Assessment of traditional knowledge of medicinal plants practiced by rural communities residing around Musk Deer National Park, Kashmir Himalaya, Pakistan

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Research

Abstract

Background: Traditional ethnomedicinal knowledge and robust association of native communities with plant biota are the key contributors to environmental sustainability. The current study was conducted to document the traditional knowledge of medicinal plants practiced by the inhabitants of Musk Deer National Park (MDNP) Azad Jammu and Kashmir, Pakistan.

Methods: The data was acquired by administrating a total of 110 detailed semi-structured interviews targeting respondents from different age groups and professions focusing on capturing the holistic picture of medicinal plants practiced with traditional wisdom. Data was analyzed using ethnobotanical indices like Use Value (UV), Relative Frequency of Citation (RFC), and Informant Consensus Factor (IFC).

Results: In total 84 plant species belonging to 69 genera and 43 families were recorded used for 66 prominent therapeutic purposes. Family Asteraceae was the main contributor followed by Polygonaceae and Fabaceae. Roots were the dominant plant parts used with 30 species followed by leaves and whole plant. Among drug formulations, powder was commonly used followed by cooked and decoction. Maximum ICF value was calculated for digestive system problems followed by respiratory and skeletomuscular system problems. *Taxus baccata*, *Saussurea costus*, *Picrorhiza kurroa* and *Jurinea himalaica* were recorded with the highest use value.

Conclusion: The ethno medicinal inventory reflects a reasonable number of wild plants with valued traditional practicing knowledge. Therefore, it required to develop a conservation and management plan clearly reflecting mechanism for their sustainable utilization and further detailed investigation in Musk Deer National Park.

Keywords: Musk Deer National Park, Traditional knowledge, Ethno medicine, Kashmir Himalaya

Background

The link between humans and nature is inextricable and being part of the system, the plant related local knowledge has remained an integral part of societies throughout human history. The dependence of human beings on plants is not only as a source of food but plants were also utilized for medicinal purpose and have been a reliable source of healthcare systems in different societies. (Dias et al. 2012; Manoharachary et al. 2016). It has been estimated that almost 50,000 plant species which are 18.9 % of the total world flora have been reported that are used in traditional medical systems worldwide (Bhat et al.2013; Baydoun et al.2015; Parmesan 2006, Ibrar et al.2007). According to folklore recipes, approximately 85% of the traditional medicines used all over the world originated from herbal source (Cohen &Ernst 2010). Low per capita income, lack of alternate modern healthcare facilities, the belief and trust of local people in herbal remedies, and easy access to medicinal products are key reasons for this high reliance on herbal medicines. (Loya et al. 2009; Ganesan et al. 2008; Sullivan &Shealy 1997). The growing scientific evidence suggests that this traditional knowledge accompanied with the novel scientific perceptions can offer culturally acceptable and environment friendly approaches necessary for the sustainable development of the local communities (Ayeni & Basiri 2018). Although traditional ethno medicinal approaches to healthcare may be considered to be outdated in comparison with modern approaches, according to WHO reports in the developing world 80% of the population still rely upon herbal medicines for curing ailments (Tangjitman et al. 2015; Azam et al. 2017).

Pakistan has been bestowed with rich biodiversity and people living in remote areas have been solely dependent upon traditional and alternative medicines. According to an empirical and most probably as hypothetical estimate, there are 600 medicinal plants that are popular for their medicinal values (Shinwari & Khan 2000; Shinwari *et al*. 2010; Shinwari *et al.* 2011). Till the 1990s, about 84% population in Pakistan depended on herbal medication, gradually with the increasing trend of modern health care practices, the traditional knowledge is confined only to remote areas of the country, particularly the mountainous regions (Alam *et al*. 2011). The traditional knowledge is dynamic and changes with time, generation, culture, and resources, the accurate and timely documentation of this knowledge is quite necessary (Alam *et al*. 2011).Besides therapeutic uses commercial extraction of medicinal plants is one of the sources of their livelihoods. Therefore, unsustainable use, poor collection and bulk extraction are continuous threats to medicinal plants (Khan *et al*. 2013; Ali *et al.* 2020).

Traditional knowledge and culture of the use of medicinal plants in health care is largely confined to elderly community members, with young people often unaware of the use of natural wealth (Rahman *et al*. 2020). The younger generations are leaving for education and work, so indigenous knowledge is disappearing day by day, due to these circumstances traditional ethno medicinal knowledge practiced by native communities is exposed to risk of decline or of complete loss that requires due consideration for its documentation and conservation (Tamang *et al*. 2021).

