*, *Marrubium vulgare*, *Rubus fruticosus*, and *Teucrium stocksianum*, grow in the mountains and other places that are far from villages, and in most cases, women are not allowed to go there and forage, as they cannot travel far from their houses due to cultural and religious obligations such as that of Veil or Parda, which is strictly followed by women in the study area. However, in rare cases, women also collect some WFPs, such as *Periploca aphylla* and *Polygonum verticillatum*. Especially among the Mehsood Pathans and the Ormuri speakers, women seem to have more time for collecting wild vegetables compared to men, as women remain back at home and are busy in managing household activities while men are responsible for earning a livelihood and have very little time to forage plants. In the Waziri Pathan community, we observed that men have more knowledge of WFPs as they remain in villages, very rarely visit

cities, and frequently tend to engage in local ecological practices because they have more opportunities to spend time with women and their families. All of these actions allow for the transmission of knowledge to take place, thus explaining their strong hold on traditional ecological knowledge. The case of the Dawar Pathans is also different, as the majority of the men often live in urban environments, and thus they have possibly forgotten the knowledge of WFPs, as shown in the findings, which show that they quoted the fewest number of plants (Table 2).

Wild food plants and threats to their biodiversity

In our study, we observed that 23.4% of species (11 species) were sold in the local market. The market price for each species was given by the informants in Pakistani rupees (PKR) which were subsequently converted into US dollars (USD) with the help of Google. A few of the commercially important species, some of which are sold fresh and a few others dried, included *Morchella esculenta* (fresh, USD 114: dry, USD 399), *Withania coagulans* (USD 1.42), *Plantago ovata* (USD 2.28), *Apteranthes tuberculata* (USD 1.03), *Portulaca oleracea* (USD 0.85), *Malva neglecta* (USD 0.57), *Iris hookeriana* (USD 0.42), *Chenopodium album* (USD 0.57), *Morus* spp. (USD 0.85), and *Amaranthus viridis* (USD 0.49). In Kurram, Abbas et al. (2020) also reported some of the WFPs that were brought to the local market including *Apteranthes tuberculata*, *Mentha spicata*, *Portulaca oleracea*, *Nasturtium officinale*, *Lepidium draba*, and *Trifolium repens*. Khan et al. (2021) mentioned that, in the Swabi district, some of the routinely used species that may be seasonally available, such as *Mentha longifolia*, *Rumex dentatus*, *Zanthoxylum armatum*, *Berberis lycium*, *Bauhinia variegata*, and *Mentha spicata*, are also sold to the local market. Abdullah et al. (2021) reported that in Bajaur 10 species of WFPs that were consumed as fruit and vegetables or used as a flavoring agent were also sold to markets, i.e., *Sideroxylon mascatense*, *Ziziphus sativa*, *Berberis lyceum*, *Diospyros lotus*, *Spinacia quadrifida*, *Mentha longifolia*, *Caralluma tuberculata*, *Malva neglecta*, and *Zanthoxylum armatum*. The prices of wild vegetables vary throughout the year and are strongly dependent on supply and demand (Khan et al. 2021). Most of the time, WFPs are gathered from mountains and brought to local markets by collectors, healers,

and small-scale local dealers. Among all WFPs, 21% of species (10 species) were rarely available in the study area. The availability of these species, i.e., *Allium carolinianum.*, *Chenopodium album.*, and *Lepidium draba.*, was reported to have decreased due to unsuitable climatic and edaphic factors; however, over-exploitation and overgrazing have also affected the growth and availability of some important species such as *Morchella esculenta.*, *Withania coagulans.*, *Rumex vesicarius.*, *Tamarix aphylla.*, *Olea ferruginea.*, *Quercus incana.*, *Morus nigra.*, and *Celtis australis.* In their study in Kaniguram, South Waziristan, Aziz et al. (2021a, c) affirmed that certain WFPs, such as *Chenopodium album.*, *Rumex dentatus.*, *Urtica dioica.*, and *Malva neglecta.*, were a crucial part of the traditional food system in a past, but the local community has now abandoned their use, indicating the erosion of gastronomic heritage. Therefore, we need a strong institutional call to focus on the protection of biodiversity in the study area, which is crucial for the conservation of rare and threatened species (Chappell and LaValle 2011). Moreover, if we lose culturally important species, this will in turn wash away the folk food practices associated with these species and threaten the local food security; their protection is therefore essential, as also outlined by the Convention on Biological Diversity (CBD), concerning also the preservation of local ecological knowledge (Krishnamurthy 2003).

