Quantitative ethnomedicinal survey of wild edible fruits used by the indigenous community in North Waziristan, Khyber Pakhtunkhwa, Pakistan

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Research

Abstract

Background: This study documented ethnomedicinal importance of wild edible Fruits (WEFs) from the wild floristic emporium of North Waziristan, Khyber Pakhtunkhwa, Pakistan. There is good diversity of plant species in the studied area which are being used for therapeutic purpose for a wide range of applications.

Methods: Ethnomedicinal data was collected through face-to-face interviews and semi-structured questionnaires. Various ethnobotanical indices such as Relative frequency of citation (RFC), Use value (UV), Fidelity level (FL), and Jaccard index (JI) were used for calculating values for the WEFs, diseases treated, and important fruit species based on use reports by the informants.

Results: A total of 57 species of WEFs belonging to 35 families were reported to be used in traditional medicines. Rosaceae Family was dominated in the area with 6 species, followed by Fabaceae (5 spp.), and Moraceae (4 spp.) with mostly tree-type growth form (49.12%). The most consumed part of plants was fruits (84.48%) used in making folk recipes, followed by seeds (15.52%). Using raw (33.33%) and powder (24.64%) formation were the major modes of crude drug preparation. The highest RFC value was reported for *Morus nigra* (0.36), followed by *Morus alba* (0.35).

Conclusions: The tradition of using WEFs in curing ailments is common in practice among the tribal people of North Waziristan, depending on the socio-economic conditions of the community. The multiple uses of these WEFs augments for further investigation regarding pharmaceutical applications and phytochemical analysis.

Keywords: Indigenous Knowledge, Wild edible fruits, Floristic emporium, Ethnobotany, North Waziristan, Pakistan.

Background

Wild edible plants, also known as WEPs refer to plants naturally grow and have not been cultivated but are used as food (Motti 2022). These are obtained from the uncultivated natural environment (Nazar *et al.* 2022). It is estimated that more than 700 million people worldwide are experiencing severe food shortages. Therefore, WEFs serve as the best alternative source of food for these individuals (Dejene *et al.* 2020). These are enriched with beneficial minerals, vitamins, and antioxidants. In developing nations, WEFs are an essential component of their diets and a crucial element of their healthcare practices (Yangdon *et al.* 2022). Wild edible fruits (WEFs) refer to edible fruit plant species that are non-cultivated but are collected from their natural environment (Beluhan & Ranogajec 2011). Wild edible fruits (WEFs) are mostly utilized during off season of cultivation of vegetables and fruits, predominated by shortage of food (Deshmukh & Waghmode 2011; Rasingam 2012). Although agricultural society depends mainly on agricultural communities rely mostly on better-cultivated varieties due to their health benefits, nutritional value, and higher yield, the tradition of utilizing wild foods has not been completely abandoned (Balemie & Kebebew 2006; Lockett *et al.* 2000). Wild food resources include a variety of edibles, comprising mushrooms; wild edible fruit, vegetables, orchids and herbal plants, and wild edible fruits (WEFs) provide the majority to the whole number of wild edible resources (FAO 2011). These nutrient-rich fruits have been discovered to be good sources of minerals, antioxidants, and vitamins (Chalise *et al.* 2010; Getahun 1974; Mahapatra & Panda 2009; Maroyi 2011). Wild edible fruits (WEFs) consist of important bioactive components and have been utilized as therapeutic agents (Sathyavthi *et al.* 2014). Fruits are a rich source of vitamin C, fiber, sugar, water, and various other nutrients (Moitreyee 2015). Wild edible fruits (WEFs) can provide an easy approach to the source of income and food, particularly for helpless groups such as malnourished and poor children (McGarry & Shackleton 2009). Foods containing wild edible fruits (WEFs) often also reveal greater diversity and nutrient quality compared to those derived from cultivated foods (Rasmussen and Watkins 2017). Wild edible fruits (WEFs) have also been found to enhance homeland food safety both under common conditions (Broegaard and Rasmussen 2017) as well as during seasons of food shortage (Erskine & Ximenes 2015), and in urban as well as rural areas (Clark & Nicholas 2013). Therefore in most of the developing countries, WEFs comprise a vital source of healthcare and food and are associated with human survival (Sundriyal & Sundriyal 2001; Ojelel & Kakudidi 2015). Wild edible fruits (WEFs) can provide an easy approach to the source of income and food, particularly for helpless groups such as malnourished and poor children (McGarry & Shackleton 2009). Foods containing wild edible fruits (WEFs) often also reveal greater diversity and nutrient quality compared to those derived from cultivated foods (Rasmussen & Watkins 2017). Wild edible fruits (WEFs) have also been found to enhance homeland food safety both under common conditions (Broegaard & Rasmussen 2017) as well as during seasons of food shortage (Erskine & Ximenes 2015), and in urban as well as rural areas (Clark & Nicholas 2013). Therefore, it is essential to document the wild species diversity and their traditional perspective for sustainable management of wild resources (Jasmine *et al.* 2016; Rehman *et al.,* 2023a) before the extinction of local plant species and their indigenous knowledge. There are many wild fruits in this area that fulfill the economic and nutritional demands; there is no proper method of improvement, collection, or agro-techniques for these important food resources. Indigenous knowledge is considered to be the basis for their utilization (Shaheen *et al.* 2017; Rehman *et al.* 2023c). Currently, indigenous knowledge about medicinal plants and their utilization is rapidly eroding as a result of socio-demographic and land use changes (FAO 2020; Bhogaonkar *et al.* 2010). No study has been carried out, particularly on WEFs in North Waziristan and their traditional uses. The current study focused on these remote indigenous communities of North Waziristan, to document their indigenous knowledge and practices relating to WEFs, which have not been previously explored.

The main objectives of the study were:

1. To record the Wild edible plants found in the study area and gather data on their uses, availability, and ethnobotanical applications of documented Wild edible plants.
2. To make a baseline of information for further research on the sustainable utilization of resources.

Materials and Methods

Study area

North Waziristan lies between 32° 35′ and “33° 20” N latitudes and “69° 25′” and “70° 40′” E longitude. It is bounded in the North by district Kurram, in the South by the district South Waziristan, in the East by district Bannu, and in the West it is bounded by Afghanistan (Fig. 1). The area consists of 4,707 km^2. It is divided into three sub-divisions i.e. Miran Shah, Razmak, and Mirali. These 3 sub-divisions consist of 9 Tehsils i.e. Miran Shah, Razmak, Mirali, Ghulam Khan, Spinwam, Shewa, Dossali, Datta Khel, Gharyum. The major tribes are Wazir and Dawar. The Indigenous people are mostly farmers.