Loss of ethno medicinal knowledge with the rapid disappearance of botanical resources is an established phenomenon. Medicinal plants' indigenous knowledge is most vulnerable in this regard as it is declining with species extinction (Singh *et al*. 2013). Documentation of ethnomedicinal knowledge not only assures the safety of knowledge but also raises the issue among the global community for taking measures to conserve the plants (Singh *et al*. 2014; Ijaz et al. 2016).

Rural communities residing around MDNP lack modern health facilities and hence rely on medicinal herbs for healthcare and prefer to practice traditional therapies due to being cost-effective, accessible, safe and affordable to prepare at home (Khan *et al*. 2015; Ahmad *et al*. 2014). The current attempt investigated and documented the traditional knowledge of medicinal plants from MDNP, Kashmir Himalaya, Pakistan that has never been recorded before. To address this information gap, the present study was carried out with the aims to (i) Explore and prepare a complete checklist of the medicinal flora in MDNP (ii) Document the traditional knowledge of plants part(s) used, drugs formulation and mode of administration (iii) Undertook various quantitative indices to evaluate and the community reliance, consistency and authenticity of traditional ethno medicinal knowledge.

Materials and Methods

Study Area

Musk Deer National Park (MDNP) located at 34.731456°N, 74.786682°E and was gazetted as National Park in the Kashmir Himalayan Range on September 24, 2007. It falls in Guraise Valley of Neelum District, Azad Jammu and Kashmir (AJ&K) Pakistan. MDNP bordered by Indian administrated Kashmir in the South, Astor and Deosai National Park (DNP) in the North-East, Muzaffarabad in the Southwest and Shounther Valley in the West**.** It covers an area of 528 Km^2 in the altitudinal amplitudes of 1942 – 4800m above sea level. The physical setting is very uneven and rich in sub-montane spur, gorges, screes

and boulders. The main water body, River Neelum flows from Indian side and enters in MDNP at Taobat village and divides the park in two halves. It receives little rainfall during summer due to its location outside the monsoon range, most of the precipitation usually occurs in the form of snowfall during the winter seasson. A total of 11villages viz. Taobat, Karimabad, Nikroon, Halmat, Shondas, Sardari, Marnat, Hanthi, Saonar, Pholawai and Dhaki Chaknot are found in the demarcation of the protected area (Musk Deer National Park). These villages are located on both river banks. The villages are basically the home for 1714 household's with 12000 population. The entire population is Muslim without any religious minority, but divided in many ethnic groups such as (Mughal, Lone, Butt, Chaudhry, Pashtoon, Dardies, Minhas, and Syed etc.). Hindko, Shina, Kashmiri and Gojri are the major languages spoken in the area. They use *Urdu* as Lingua Franca. They use forest resources for instance fuel wood, timber, pasturelands, fodder, medicinal herbs and mushrooms on commercial basis. Medicinal plants and mushrooms particularly extracted in bulk are used for daily remedies as well as a source of income by selling them in the market.