The storage and perceived medicinal properties of the gathered wild food plants

Among the quoted species, only 3 species (6%) were reported to be stored, i.e., the leaves of *Mentha longifolia.*, the fruits of *Withania coagulans.*, and *Plantago ovata.* The drying and storing of traditional vegetables is an important process which provides stability to the food system and has proved helpful in times of food shortages (Abdullah et al. 2021). Our results are in line with those of Abbas et al. (2020) who reported that the leaves of *Mentha longifolia* and *trifolium repens* are stored, dried, and cooked in the offseason. Khan et al. (2021) also mentioned that the leaves of *Mentha spicata.*, *Bauhinia variegata.*, and *Mentha longifolia* are stored, dried, and cooked as vegetables. In addition, Ahmad and Pieroni (2016) reported that in the Takht-Sulaiman hills some species, such as *Allium.*, *Sideroxylon.*, and *Olea* spp. are stored in summer

and then used in winter. The current research study also focused on medicinal uses, which are presented in Table 2. The findings revealed that thirty-five species were used for medicinal purposes by the Mehsood group, twenty-eight species by the Wazir group, twenty-five species among the Ormuri speakers, and 10 species among the Dawar peoples. The highest consumption of WFPs by the Mehsood community may be attributed to their close connection to nature and thus they are possibly more experienced with the use of these reported species. Dawar peoples live in urban environments and have access to local health care services and hospitals which has possibly influenced their medicinal use of plants and plant-centered knowledge. This result may also be linked to the results of Abbas et al. (2020) which indicated that Sikh and Christian communities live in urban environments and thus have less interaction and limited access to/with the natural environment, such as fields and agricultural lands. Those living in high mountain areas are more reliant on WFPs (Khan et al. 2021). Some of the most important and widely used plants for various medicinal purposes included *Withania coagulans.*, *Trachyspermum ammi.*, *Thymus linearis.*, and *Olea ferruginea.* In this study, the roots of *Berberis lycium* were used against hepatitis and skin disorders, but Amjad et al. (2020) documented the same species used for cough and liver problems. The leaves of *Lepidium draba* were used against facial skin infections and gastric pain, while Ullah et al. (2013) and Aziz et al. (2016) mentioned the use of the same species as a tonic and a carminative. The fruits of *Morus nigra* were used to strengthen the nervous system and to aid sleeping, while Umair et al. (2019) found that the same species was effective against respiratory and digestive problems. The fruits of *Olea ferruginea* were used to purify the blood, while Farooq et al. (2019) documented the use of the same species for mouth infections, digestive disorders, and as an anti-diabetic. The flowers of *Salvia yangii* were used for cooling and against respiratory problems. Aziz et al. (2021a, b, c) also reported the use of the same plants for respiratory disorders in South Waziristan. The seeds of *Plantago ovata* were used to keep the gastrointestinal tract healthy, while the same species was documented for treating dysentery and hematuria by Manduzai et al. (2021). The roots of *Polygonum*