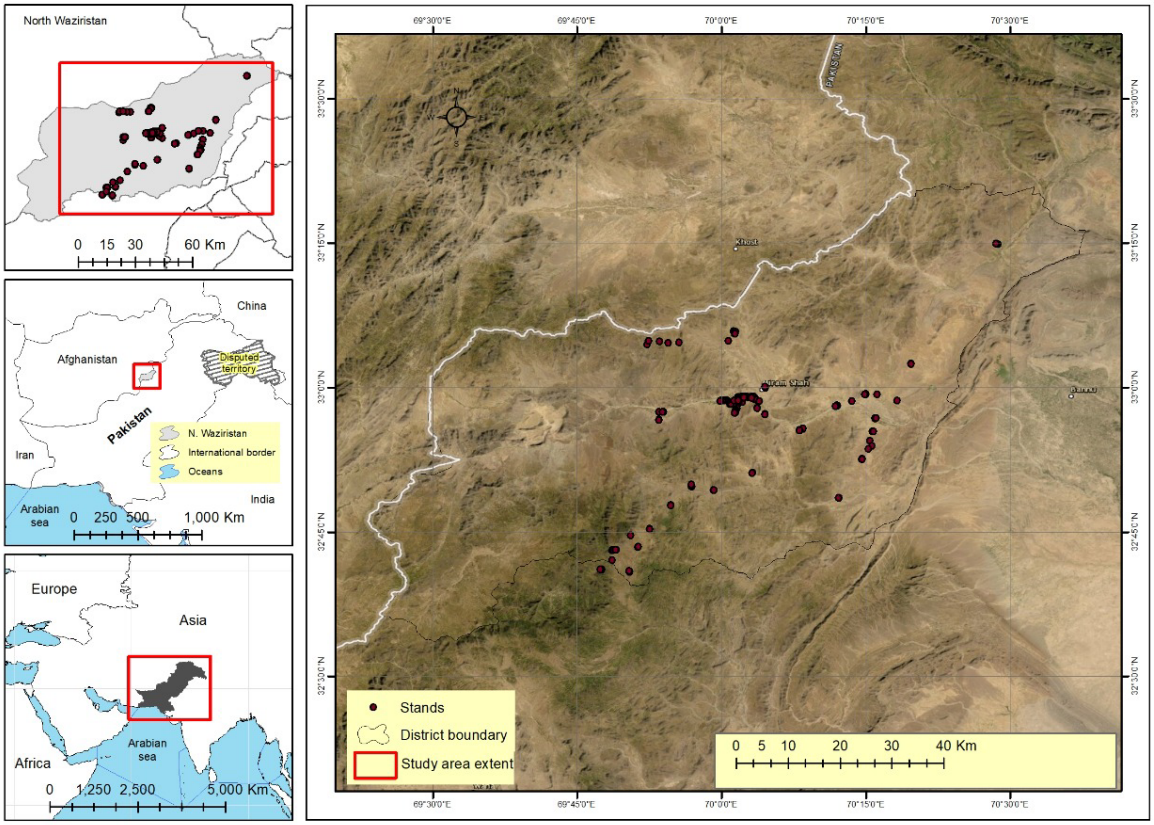

Figure 1. Map of the study area.

Ethnomedicinal documentation

The ethnomedicinal study of wild edible fruits (WEFs) was conducted during 2018 to 2020 from traditional healers (*Hakeem*) and indigenous people of North Waziristan district. The ethnobotanical data was collected through semi-structured and open-ended interviews (Martin 1995). One hundred and thirty (130) informants including 106 males and 24 women were interviewed of various age groups (35 to above 75 years). Socio-demographic data of the informants such as gender, age, experience, and education level was also recorded. Social bio-data of the participants such as age, class, gender, experience, and educational background was also recorded. The questionnaires were including: ethnomedicinal uses of WEFs, botanical name, part used, source, local name, mode of utilization, and diseases treated.

Plant species collection and identification

The plant specimens of WEFs were collected, properly pressed, dried, preserved, and mounted on herbarium sheets. These vouchers were identified by a plant taxonomist (Prof. Dr. Rahmatullaha Qureshi) and confirmed with the help of the flora of Pakistan (Nasir & Ali 1970-2002). The plant specimens were deposited in the herbarium at the Department of Botany, Hazara University Mansehra, Pakistan, for future record

Data analysis

The collected data was analyzed statistically by using various indices such as Use value (UV), Use Reports (URs), Relative Frequency of Citation (RFC), and Fidelity Level (FL %) as described below:

Relative Frequency of Citation (RFC)

Relative Frequency of Citation (RFC) was used to determine the value of the highest therapeutic plants, which are used for the treatment of various ailments. RFC value was calculated by the following formula: (Vitalini *et al.* 2013; Butt *et al.* 2015; Rehman *et al.* 2022c).

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} (0< \mathrm{RFC} < 1)$$

Where

"FC" is the number of informants, who cited the use of plants, and "N" is the total number of respondence in the survey.

Use Value (UV)

The use value (UV) of therapeutic plant species is used to determine their relative importance. It is calculated by the following formula: (Savikin *et al.* 2013; Rehman *et al.* 2023b)

$$UV = \frac{u}{n}$$

Where

u = Number of informants who cite different uses of therapeutic plants.

n = Number of informants

Fidelity Level (FL %)

The FL indicates the percentage of informants who mentioned the use of specific plants to cure a particular ailment in the study area. The FL is calculated as follows: (Friedman *et al.* 1986; Yaseen *et al.* 2015; Rehman *et al.* 2023a).

$$FL\ (\%) = \frac{Np}{N} \times 100$$

Where "NP" is the specific number of citations for a particular ailment, and "N" is the total number of informants who mentioned the plants for any disorder.

Jaccard index (JI)

This index is used to find out the similarity of indigenous knowledge among different ethnic groups; the current study was compared with earlier published literature from the adjacent areas by using the Jaccard index (Gonzalez-Tejero *et al.* 2008).

$$JI = \frac{C\ x\ 100}{(a + b) - c}$$

Where 'a' is the recorded number of plants in the current research area, 'b' is the number of plants in the nearby area, and 'c' is the number of plant species common in both areas.

Results and Discussion

Socio-demographic Information

During the present study, a total of 130 informants were interviewed from the local communities of District North Waziristan, out of which 79.23% were male and 20.77% were female. This result shows the cultural barriers of the research area because women in the research area cannot talk with men outside of their families. Our study agreed with previous studies (Malik *et al*. 2018; Amjad *et al.* 2020). The respondents were comprised of 74 herbalists, 33 professionals, and 23 shepherds. According to age, 11.54% were between 35-50 years of age, 40% were 50-75 years and 48.46% were above the age of 75 years. Most of the respondents were illiterate (41.54%), followed by informants having primary-educated (25.38%), and graduate (3.85%) (Table 1).