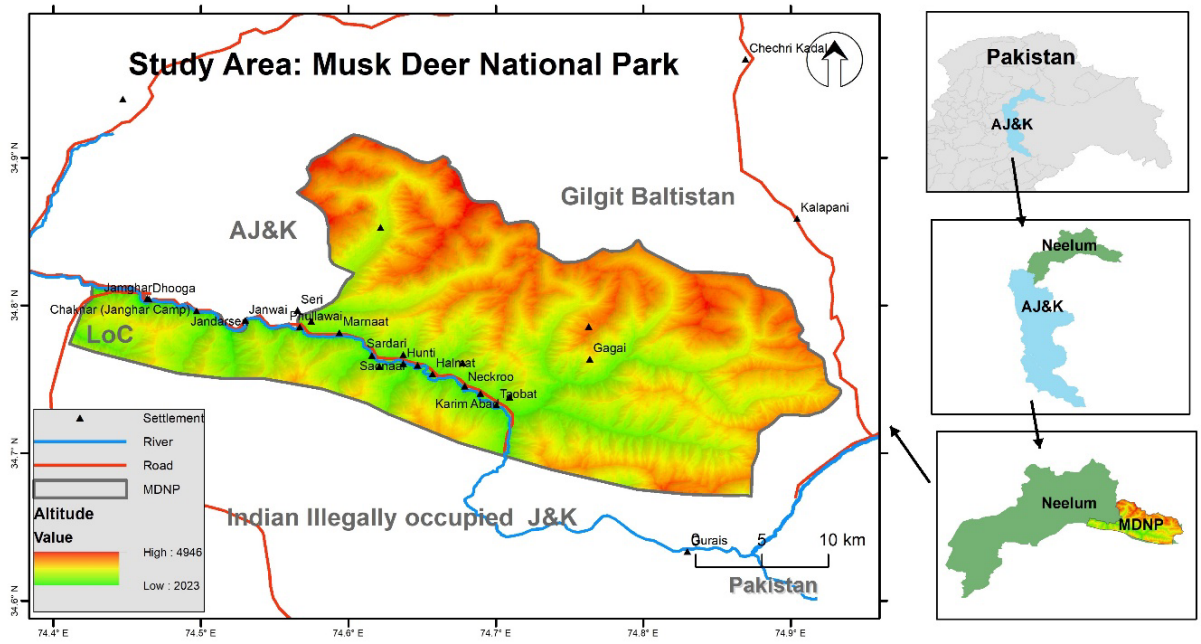

Figure 1**.** Map of the study area

Entire population residing around MDNP follows agro-pastoral practices, they used to move their livestock herds to high alpine pastures during summer season for grazing .Prior to the onset of winter, they make their way back to the permanent settlements. They rely on agriculture, livestock rearing and forest-based resources as source of their livelihoods.

Data Collection

Field surveys were conducted in 11 villages of MDNP following Heinrich and coworker (Vijayakumar *et al*. 2015). From each village, 10 household were randomly sampled with different socioeconomic background and age groups. These including mainly traditional healers, elderly people, plant collectors, representative of forest department, youth and market dealers. The age of these interviewed people rangd from 20 to 75 years

Plant collection, Identification and Herbarium Deposition

Collected Plants specimens were pressed, dried, poisoned and mounted on standard size herbarium sheet (17.5"x 11.5"). Medicinal plants specimens were initially identified by Dr.Jan Alam (plant taxonomist at Hazara Unversity Mansehra Pakistan), later on confirmed by Flora of Pakistan (Ali and Nasir (1990-1991, 1993-2001, 2002 - 2019).The assigned botanical nomenclature of names and families were cross-checked by two online plant databases i.e., The Plant List (2010) (http://www.theplantlist.org.) and World Flora Online (http://www.worldfloraonline.org/).The identified specimens were labelled, given voucher numbers and were deposited at the herbarium Department of Botany, Hazara University Mansehra, Pakistan.

Data Analysis

The data was analyzed by using quantitative indices including Relative Frequency of Citation (RFC), Use Value (UV) and Informants Consensus Factor (IFC)

Informant consensus factor (ICF)

ICF determine the consensus value of the informants on reported uses of medicinal plants for disease groups and later on various infirmities categorized in different groups. ICF was calculated by the following formula (Heinrich *et al.* 1998; Trotter *et al*. 2019)

$$ICF = \frac{Nur - Nt}{(Nur - 1)}$$

Where Nur is number of use citations in each category/group minus (-) Nt that is total number of plant species used; divided (/) by the number of use citations in each category minus one as per given formula above (Amjad *et al.* 2017; Tabuti *et al* .2003; Moerman 1996) [79-81]. This maximum value in ICF is one (01), if experimental values are one or near to one then it means that reported plant species are prevalently used by major part of the local communities confirming their authenticity regarding the ailments' cure. If ICF value is zero (0) or near to zero then it confirms that local people randomly use the plant(s) to treat the cited infirmity (Amjad *et al.* 2017).

Relative Frequency of Citation (RFCs)

RFC determines the importance of every plant species dependent on the number of informants reported a species concerning the total number informants who participate in the survey and was calculated by using the formula

RFC= FC/N, (Phillips et al. 1994).

Where FC is the number of informants who reported uses of a particular species and N is the total number of informants.

Use value (UV)

UV determines relative importance of each species calculated by using the formula (Vitalini et al. (Gairola *et al.* 2013; Savikin *et al*. 2013).

$$UV = \sum Ui / N$$

Where Ui is the number of uses mentioned by each informant for a given species and N is the total number of informants

Results and Discussion

Demographic Description

Field surveys were conducted in 11 villages of MDNP following Heinrich and coworker (Heinrich *et al*.1998). From each village, 10 household were randomly sampled with different socioeconomic background and age groups. These including mainly traditional healers, elderly people, plant collectors, representative of forest department, youth and market dealers.

Majority of the respondents were men (65.45%) followed by women (34.55%).Men actively participated in information sharing process, women of young age normally reluctant to interact having less participation, but women of old ages participated in the survey and shared ample folk wisdom as reported by Reyes-Garcia *et al*. (2013). Women have more knowledge about the treatment of medicinal plants against gynecological diseases than men. Our results agreed with research studies conducted in differetn parts ot the country (Khadim et al. 2023; Rafique *et al*. 2021)

Maximum number of informants (66.36%) were above 40 years of age and 33.64 % were below the age of 40 years (Table 1). Young people seemed less interested in herbal treatments, they prefer modern healthcare system over the conventional healthcare system and traditional knowledge of their elders as reported in various ethnobotanical studies (Abbas *et al*. 2017b; Bibi *et al*. 2022; Jan *et al*. 2017; Bhatia *et al*. 2014). Elderly people have accurate practicing knowledge about the plant parts used and recipes than the young (Farnsworth 1988).