verticillatum and *Morchella esculenta* were used as aphrodisiacs, while Aziz et al. (2021a, b, c) reported the use of this species for eliminating phlegm. The fruits of *Tamarix aphylla* were used against leucorrhoea, cancer, and back pain, but Umair et al. (2019) mentioned the same species used for febricity, wounds, eye infections, cough, and cold. The fresh leaves of *Thymus linearis* were used to treat tobacco addiction, while the tea was used against stomach problems and to eliminate kidney and bladder stones; also Aziz et al. (2016) reported that the leaves of *Thymus linearis* were medicinally used, mainly for treating cough and asthma and to expel worms from the intestinal tract. *Amaranthus viridis*, *Allium carolinianum*, *Rubus fruticosus*, and *Teucrium stocksianum* were reported to be used as stimulants, while *Malva neglecta* and *Marrubium vulgare* were used for cough, *Chenopodium album* and *Morus alba* for constipation, *Apteranthes tuberculata*, *Trachyspermum ammi*, and *Withania coagulans* as carminatives, and *Solanum nigrum* for fever.

Wild food plants in the local consumption customs and folk cuisine

Most of the wild vegetables are cooked through a simple culinary process: different plant parts are cut into small pieces before boiling in water. The duration of boiling depends upon the species and part used. Onions are fried in ghee or oil (poor people mostly use ghee while rich people use oil). When the onions turn brown, they are added together with some condiments, i.e., green chilies and tomatoes depending on taste preferences and availability. The leaves of some WFPs, such as *Amaranthus viridis*, *Convolvulus arvensis*, *Iris hookeriana*, *Lepidium draba*, and *Tricholepis furcata*, are cut into small pieces and directly cooked. The soft leaves of a few wild vegetables are boiled in water and used as a tea (*Marrubium vulgare*, *Mentha longifolia*, *Thymus linearis*, and *Trachyspermum ammi*). The leaves of *Medicago polymorpha* are fried on a *teghna* (metal plate used for cooking) with oil and salt and then eaten with a piece of bread. The young fruit of *Morus alba* and *Morus nigra* are fried in oil and cooked, while the fruit of *Quercus baloot* and *Q. incana* (locally called *Pargai*) are cooked over coals (Table 2). In contrast, a few vegetables go through an interesting culinary process, namely: *Tamarix aphylla* fruits are ground

with the help of a grinder and mixed with coconut bark, and *Teucrium stocksianum* fruits are shade dried and mixed with *desi ghee* (a clarified, commercially processed butter made from the milk of a cow or buffalo). The young stems of some WFPs, such as *Apteranthes tuberculata*, *Nasturtium officinale*, and *Portulaca oleracea*, are chopped and cooked directly. The young stems of *Periploca aphylla*, however, are cut into small pieces with a sharp blade or pebble, and the latex that comes out is dried for one day, after which it can be used as gum. In this study, *Chenopodium album* was reported to be cooked with a combination of other wild vegetables, while Iqbal et al. (2019) reported more specifically that this species was cooked with the young shoots of *Amaranthus viridis* and *Digera muricata*. Some species like *Allium carolinianum*, *Celtis australis*, *Chenopodium botrys*, and *Fragaria nubicola* were frequently consumed as raw snacks. In Chitral and Gilgit-Baltistan, Aziz et al. (2020a, b) mentioned some frequently reported WFPs consumed as raw snacks, i.e., *Berberis lycium*, *Tulipa clusiana*, *Cotoneaster nummularius*, *Prunus dulcis*, and *Echinops echinatus*. Some species, including *Apteranthes tuberculata*, *Iris hookeriana*, *Malva neglecta*, *Medicago polymorpha*, *Mentha longifolia*, *Morus alba*, *Morus nigra*, *Nasturtium officinale*, *Polygonum verticillatum*, *Portulaca oleracea*, *Teucrium stocksianum*, and *Thymus linearis*, were used both as raw snacks and as cooked vegetables.