Table 1. Socio-demography of respondents in the study area.

Variable	Categories	No. of Informants N=130	Percentage (%)
Gender	Male	103	79.23
	Female	27	20.77
Age	35–50	15	11.54
	50–75	52	40.00
	Above than 75	63	48.46
Major Tribes	Wazir	84	64.62
	Dawar	46	35.38
Occupation	Herbalists	74	56.92
	Shepherds	23	17.69
	Professionals	33	25.38
Education qualification	Illiterate	54	41.54
	Primary level	33	25.38
	Middle level	17	13.08
	Secondary level	12	09.23
	Undergraduate level	9	06.92
	Graduate level	5	03.85

Taxonomic diversity of Wild edible Fruits (WEFs) plants and growth form

A total of 57 wild edible fruits (WEFs) plants belonging to 35 families were documented from the district of North Waziristan (Table 2). These were used for treating 92 different disorders. A maximum number of these plants belonged to the family Rosaceae (6 spp.), followed by Fabaceae (5 spp.), Moraceae (4 spp.), Fagaceae, and Solanaceae (3 spp. each) respectively (Fig 2). The dominancy of the Rosaceae family is also reported by other researcher (Abbasi *et al.* 2013; Ijaz *et al.* 2022; Rehman *et al.* 2023b; Shivprasad *et al.* 2016; Kayabasi *et al.* 2018). The dominance of the family Rosaceae may be attributed to appropriate habitats, favorable environmental conditions for the growth of its species, and increased interactions of local people with them. As a result, the traditional practice of these plant species is commonly known by the inhabitants (Shah *et al.* 2016).

In the present study, the dominant growth forms were trees (49.12%), followed by shrubs (26.32%), and herbs (24.56%) (Fig. 3).When compared with herbaceous plant species, the prevalence of tree species in traditional medication is related to their comparatively longer availability and persistence of the various bioactive components used (Albuquerque & Lucena 2005; Muleba *et al.* 2021). A similar result was reported that tree types of WEFs are in the majority (Abbasi *et al*. 2013; Jin *et al.* 1999; Redzic 2007; Shah *et al.* 2015; Shah *et al.* 2020).

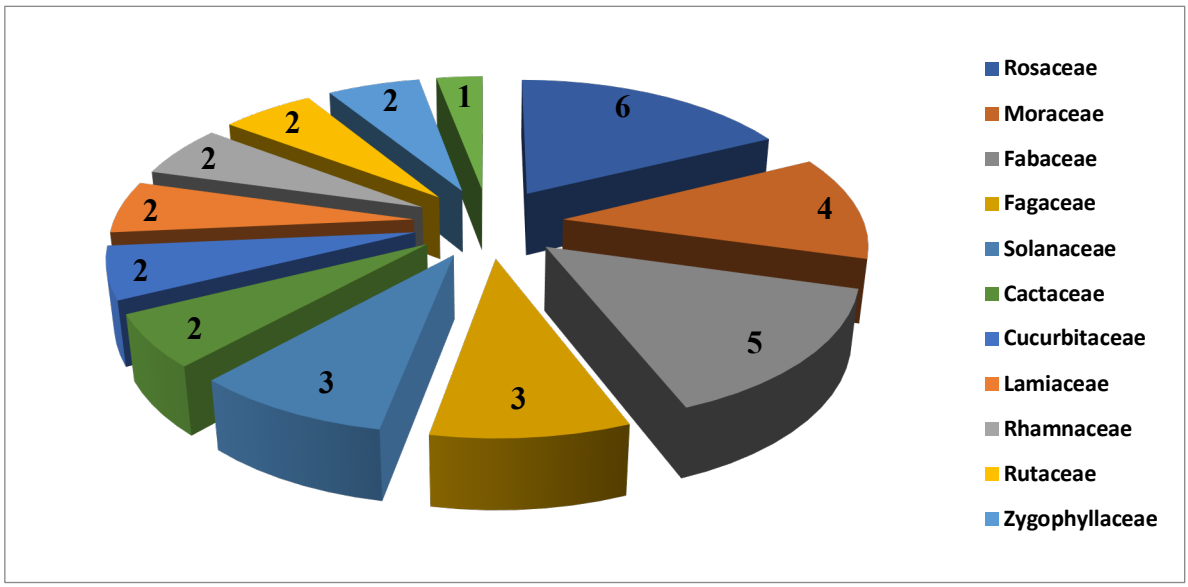

Figure 2. Top-ranked families of wild edible fruit plant species

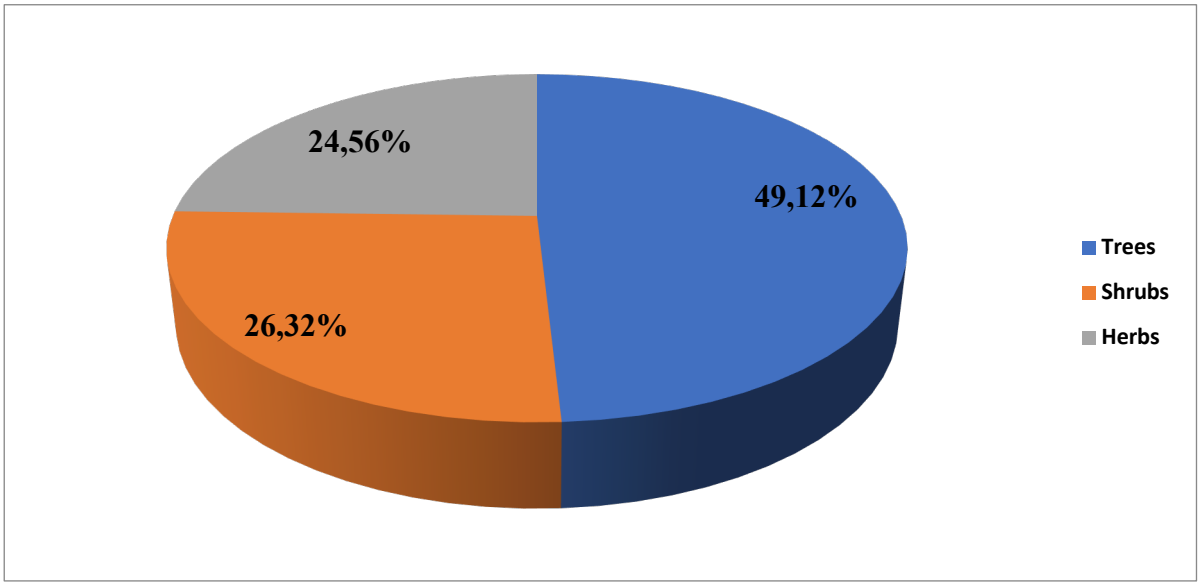

Figure 3. Percentage of growth form of Wild edible fruits.