Diversity of Ethnomedicinal Flora in the Study Area

The results showed that 84 medicinal taxon belonging to 69 genera and 43 families used by local community for therapeutic purpose. Most frequently used families were Asteraceae with 16 species (19.05 %) followed by Polygonaceae with 7 species (8.33) and Fabaceae with 4 species (4.76 %) respectively. Other families such as Apiaceae, Geraniaceae, Lamiaceae,

Ranunculaceae and Rosaceae were represented by 03 species (3.57 5) each, whereas Plantaginaceae, Primulaceae, Schrophulariaceae and Violaceae have 02 species each. Remaining 28 families were monotypic in medicinal plant representation (Figure 2).

Table 1. Demographic attributes (sex ratio, age, education levels, and social livelihoods) of native communities showing their social and economic background

Variables	Categories	No. of Informants	Percentages (%)
Gender	Male	72	65.45
	Female	38	34.55
Age Group	< 40	37	33.64
	> 40	73	66.36
Educational Level	Uneducated	30	27.27
	Primary level	31	28.18
	Middle	26	23.64
	Secondary level	13	11.82
	Graduate	10	9.09
Main Source of Family Income	Labor	24	21.82
	Job holder	14	12.73
	Agriculture and Livestock	47	42.73
	Business	24	21.82
	Traditional Healer	1	0.91

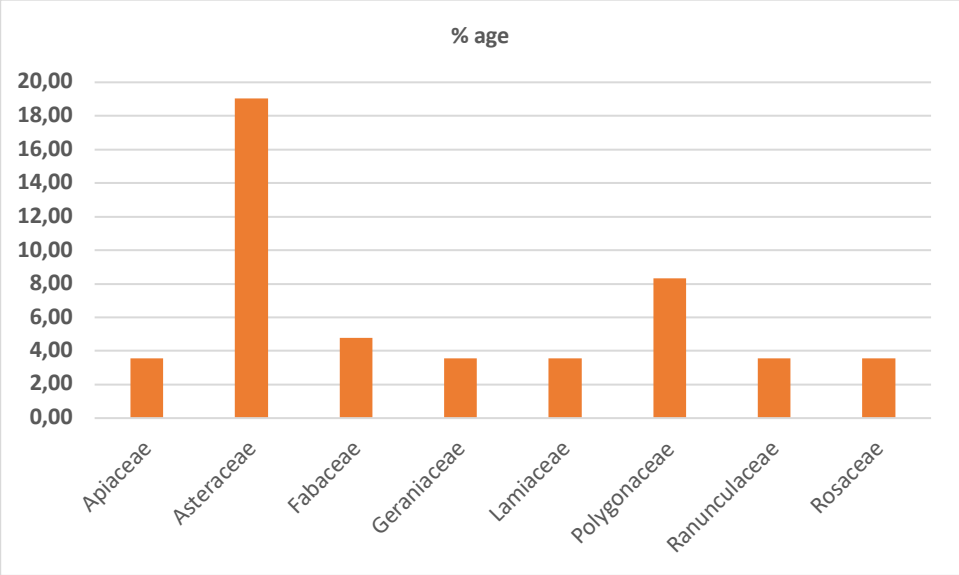

Figure 2. Dominant plant families

Asteraceae is one of the largest families in the flora of Pakistan. It is one with high ecological niche and distribution including mostly herbaceous species; inhabit varied geographical features and climatic conditions favorable for their growth, studies from northern mountain ranges endorse it (Mesfin et al. 2009, Bhattarai et al .2010; Abbas et al. 2019).

Asetraceae was the leading family with maximum number of medicinal plants species to cure diseases (Vijayakumar et al. 2014; Shinwari et al.2000) . Medicinal significance of family Asteraceae is also well established through previous studies (Saini et al. 2020; Achika et al. 2014).

Similar reports presented earlier showed that Lamiaceae, Rosaceae, Asteraceae, Papilionaceae ,Ranunculaceae , Brassicaceae, Chenopodiaceae and Amaranthaceaewere were documented as dominant ethnomedicinal plant families from different areas of Kashmir, Pakistan (Amjad *et al.*2017, Rahim et al.2023). The dominance of these families is attributed to the fact that they are abundant in the area and easily available to the local people.

Plants Growth Form and Utilization

Present work reflected herbaceous species of ethnomedicinal value were commonly cited 88.10 %, followed by tree 5.95 %, shrubs (11 species) 4.76% and subshrub ferns (1.19) (Figure 3). The major utilization of herbs for medicinal purpose might be due to availability and easy access and applications (Kaval *et al.*2014; Hussain *et al.* 2012). Similar results were reported from previous ethnomedicinal literature where most of medicinally valuable species were of herbacious nature (Bibi *et al.* 2022; Birjees *et al.* 2022; Irfan *et al*.2023).