Cross-cultural comparison

The cross-cultural comparison of WFP uses among the four studied groups has shown that only a quarter of the WFPs were commonly used by all the groups (Fig. 6, 7). Remarkable similarities were found among the Mehsood and the Ormur followed by the Mehsood and the Wazir, which could be due to the fact that the Mehsood and the Ormur have gone through crucial sociocultural negotiations, such as intermarriages, which may have resulted in the sharing of cultural knowledge on WFPs between these two groups. Our results are in line with the work of Aziz et al. (2021c) in South Waziristan. The close similarity in WFP uses among the Mehsood and the Wazir may also be attributed to their sociocultural interactions, which has brought about intermarriages. It is important to note that in the study area the Ormuri speakers are an important minority

Fig. 6 Best fit proportional Venn diagram showing the overlap of overall WFPs reported by the four considered groups

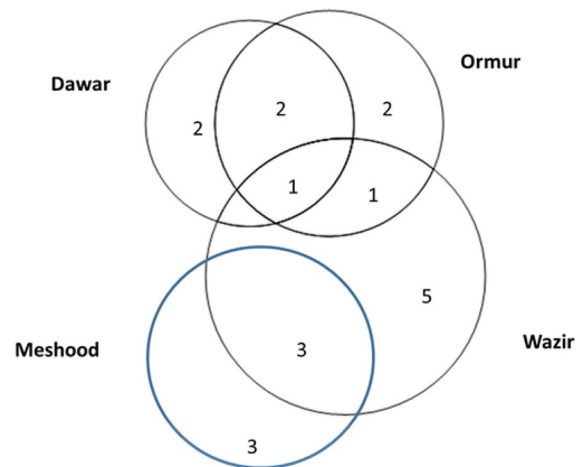
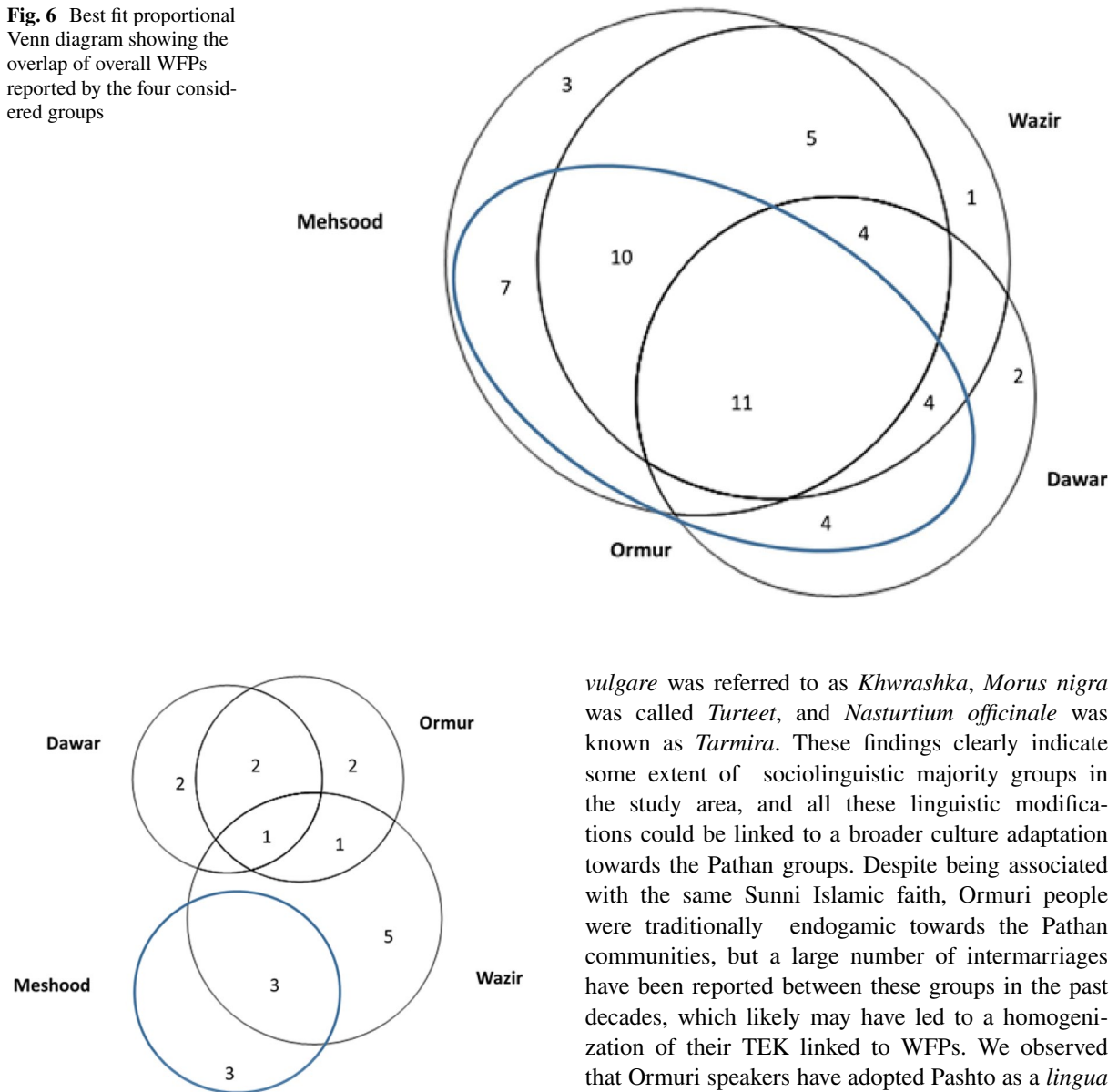