Table 2. Medicinal plants with scientific name, local name, family name, Voucher no., growth form, part used, UV, URs, FC, RFC, and FL.

Plant species/ Voucher No.	Family	Local name	Growth Forms	Parts used	Method of preparation	Disease treated	FC	RFC	UV	URs	FL %
Acacia modesta Wall. SR-13196	Fabaceae	Palosa	Tree	Fruit	Decoction	Increase libido	44	0.34	0.84	37	97.73
Berberis lycium Royle SR-13444	Berberidaceae	Terkha	Shrub	Fruit	Raw eaten	Blood purifier, cooling agent, jaundice, diarrhea	40	0.31	0.77	34	100.00
Calotropis procera (Wild) R. Brown SR-13185	Asclepiadaceae	Spelmaka	Shrub	Fruit	Milky latex	Snake bite, removal of spine, skin infection	37	0.28	0.75	33	91.89
Capparis decidua (Forssk.) Edgew. SR-13484	Capparidaceae	Sre dane	Shrub	Fruit	Raw eaten, powder,	Constipation, malaria, bad breath, expectorant, rheumatism	34	0.26	0.70	31	91.18
Cassia fistula L. SR-13483	Fabaceae	Gernalay	Tree	Fruit	Pulp	Purgative, flatulence, stomach disorder, indigestion	39	0.30	0.77	34	89.74
Citrullus colocynthis (L.) Schrad. SR-13486	Cucurbitaceae	Maraghenaye	Herb	Fruit	Sweet dish, powder	Laxative, body tonic, rheumatoid arthritis	31	0.24	0.64	28	93.55
Citrus limon (L.) Burm. f. SR-13526	Rutaceae	Nembo	Shrub	Fruit	Juice	Body tonic, vomiting, pimples and dandruff	27	0.21	0.55	24	88.89
Citrus medica L. SR-13527	Rutaceae	Malta	Shrub	Fruit	Juice	Cooling agent, appetizer, refrigerant, dyspepsia, tonic	28	0.22	0.57	25	89.29
Cordia myxa L. SR-13476	Boraginaceae	Lawsera	Tree	Fruit,	Raw eaten	Joint pain, seminal stress, cough, wounds healing, chest infection	40	0.31	0.80	35	97.50
Cucumis melo subsp. *agrestis* (Naud.) Grebensc. SR-13251	Cucurbitaceae	KHarbezgai	Herb	Fruit, Seeds,	Powder	Expel intestinal worms, cooling agent	29	0.22	0.52	23	79.31
Daphne mucronata Royle SR-13440	Thymelaceae	Sra dana	Shrub	Fruit	Powder	Joint pain, anti-inflammatory	25	0.19	0.43	19	52.00
Diospyros lotus L. SR-13490	Ebenaceae	Tor amlok	Tree	Fruit	Raw eaten, juice	Constipation, expectorant, wound healing, purgative, gonorrhea, leprosy	33	0.25	0.50	22	63.64

Plant species/ Voucher No.	Family	Local name	Growth Forms	Parts used	Method of preparation	Disease treated	FC	RFC	UV	URs	FL %
Elaeagnus hortensis M. Bieb. SR-13313	Elaeagnaceae	Sunzala	Tree	Fruit	Raw eaten	Stomach disorder, dysentery, anemia, rheumatoid arthritis	26	0.20	0.48	21	69.23
Ficus carica L. SR-13124	Moraceae	Inzar	Tree	Fruit	Raw eaten	Constipation, indigestion, headache, leprosy	33	0.25	0.55	24	78.79
Ficus palmata Forssk. SR-13139	Moraceae	Inzar kai	Tree	Fruit	Raw eaten	Eye vision problems, constipation, respiratory disorders	31	0.24	0.50	22	83.87
Fragaria nubicola (Hook. f.) Lindl. SR-13429	Rosaceae	Zangali	Herb	Fruit	Juice, raw eaten, paste	Regulate menstrual flow, laxative, crack on the tongue, bleaching skin	34	0.26	0.52	23	55.88
Gymnosporia nemorosa (Eckl. & Zeyh.) Szyszyl. SR-13364	Celastraceae	Sagherzai	Shrub	Fruit	Powder	Constipation, diarrhea, dysentery, labor pain	29	0.22	0.48	21	62.07
Helianthus annuus L. SR-13475	Asteraceae	Ghurma gul	Herb	Seeds	Powder	Enhance egg yield	27	0.21	0.34	15	74.07
Juglans regia L. SR-13457	Juglandaceae	Matak	Tree	Nuts	Eaten raw	Brain tonic, heart tonic, aphrodisiac, rheumatism	44	0.34	0.82	36	100.00
Linum strictum L. SR-13192	Linaceae	Sreshan	Herb	Seed	Oil	Itchy skin	26	0.20	0.25	11	65.38
Malus domestica Borkh. SR-13522	Rosaceae	Mana	Tree	Fruit	Eaten raw	Heart tonic, appetizer, stomach acidity, constipation	29	0.22	0.36	16	79.31
Melia azedarach L. SR-13266	Meliaceae	Bhakana	Tree	Fruit	Pulp, powder	Malaria fever, diabetes	28	0.22	0.32	14	78.57
Monotheca buxifolia (Falc) A. DC. SR-13267	Sapotaceae	Gurgura	Shrub	Fruit	Eaten raw	Blood purifier, laxative, cooling agent,	39	0.30	0.77	34	89.74
Morus alba L. SR-13435	Moraceae	Speen tooth	Tree	Fruit	Eaten	Constipation, body tonic, anthelmintic, cooling agent	45	0.35	0.86	38	100.00
Morus nigra L. SR-13330	Moraceae	Toor tooth	Tree	Fruit	Juice	Cough, sore throat, wheezing in the chest	47	0.36	0.89	39	100.00