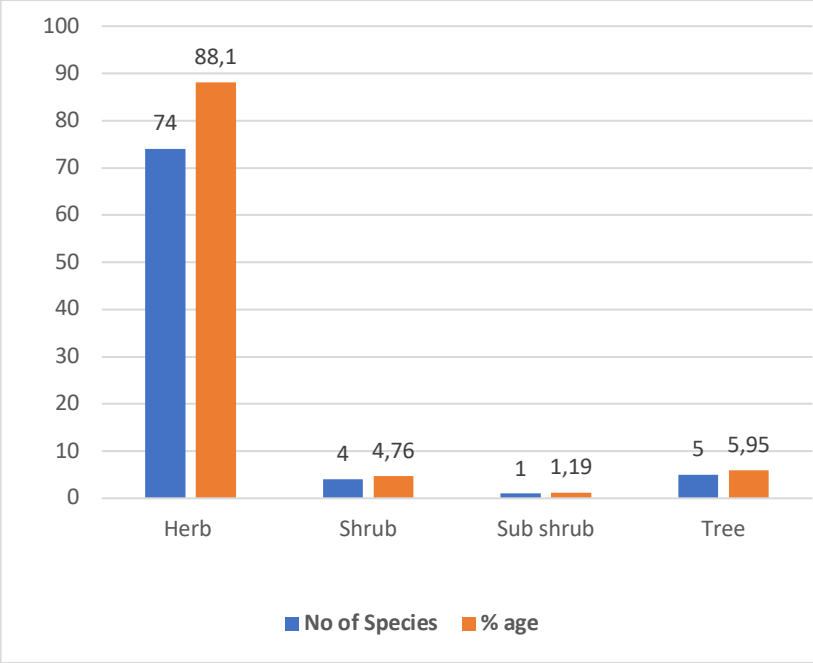

Figure 3. Plants growth form and Utilization

Plant Part(s) Used for Medicinal Purpose

Different plant parts were used differently in herbal medicines depending upon the prevailing indigenous knowledge and availability of those parts to local community. Data of current study indicates roots (30 species, 29%) were the most commonly used plant parts followed by leaves (19 species, 18 %), whole plant (15 species, 15%), flower (9 species, 9%) and seed (7 species, 7 %) etc. (Figure 4). The higher utilization of roots might be because of their use to make powder, they are easily stored, are used during off season when fresh material is not available around and have higher concentrations of bioactive compounds (Muthu *et al* .2006; Hart &Bussmann 2018; Marwat 2008; Srithi *et al*. 2009; Basualdo *et al*.1995). Besides roots, leaves are also preferred parts in many cases for herbal medicine preparation because they contain easily extractable chemical used in crude drugs by communities residing in remote areas which may be proven valuable in therapy (Ijaz et al.2015, Majid *et al*.2020; Shaheen *et al*.2014). Roots, leaves, seeds, tubers and fruits restrain the high amount of biologically active substances compared to other plant parts, hence most preferred in the traditional medicines (Hart & Bussmann 2014). Frequent use of root, seed and fruit leads to destructive effects on plants growth and population in nature, whereas the use of leaves is safe and sustainable (Bano *et al*.2014; Bano *et al*.2014b). Likewise increased population and subsequent agriculture expansion, overgrazing,commercial extraction of medicinal plants and deforestation for timber and fuel wood were reported as main factors in decline of medicinal plants populations in remote mountainous areas (Ghimire *et al*.2008; Giday *et al*.2003; Balemie *et al*.2004).

Drug Formulation and Administration

The inhabitants of MDNP were using local medicinal plants in drug formulation to treat various ailments. Among these, drug used in powder form was dominant (34.46 %), followed by plant part(s) used as cooked/boiled (25.68), extract(18.92 %), decoction (14.19 %), chewed/eaten as fresh (4.73 %), and infusion (2.03 %) as reflecteed in (Figure 5, Table 2).