Fig. 7 Proportional Venn diagram showing the overlap of the most frequently reported WFPs (quoted by more than 50% of the informants) among the four considered groups

group. While documenting the folk names of each plant taxon, we observed that the Ormuri group used Pathan phytonyms for certain plant species; for instance, *Berberis lycium* was referred to as *Kerai*, *Apteranthes tuberculata* was called *Pawanai*, *Convolvulus arvensis* was known as *Parwatiay*, *Cotoneaster nummularius* was called *Sherawa*, *Marrubium*

vulgare was referred to as *Khwrashka*, *Morus nigra* was called *Turteet*, and *Nasturtium officinale* was known as *Tarmira*. These findings clearly indicate some extent of sociolinguistic majority groups in the study area, and all these linguistic modifications could be linked to a broader culture adaptation towards the Pathan groups. Despite being associated with the same Sunni Islamic faith, Ormuri people were traditionally endogamic towards the Pathan communities, but a large number of intermarriages have been reported between these groups in the past decades, which likely may have led to a homogenization of their TEK linked to WFPs. We observed that Ormuri speakers have adopted Pashto as a *lingua franca* and the majority of the study participants were able to report plant names in that language. In addition to that, most Ormuri study participants had difficulties in remembering phytonyms (plant names) in their original Ormuri language, which may be indicative of the phenomenon of “linguicide” or “language death” (Skutnabb-Kangas 2000) the Ormuri language is facing in the ongoing context. The majority of the study participants asserted that the “military conflict” in the study area generated in recent years forced people to migrate to other cities and neighboring communities, where it became difficult for them to maintain their native languages as they frequently interacted

Table 3 Jaccard similarity indexes for the overall recorded plant uses and frequently reported uses (quoted by more than 50% of the participants) among the four considered groups

×	Overall plant use				Frequently reported uses			
	Wazir	Dawar	Mehsood	Ormur	Wazir	Dawar	Mehsood	Ormur
Wazir	×	0.41	0.67	0.50	×	0.08	0.23	0.14
Dawar	0.41	×	0.41	0.39	0.08	×	0.00	0.43
Mehsood	0.67	0.41	×	0.73	0.23	0.00	×	0.17
Ormur	0.50	0.39	0.73	×	0.14	0.43	0.17	×