Plant species/ Voucher No.	Family	Local name	Growth Forms	Parts used	Method of preparation	Disease treated	FC	RFC	UV	URs	FL %
Nepeta laevigata (D. Don) Hand. SR-13259	Lamiaceae		Herb	Seed	Soaking	Dysentery	31	0.24	0.36	16	74.19
Olea ferruginea Royle. SR-13404	Oleaceae	Zaitoon	Tree	Fruit	Eaten raw	Body tonic, diabetes	39	0.30	0.30	13	87.18
Opuntia dillenii Haw. SR-13168	Cactaceae	chechan	Shrub	Fruit	Eaten raw, juice	Diabetes, gastric ulcer, refrigerant, inflammation, gonorrhea, chest infection	36	0.28	0.34	15	86.11
Opuntia ficus-indica (L) Mill. SR-13481	Cactaceae	Sapare gul	Shrub	Fruit	Juice	Joint inflammations, burns, stomachache	37	0.28	0.82	36	89.19
Papaver rhoeas L. SR-13395	Papaveraceae	Afeem	Herb	Fruit (capsule)	Latex	Sedative, mind refreshment	30	0.23	0.32	14	76.67
Parkinsonia aculeata L. SR-13141	Fabaceae	Zeer keekar	Shrub	Fruit	Decoction	Diabetes, malaria, diaphoretic, abortifacient	28	0.22	0.34	15	67.86
Peganum harmala L. SR-13163	Zygophyllaceae	Spoonda	Herb	Fruit	Smoke	Antiseptic, mastitis	34	0.26	0.61	27	85.29
Phoenix sylvestris (L.) Roxb. SR-13248	Arecaceae	Khajeera	Tree	Fruit	Soaking	Increase fertility, brain memory	37	0.28	0.70	31	89.19
Pinus gerardiana Wall. ex Lamb. SR-13505	Pinaceae	Chilghozi	Tree	Seeds	Eaten raw	Energizer	40	0.31	0.80	35	95.00
Pistacia integerrima J. L. Stewart ex Brandis. SR-13464	Anacardiaceae	Sheena	Tree	Fruit	Eaten raw	Flatulence, digestion, diarrhea, dysentery, diabetes, cough, asthma, liver diseases	43	0.33	0.84	37	95.35
Plantago ovata Forssk. SR-13391	Plantaginaceae	Isphaghol	Herb	Seed	Soaking	Constipation, gastrointestinal disorders, Jaundice, hemorrhoids, steatorrhea	41	0.32	0.86	38	95.12
Prunus armeniaca L. SR-13125	Rosaceae	Mondata	Tree	Fruit	Eaten raw	Laxative, purgative, brain tonic, constipation, expectorant	36	0.28	0.52	23	77.78
Prunus domestica L. SR-13526	Rosaceae	Volai	Tree	Fruit	Eaten raw, juice	Reduce thirst, cooling agent, astringent, refrigerant, leucorrhea	34	0.26	0.39	17	85.29

Plant species/ Voucher No.	Family	Local name	Growth Forms	Parts used	Method of preparation	Disease treated	FC	RFC	UV	URs	FL %
Prunus microcarpa C. A. Mey. SR-13527	Rosaceae	Alocha	Tree	Fruit	Eaten raw	Appetizer, nausea, vomiting	33	0.25	0.36	16	81.82
Punica granatum L. SR-13333	Punicaceae	Valengai	Shrub	Fruit, peel	Juice, powder	Body tonic, appetizer, blood purifier, vomiting, urinary incontinence, nocturia, stomachache, heart problems, biliousness	42	0.32	0.80	35	97.62
Pyrus communis L. SR-13299	Rosaceae	Batang	Tree	Fruit	Eaten	Urine flow, blood pressure, kidney stones, digestive problems	31	0.24	0.39	17	77.42
Pyrus pashia Buch.Ham. ex D. Don. SR-13278	Rosaceae	Nashpati	Tree	Fruit	Extract	Constipation, astringent, hair loss, sedative, febrifuge	30	0.23	0.30	13	73.33
Quercus baloot Griff. SR-13258	Fagaceae	Pergay	Tree	Fruit(acorn)	Powder	Diuretic	32	0.25	0.39	17	65.63
Quercus incana Roxb. SR-13212	Fagaceae	Pergay	Tree	Fruit	Powder	Diarrhea , dysentery,	32	0.25	0.41	18	59.38
Quercus dilatata Royle. SR-13491	Fagaceae	Pergay	Tree	Fruit	Powder	Wounds healing, lesion	31	0.24	0.43	19	54.84
Robinia pseudoacacia L. SR-13298	Fabaceae	Rambel	Tree	Fruit	Decoction	Ingestions, burns, eye ailment	26	0.20	0.34	15	53.85
Salvdora oleoides Decne. SR-13148	Salvadoraceae	Plawan	Tree	Fruit	Eaten raw	Enhance libido, flatulence, tuberculosis, lochia, rheumatism	41	0.32	0.82	36	100.00
Salvia aegyptiaca L. SR-13273	Lamiaceae	Malnga	Herb	Seeds	Soaking	Constipation, digestive problem	29	0.22	0.48	21	72.41
Solanum nigrum L. SR-13321	Solanaceae	Beeian boti	Herb	Fruit	Eaten raw	Blood purification, tonic malaria, jaundice, constipation, urinary problems	29	0.22	0.52	23	51.72
Solanum surratense Brum. f. SR-13396	Solanaceae	Kurkundai	Herb	Fruit	Powder, decoction	Hemorrhoids, urine retention disorder, asthma, blood purifier, abdominal pain,	39	0.30	0.75	33	79.49
Sophora mollis (Royle) Baker. SR-13249	Fabaceae	Zeer gulai	Shrub	Fruit	Powder, paste	Expel intestinal worm, headache	36	0.28	0.50	22	44.44
Trachyspermum ammi L. SR-13206	Apiaceae	Sperkai	Herb	Seeds	Powder	Indigestion, flatulence, appetizer	41	0.32	0.77	34	92.68

Plant species/ Voucher No.	Family	Local name	Growth Forms	Parts used	Method of preparation	Disease treated	FC	RFC	UV	URs	FL %
Tribulus terrestris L. SR-13236	Zygophyllaceae	Chechan	Herb	Seeds	Powder	Aphrodisiac, enhances libido, flatulence, and urinary disorder	39	0.30	0.75	33	76.92
Viscum album L. SR-13244	Loranthaceae	Zarkatel	Tree	Fruit	Juice	Warts, rabid dog bite	17	0.13	0.16	7	35.29
Withania coagulans (Stocks.) Dunal. SR-13188	Solanaceae	Shapianga	Shrub	Fruit	Powder	Abdominal pain, cooling agent, blood purifier	42	0.32	0.80	35	100.00
Zizyphus mauritiana Lam. SR-13198	Rhamnaceae	Bera	Tree	Fruit	Eaten raw	Constipation, blood purifier, appetizer, cough, asthma, indigestion, biliousness	38	0.29	0.66	29	81.58
Zizyphus nummularia (Burm.f.) Wight & Arn. SR-13179	Rhamnaceae	Karkena	Shrub	Fruits	Decoction	Diabetes, stimulant, aphrodisiac, antiseptic, mental retardation	37	0.28	0.64	28	78.38

Key words: FC= Frequency of citation, RFC= Relative frequency of citation, UV= Use value, URs= Used Reports, FL= Fidelity level