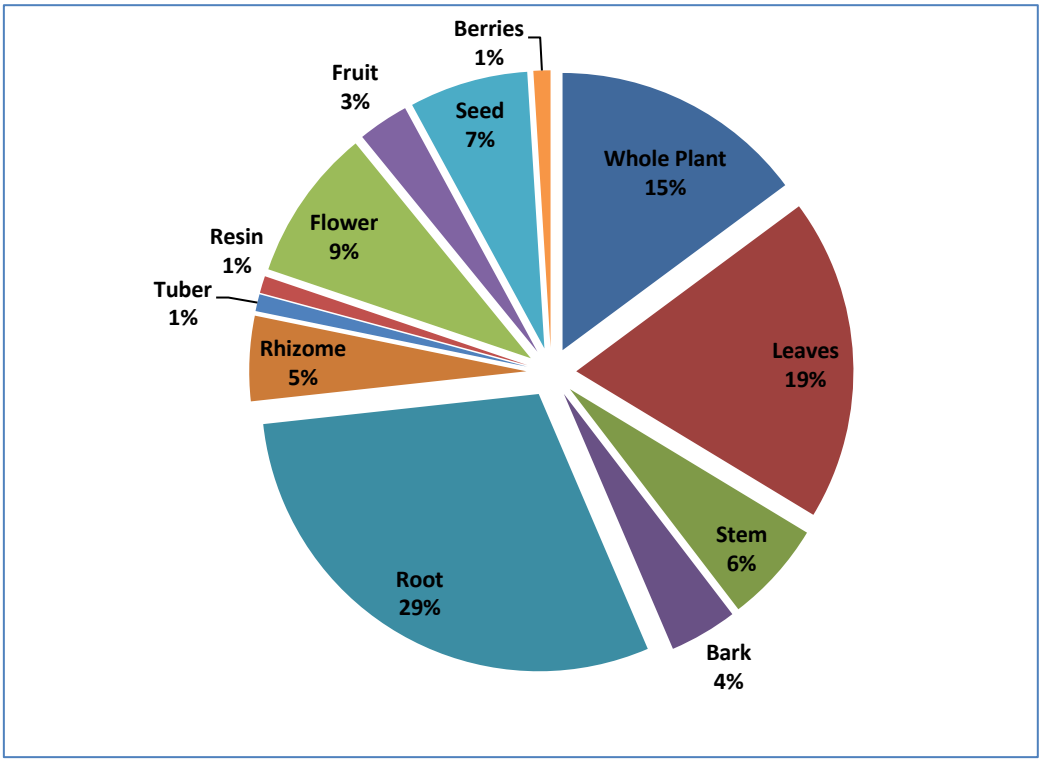

Figure 4. The percentage of used part(s) of medicinal plants.

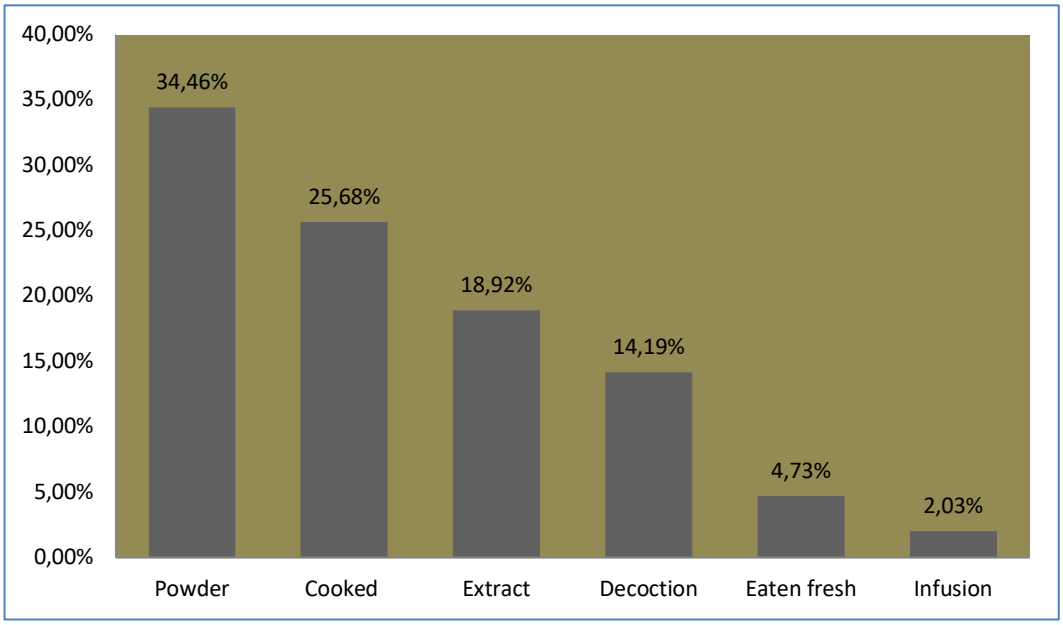

Figure 5. The percentage of different modes of drugs formulation of medicinal plants.