with Pathans. Our research is in line with Aziz et al. (2021c), who reported the similar results from South Waziristan, Pakistan. Morgenstierne (1929) mentioned that Pathan culture had an impact, both culturally and linguistically, on Ormuri speakers in Logar and Kaniguram, where they used many words related to Pathan culture. Kieffer (1977) asserted that due to exogamous marriages, i.e., the practice of marrying outside one's own social group with other communities, the Ormuri language has reached the final stages of extinction and its uses are diminishing. In North Waziristan, the Ormur are scattered in different villages, where they have mixed with populations of the three Pathan groups. We found relevant divergences especially between the ethnobotanies of the Dawar people and the Ormuri speakers, which could also be attributed to the fact these two groups do not normally intermarry, possibly preventing them from sharing knowledge on WFPs; moreover, the Dawar Pathans live in plain areas strongly isolated from the other communities. The Mehsood Pathans reported the highest number of WFPs, along with some idiosyncratic or unique uses, which may be attributed to their geographical location, as they live at high elevations and thus could have greater access to specific patches in which to gather WFPs. This is consistent with earlier research by Pieroni and Söukand (2019), who specifically highlighted that geographical isolation could enhance the resilience of TEK. The Mehsood Pathans rear animals and have considerable traditional ecological knowledge of natural resources; they are also strongly linked to nature because they are economically more disadvantaged and largely dependent on wild food plants. This confirms the results of Ceuterick et al. (2008), who stated that the communities that are more vulnerable from a socioeconomic perspective have a higher probability of using their own traditional environmental resources. Also Manduzai et al. (2021) reported that the Afghan communities in NW Pakistan, which

are more exposed to the natural environment, play a crucial role in keeping foraging and wild food plant-centered gastronomic practices alive. The Dawar Pathans reported a smaller number of plants, possibly because they live in urban environments and are more exposed to food markets and grocery shops and can easily find cultivated vegetables in the bazaar. It is important to note that despite the fact that the Dawar live in urban environments they also reported idiosyncratic plant uses of *Tamarix aphylla* and *Morus* spp. This could also be due to the fact that while Mehsood, Ormur, and Wazir communities are exogamous with each other, and intermarriages are common, the Dawar group is strongly endogamous due to its geographical isolation. We also compared the use of plants which were quoted by more than the half of the participants and we observed that each group exhibits a specific tendency in the use of frequently reported plants (Table 3). It is worth mentioning that we observed close similarities between the Ormur and the Dawar groups in the use of frequently quoted species, perhaps because the Ormur have moved to urban areas and are physically closer to the Dawar and thus they have similar access to similar WFPs and more intense social exchanges. We did not find any overlap instead between the Dawar and the Mehsood groups for what concerns frequently quoted species, which could be explained by the fact that the Mehsood group lives at higher elevations compared to the other groups, and thus it has greater access to other ecological patches of WFPs, as described in a previous study (Pieroni and Söukand 2019).

Comparison with the NW Pakistani food ethnobotany

The current data was comprehensively compared with the available food ethnobotanical literature of Pakistan, as Pakistani ethnobotany has focused very little on the food uses of plants and only a limited number of studies have been conducted in the