Wild Edible Fruit species parts used

The indigenous people use almost all parts of the wild edible fruits with a high percentage of fruits (84.48%) used in folk recipes, followed by seeds (15.52%) (Fig.4).The frequent utilization of fruits in herbal recipes may be attributed to the presence of bioactive compounds in high percentage because in most plants, fruit serves as a storage organ (Shah *et al.* 2016). Our findings of plant parts utilization are similar to previous studies reporting maximum use of fruits in the area (Vitalini *et al.* 2013; Assefa & Abebe 2014; Aziz *et al.* 2020). The highest use of fruits compared to other plant parts revealed that the plants are continuously used during the season of shortage of food because fruits are easy to prepare for consumption (Sina & Degu 2015; Aziz *et al.* 2020). Furthermore, other studies observed similar findings (Hamayun *et al.* 2003; Hassan *et al.* 2019). Fruit were commonly used as reported by Leonti *et al.*(2006), Rokaya *et al.* (2010), Lulekal *et al.*(2011), Dogan *et al.*(2013),Tareen *et al.* (2016), and Leon-Lobos *et al.*(2022). Such kind of use may be because of the nutritional aspect and taste preference of fruits and confirms the findings of Jin *et al.*(1999) and Abbasi *et al.*(2013). These wild fruits, therefore, are supportive of alleviating subsistence wealth (Sundriyal 1999).

Mode of preparation and administration of wild edible fruits

Wild edible fruits are consumed by the local communities in various forms of preparations to cure different ailments. The most frequent form of wild edible fruits consumption was raw fruits (33.33%), followed by powder (24.64%), juice (14.49%), decoction (7.25%), and soaking (5.80%), respectively (Fig.5). WEFs were mostly consumed raw according to the findings of Chauhan *et al.*(2014) and Soukand & Kalle (2016). A similar result was also reported by Leon-Lobos *et al.* (2022). The second most dominant mode of administration was powder which agrees of by another researcher (Sing *et al.* 2017; Andhikari *et al.* 2019; Haq *et al.* 2020). The fruits were consumed orally as they were edible and deemed a valuable source of nutrients and medicinal benefits. Similar findings were reported by Bano *et al.* (2014) and Chothe *et al.*(2014).

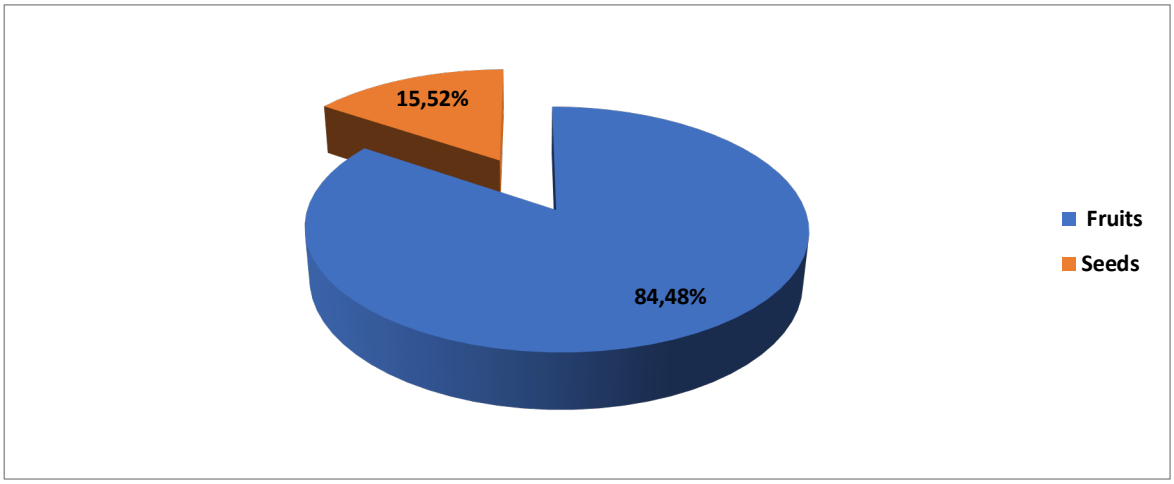

Figure 4. Part used percentage of wild edible fruits.

Use of Wild edible fruits (WEFs) for treating various disorders

The indigenous communities have great traditional knowledge of basic healthcare needs. During the present study, 92 different disorders were reported which were treated by using 57 wild edible fruits. The most common disorders in the research area were constipation for which 13 species were used, followed by indigestion (8 spp.), blood purifier and cooling agent (7 spp. each), appetizer and diabetes (6 spp. each), body tonic, dysentery, flatulence, stomachache, urinary disorder (5 spp. each), and so on (Fig. 6). Because of poverty, high cost of allopathic medicines, and absence of modern medical facilities, indigenous people primarily turn to wild edible fruits to address their health issues. A similar finding was reported by Aziz *et al.*(2018), Chaachouay *et al.*(2019) and; Dastagir *et al.*(2022).