The use of herbal medicines has been observed in various forms, but oral administration (67.6%) is ranked first, followed by tropical use/paste (17.65%) and 15.29 % were used both orally and topically (Figure 6, Table 2). Similar results were reported in the literature that therapists mostly used medicinal plants in the form of decoction, powder, extracts, cooked, eaten fresh, and infusion (Khadim *et al*.2023; Farooq *et al*. 2019; Maqsood *et al.* 2022, Gurdal and Kultur 2013; Bano *et al*. 2014)

Oral mode is preferred because of its easy to take in and also by providing instant relief (Tamang *et al*. 2014; Mahmood *et al* .2012;Mahmood *et al* . 2011; Ssegawa *et al*.2007; Alam *et al*.2011).The potential of herbal medicine depends a lot on drug formulation and utilization technique (Arshad *et al*.2014).

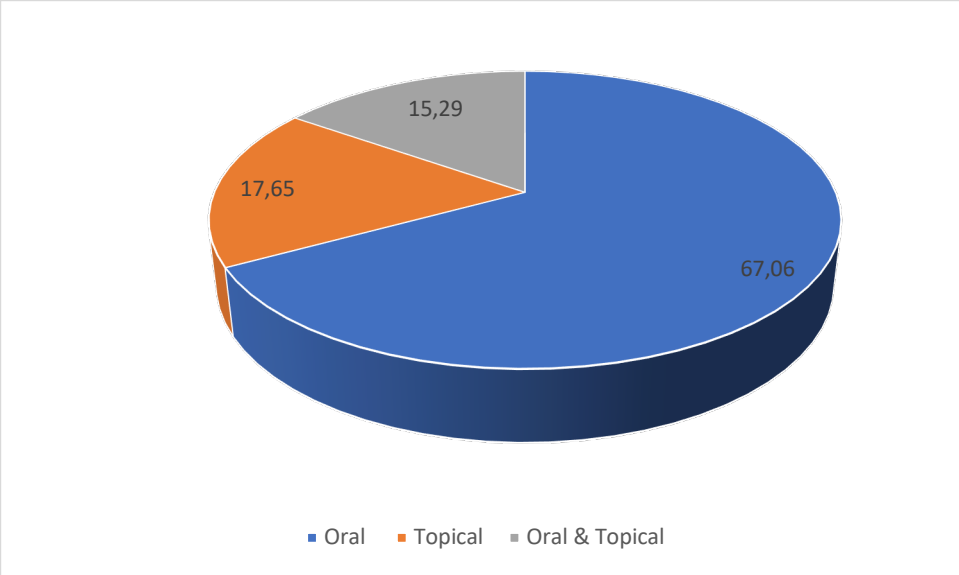

Figure 6. The percentage of Mode of application of folk recipes

Figure 7. **(a)** *Trillium govanianum*, **(b)** *Picrorhiza kurroa* , (**c)** *Aconitum heterophyllum* medicinal plants species extracted on commercial basis

Table 2. Description of the Medicinal flora of Musk Deer National Park, Azad Jammu & Kashmir, Pakistan

Family	Scientific Name	Voucher Number	Local Name	Habit	Parts Used	Disease (s) Treated	Drug Formulation	AD	UV	RFC
Amaryllidaceae	*Allium fedtschenkoanum* Regel	G.H.No: 9798	Bhook	Herb	Fruit	Skin Infection	Fruit paste	Topical	1.44	0.15
Amaryllidaceae	*Allium humile* Kunth	G.H.No: 9796	Pari Pyaz	Herb	Whole plant	Gastrointestinal disorder	Salad	Oral	2.26	0.39
Amaranthaceae	*Amaranthus spinosus* L.	G.H.No:9455	Ghanhar	Herb	Seed	Backache	Seeds boiled in milk, added maize flour to make dumplings	Oral	2.00	0.78
Apiaceae	*Angelica cyclocarpa* (C. Norman) Cannon	G.H.No: 9799	Murchar	Herb	Root	Respiratory tract infection, Gastrointestinal disorder	Root powder used with water.	Oral	1.18	0.10
Apiaceae	*Heracleum canescens* Lindl.	G.H.No:9801	Palhar	Herb	Root	Wound healing	Root powder is applied to heal wounds.	Topical	1.13	0.97
Apiaceae	*Heracleum cachemiricum* C.B. Clarke	G.H.No: 9802	Chora	Herb	Root	Asthma, Gastrointestinal disorder	Root powder is used with water	Oral	1.05	0.80
Asclepiadaceae	*Aesculus indica* (Wall. ex Camb.)c Hook.	G.H.No: 9763	Ban-Khoor	Tree	Fruit	Indigestion	Dried fruit powder	Oral	1.92	0.69
Asphodelaceae	*Eremurus himalaicus* (Baker) L.	G.H.No:9806	Shilii	Herb	Shoot	Diarrhea, Dysentery	Young shoots are cooked and used as vegetable	Oral	1.85	0.55
Asteraceae	*Inula orientalis* Lam.	G.H.No:9755	Sabir Jari	Herb	Root	Asthma, Urinary tract infection	Root powder	Oral	1.70	0.25
Asteraceae	*Inula royleana* DC.	G.H.No: 9466	Sabir Jari	Herb	Flower, Root	Skin and respiratory tract infection	Decoction of the root is used as an expectorant and paste of the flower used to cure some skin diseases.	Both oral & topical	1.58	0.17
Asteraceae	*Inula racemosa* Hook.f.	G.H.No: 9756	Sabir Jari	Herb	Root	Asthma, bronchitis	Decoction.	Oral	1.41	0.15
Asteraceae	*Jurinea himalaica* R.R. Stewart	G.H.No: 9758	Gugal Dhoop	Herb	Root	Backache, bleeding wounds, rheumatism, aphrodisiac	Roots are boiled in water and maize flour and sugar is added to make dumpling. Fresh roots are chewed as gum as well. In case of bleeding root paste is applied on wounds	Topical	1.00	0.71
Asteraceae	*Achillea millefolium* L.	G.H.No: 9759	Sultani Booti	Herb	Whole plant	Constipation, stomach disorder, antiseptic, toothache	Dried powder is used as an antiseptic, and demulcent, Fresh leaves are chewed for toothache and jaw pain. The	Both oral & topical	1.25	0.79