country. However, a few cross-culture research studies have produced path breaking results, creating a sound foundation for conducting future field research in ethnobotany which is still very poorly understood. A comprehensive literature review reveals that the majority of frequently reported WFP species were documented in previous food ethnobotanical studies such as *Amaranthus viridis*, *Mentha longifolia*, *Olea ferruginea*, *Plantago ovata*, and *Morchella esculenta* (Aziz et al. 2020a, b; Aziz et al. 2021a, b, c). The comparative analysis with the previous food ethnobotanical literature of Pakistan revealed some new food ingredients, including *Chenopodium botrys*, *Iris hookeriana*, *Marrubium vulgare*, *Pistacia khinjuk*, *Tricholepis furcata*, *Polygonum verticillatum*, and *Tamarix aphylla* (Aziz et al. 2020a, b; Khan et al. 2021; Abdullah et al. 2021; Aziz et al. 2021a, b, c; Abbas et al. 2020). The study revealed that, from a total of forty-seven WFPs, 11 (23%) were used for commercial purposes, of which 7 (14%) WFPs (*Morchella esculenta*, *Apteranthes tuberculata*, *Portulaca oleracea*, *Malva neglecta*, *Withania coagulans*, *Teucrium stocksianum* and *Plantago ovata*) were already documented as traded in Pakistan (Abbas et al. 2020; Khan et al. 2021; Abdullah et al. 2021), while 4 WFPs (*Morus* spp., *Iris hookeriana*, *Chenopodium album*, and *Amaranthus viridis*) were reported for the first time to be used for commercial purposes in NW Pakistan. A few WFPs were also quoted along with their medicinal uses, which have rarely been reported in the food ethnobotanical literature of Pakistan: *Allium carolinianum* use as a stimulant (Abdullah et al. 2021), *Berberis lycium* use in treating hepatitis (Aziz et al. 2016), and *Lepidium draba* in curing skin diseases. Similarly, as underlined in previous studies (Aziz et al. 2021a, b, c), *Morus nigra* is considered beneficial for the nervous system and for inducing sleep (Khan et al. 2015), *Olea ferruginea* purifies the blood (Ahmad and Pieroni 2016), *Plantago ovata* improves the digestion (Manduzai et al. 2021), *Salvia yangii* is used to treat respiratory problems and acts as a cooling agent, *Polygonum verticillatum* is used as a sexual tonic (Abbas et al. 2020), and *Tamarix aphylla* is recognized as useful in treating cancer and back pain; moreover, *Thymus linearis* is used to treat tobacco addiction (Aziz et al. 2020a, b). It is worth mentioning that the culinary processing or herbal uses of 8WFPs, i.e. *Marrubium vulgare*, *Morus alba*, *Morus nigra*, *Polygonum verticillatum*,

Quercus incana, *Tamarix aphylla*, *Teucrium stocksianum*, and *Trachyspermum ammi* were never or rarely reported in the food ethnobotanical literature of NW Pakistan (Tareen et al. 2016; Ahmad and Pieroni 2016; Manduzai et al. 2021; Aziz et al. 2020a, b; Abbas et al. 2020).

Conclusions

We can conclude that the food ethnobotanies of the considered groups have varying degrees of divergence, but more specifically the ethnobotany of the Ormur has been completely homogenized with the ethnobotanies of the three Pathan linguistic groups. This may have resulted from the cultural assimilation of the Ormur to the dominant Pathan culture, through crucial sociocultural negotiations, which in turn led them to standardize their food ethnobotany. The food ethnobotanies of the Mehsood, the Ormur, and the Wazir were more similar as compared to the Dawar community, and we observed more divergences among the ethnobotanies of the Dawar and the Ormur. We also found linguistic adaptation of Ormur plant nomenclature to Pathan nomenclature: the local names of fourteen plant species quoted by the Ormuri speakers were similar to the Pathan linguistic group. In light of the findings of the current research, we need additional studies to better understand how traditional ecological/environmental knowledge has changed across time and space, and more particularly to research the traditional knowledge linked to plants held by the younger generation in the study area as well as Pakistani-Afghan border areas. This study represents however an important contribution to ethnobiology as it presents a significant attempt to document folk plant knowledge that shapes an important part of local biocultural heritage. The preservation of this food heritage through future development programs should be the focus of policymakers, and this especially applies to the Ormur, an important cultural and linguistic diaspora of Waziristan and Southeast Afghanistan; being a minority group, the biocultural heritage of the Ormuri speakers should find its proper place in international agendas, as called for in the Sustainability Agenda 2030. We also suggest that future research studies better assess

the conservation status of the frequently collected species and examine the issue of intergenerational transmission.

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Author's contributions AP, LB, and AAS designed the project. NK and AU collected the data. NK helped in data compilation. AAS analyzed the data. AAS and MAA wrote the first draft of the MS and interpret the data. RS and AP commented on the draft and improved the manuscript. All the authors have read and approved the final draft of the manuscript.

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Data availability All the data is available in this article.

Declarations

Conflict of interest The authors have no conflicts of interest.

Ethics approval Not applicable.

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Consent for publication All coauthors have read and agreed to submit the manuscript.

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