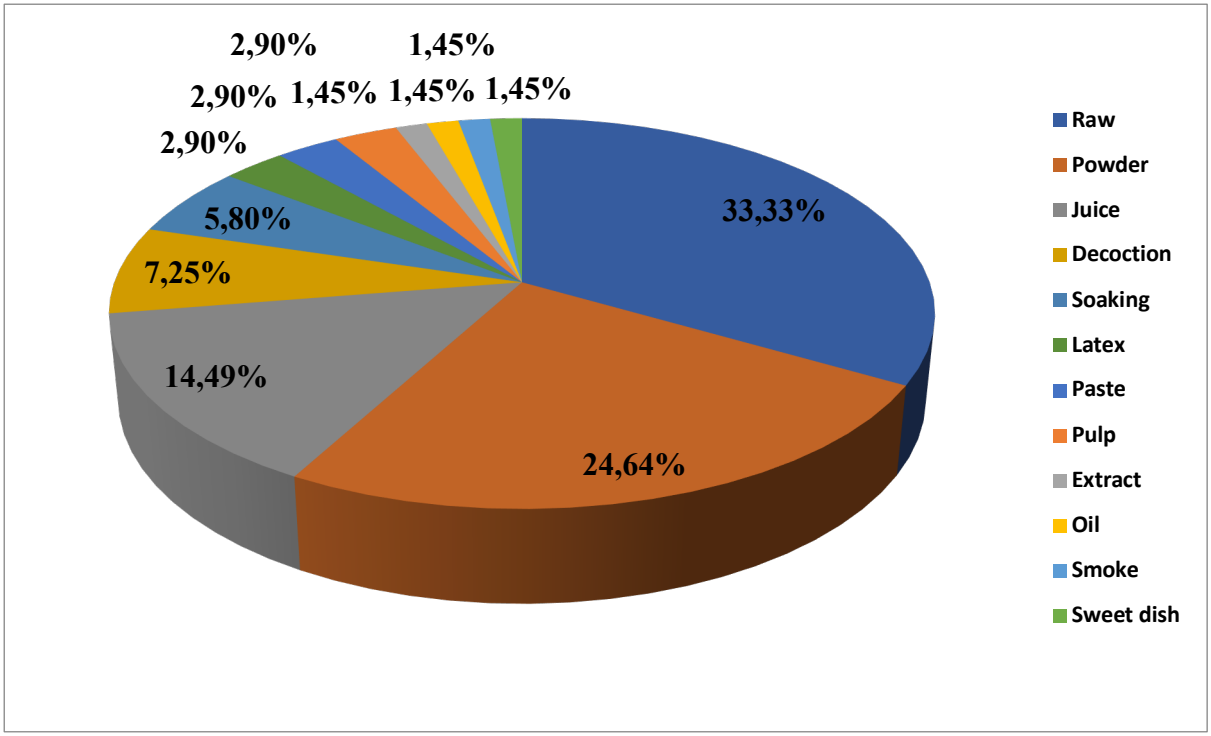

Figure 5. Mode of consumption of Wild edible fruits.

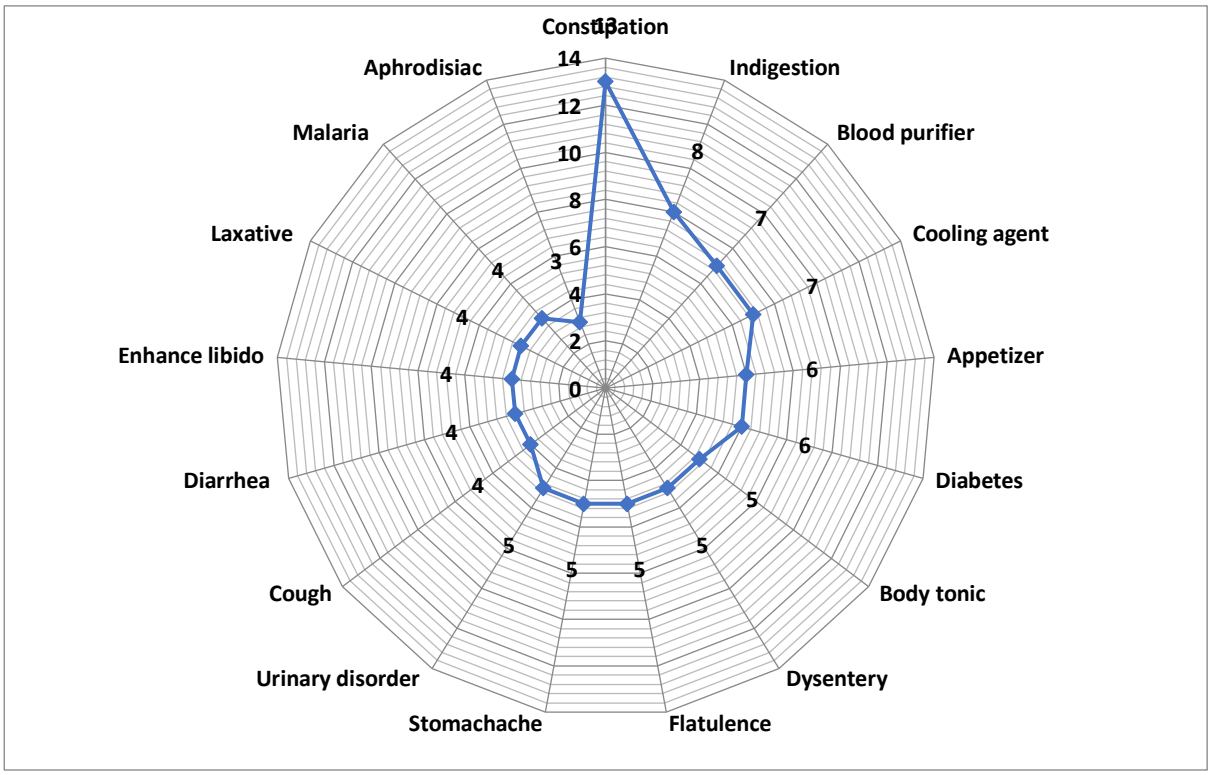

Figure 6. The number of plants used for the treatment of the top 17 disorders.

Relative Frequency of Citation (RFC)

The relative citation of frequency (RFC) not only shows the common practice of therapeutic plants but also reveals the plants association with traditional communities (Hayat & Shah 2017; Rehman *et al.* 2022a). It also shows their original status as respondents describe their utilization as medication (Vitalini *et al.* 2013). The RFC value was used to determine the most frequently occurring wild edible fruits. The values were ranged from 0.13 to 0.36 for the reported species (Table 2). The

highest RFC value was reported for *Morus nigra* (0.36), followed by *Morus alba* (0.35), *Acacia modesta*, *Juglans regia* (0.34 each), and *Pistacia integerrima* (0.33), *Plantago ovata, Punica granatum* and *Salvdora oleoides* (0.32 each), while the lowest RFC value was reported for *Viscum album* (0.13) as shown in Table 2. The RFC values are used to estimate the most commonly cited plant species for the cure of different disorders by indigenous peoples (Vitalini *et al.* 2013). The highest values of RFC report the fact that these EWFs are familiar in the study area, available to all the groups equally, and used frequently for several disorders all over the region, confirming the findings of Abbasi *et al.*(2013). These medicinal plants are familiar amongst the highest number of respondents. Those WEFs having maximum RFC value should be further assessed biologically, pharmaceutically, and phytochemically to identify their bioactive compounds for any medicine preparation (Vitalini *et al.* 2013).

Use Value (UV)

According to Kayani *et al.* (2014), the use value is a quantitative index of ethnobotany that links the importance of therapeutic plants among indigenous people to their utilization. The use value (UV) is used to determine the relative importance of wild edible fruit plants in the study area. In the present study, UV data was ranged from 0.16 to 0.89 (Table 2). The highest UV was reported for *Morus nigra* (0.89), followed by *Morus alba* and *Plantago ovata* (0.86 each), *Acacia modesta* and *Pistacia integerrima* (0.84 each), while the lowest UV was reported for *Viscum album* (0.16). It was observed that the maximum UV was due to the highest number of use reports (URs) in the study area. The maximum UV of documented therapeutic plants might show their indigenous professional expertise which leads to a preference option for the ailments (Ullah *et al.* 2014). Medicinal plants with the lowest use value do not mean that they are not medicinally important, but it is shown that the traditional knowledge about these medicinal plant species is limited and less availability of the medicinal plants (Chaudhary *et al.* 2006; Mahmood *et al.* 2013). Therapeutic plant species having maximum UV may be attributed due to their frequent distribution in the research area and the indigenous communities are well-known for their curative value (Rehman *et al.* 2022b). It also reveals the relative importance of the use of medicinal plants in a particular area (Hassan *et al.* 2019). It is recommended that medicinal plants with the maximum UV should be further studied for biological and phytochemicals activities (Vitalini *et al.* 2013; Yaseen 2019).

Fidelity level (FL %)

Fidelity level (FL %) is used to recognize the therapeutic plant species that are most preferred by the local people to cure particular disorders (Friedman *et al.* 1986). The therapeutic plant species with the maximum therapeutic effects have a maximum fidelity level of 100%. The FL value was ranged from 35.29 to 100% (Table 2). In the current study, the highest FL value was recorded for *Berberis lycium* (jaundice)*, Juglans regia* (heart tonic)*, Morus alba* (constipation)*, Morus nigra* (sore throat)*, Salvdora oleoides* (enhance libido)*, Withania coagulans* (abdominal pain) with 100% FL each, followed by *Acacia modesta* (increase libido) with 97.73% FL, and *Punica granatum* (blood purifier) with 97.62% FL, while the lowest FL% was recorded for *Viscum album* (warts) (35.29%). The FL value determines the preference of informants to treat the specific disease (Bisi-Johnson *et al.* 2010; Karakose 2022; Rehman *et al.* 2022c). It is a fact that the higher the plant's uses, the higher will be the FL value (Farnsworth *et al.* 1988; Sahil 2014; Rehman *et al.* 2023d).

Jaccard index (JI)

Ethnobotanists use the Jaccard index (JI) to make comparisons of recorded plant species with previously published literature gathered from nearby areas (Yaseen *et al.* 2015). A few ethnobotanical research works were chosen from adjacent areas for review in the Jaccard index (JI) (Table 3). The comparative analysis of these 57 plant species showed that similarity index was ranged from 23.81% to 2.00% and the dissimilarity index was ranged from 45.45% to 4.44%. The maximum JI was found in the literature with the studies of Khan *et al.* (2015), Abbasi *et al.* (2013), Hussain *et al.* (2023), Khattak *et al.* (2021) and Shabbir *et al.* (2022) with JI values (23.81, 21.05, 17.65, 13.33% and 11.34% respectively (Table 3).The maximum degree of similarity index (27.27%) was recorded for Khattak *et al.* (2021) in the area of Tehsil Takht-e-Nasrati, Pakistan, revealed similarity in ethnic group, geography and vegetation in both regions. The minimum level of the (JI was noted for the work of Abbasi *et al.* (2013) with 2% JI value (Table 3). The minimum JI values indicate partial cultural exchange between the adjoining areas, which are separated by mountain ranges and other cultural differences. The ecological barriers had a significant influence on the flora. The low similarity may be due to variations in the traditional knowledge among different communities, with difference in their social and culture behaviors (Ullah *et al.* 2014). The main reasons for the minimum similarity index used in a literature study of the nearby area are cultural adaptations in response to changes in habitat, and population, which could be directly noted in the loss of ethnobotanical, ethnopharmacological and ethnomedicinal knowledge in the adjacent areas (Abbasi *et al.* 2013). The Jaccard index (JI) shows the results by comparing the similarity of frequent plants with similar uses and common plants with dissimilar uses. Some researchers had thought that the variation in ethnographic knowledge might be due to the impact of climatic conditions on the curative properties of some plants (Hussain *et al.* 2023).

Table 3. Jaccard index comparaison of the current study with previous reports.

Previous studies	No. of species reported (A)	No. of species in present study area (B)	Plants common in both areas (C)	Species only in aligned areas	% of Similarity	% of Dissimilarity	Species only in studied area	c×100	A+B	(A+B)-C	Jaccard Index (JI)	References
Lesser-Himalayas, Pakistan	20	57	6	14	0.00%	30%	51	600	77	71	8.45	Abbasi et al. 2013
D.I. Khan district	11	57	6	5	18.11%	36.36%	52	600	68	62	9.68	Marwat et al. 2011
Lesser-Himalayas,Pakistan	45	57	2	43	0.00%	4.44%	55	200	102	100	2.00	Abbasi et al. 2013
Surghar range, Pakistan	43	57	15	28	12%	23.26%	42	1500	100	85	17.65	Hussain et al. 2023
Tehsil Takht-e-Nasrati, Pakistan	11	57	8	3	27.27%	45.45%	49	800	68	60	13.33	Khattak et al. 2021
Lesser-Himalayas,Pakistan	35	57	16	19	17.14	25.71	38	1600	92	76	21.05	Abbasi et al. 2013
Bagh, Azad Kashmir, Pakistan	51	57	11	40	7.84%	13.73%	46	1100	108	97	11.34	Shabbir et al. 2022
Peshawar Valley, Pakistan	71	57	10	61	4.22%	9.85%	47	1000	128	118	8.47	Bahadur et al. 2020
Swat Valley, Northern Pakistan	47	57	20	27	14.9%	27.66%	37	2000	104	84	23.81	Khan et al. 2015

Conclusion

The present study is the first of its kind from the North Waziristan district assessing the ethnomedicinal information related to the use of wild edible fruits (WEFs) as a source of medicine for treating various ailments. The custom of using plant-based herbal remedies for various diseases is frequent in practice among the tribal communities of this area. This is mainly due to inadequate access to modern facilities for medical care. A total of 57 WEFs were identified which are commonly used to treat 92 different disorders in which constipation, and digestive disorders being the most common. Based on the present study's results, therapeutic plant species scoring high relative frequency of citation, use value, and fidelity level values must be further tested for their phytochemical and pharmacological analysis. Furthermore, there is a need for awareness among the local people of the study area concerning the sustainable use of therapeutic plant species for long-term conservation.

Declarations

List of abbreviations: Relative Frequency of Citation (RFC), URs, Use Reports; Use Value (UV), and Fidelity Level (FL), Wild Edible Fruits (WEFs).

Ethics statement: Prior to the survey, we obtained oral informed consent from each participant.

Consent for publications: Not applicable.

Funding: Authors have not received any funding during this research.

Conflicts of Interest: The authors declare that there are no conflicts of interest in this article.

Availability of data and materials: The figures and tables supporting the results of this study are included in the article, and the original data sets are available from the first author upon request.

Authors' contributions: SR conducted the field work and collected the data. The manuscript is written by SR. ZI and QR Supervised this work. RQ, WH and GMS helped in data analysis. Review and editing were done by AA, AS, KR, SL, MY, SSHS and WH. All the authors approved the final manuscript after revision.

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