							extract is used against constipation and stomach disorder			
Asteraceae	*Saussurea costus* (Falc.) Lipsch.	G.H.No: 9765	Kuth	Herb	Root	Stomach worms, backache, rheumatism and obesity	Ground or chopped roots are boiled in water. The extract is added in milk or water. Sugar and maize flour is also added to it to prepare dumpling. Dumpling is eaten during the night at sleeping time, it is diaphoretic so advised to use during sleeping time at night and the body is covered by warm cloths.	Oral	1.00	0.95
Asteraceae	*Anaphalis nepalensis* (Spreng.) Hand. - Mazz.	G.H.No: 9423	Jarri	Herb	Flower	Wound healing	Dried powder is applied to the puss and wound	Topical	1.00	0.05
Asteraceae	*Arctium lappa* L.	G.H.No: 9768	Dhatura	Herb	Root	Boils	Root past	Topical	1.62	0.19
Asteraceae	*Artemisia elagantissima* Pamp.	G.H.No: 9785	Jahoo	Herb	Whole Plant	Skin Infection	The extract is applied to infected skin	Oral	1.48	0.23
Asteraceae	*Artemisia incisa* Pamp.	G.H.No: 9786	Jahoo	Herb	Flower	Worms in children,	Powders	Topical	1.61	0.28
Asteraceae	*Artemisia vulgaris* L.	G.H.No: 9787	Jhaoo	Herb	Shoot	Irregular Menstruation	Extract of young shoot	Oral	1.30	0.49
Asteraceae	*Ligularia jacquemontiana* (Decne.) M.A.Rau	G.H.No:	Muta Kesh	Herb	Root	Rheumatism	Root extract	Oral	1.71	0.32
Asteraceae	*Senecio analogus* DC.	G.H.No: 9790	Bagoo	Herb	Whole plant	Stomach -ache, Hepatic disorder	Extract	Oral	1.25	0.50
Asteraceae	*Senecio nudicaulis* Buch.-Ham.ex.D.Don	G.H.No: 9795	Bagoo	Herb	Leaves	Skin infection, scabies	Leaves extract mixed with water and given bath to children	Topical	1.29	0.64
Asteraceae	*Taraxacum officinale* Webb.	G.H.No: 9796	Hund	Herb	Root, leaves	Kidney and liver disorders, Constipation,	The root is a diuretic; tonic is used in kidney and liver disorders. The powder mixed with *Hyoscyamus niger* L. is used for constipation	Both oral & topical	1.80	0.88
Family	Scientific Name	G.H.No: 9799	Local Name	Habit	Parts Used	Disease (s) Treated	Drug Formulation	AD	UV	RFC
Balsaminaceae	*Impatiens edgeworthii* Hoo.f.	G.H.No: 9801	Buntil	Herb	Seed	Pneumonia	Seeds fried in ghee are used to cure pneumonia	Oral	1.22	0.45

Balsaminaceae	*Impatiens balfourii* Hook. f.	G.H.No: 9805	Buntil	Herb	Whole plant	Rheumatism, Constipation	Leaves past for joint pain. Extract of the plant for constipation	Both oral & topical	1.31	0.59
Betulaceae	*Betula utilis* D.Don	G.H.No: 9809	Bhurj	Tree	Root Bark	Rheumatism, gallbladder stone	Tea made up of bark	Oral	1.83	0.79
Berberidaceae	*Berberis lycium* Royle	G.H..No: 9821	Sumbel	Shrub	Root bark	Backache, bone fractures	Root extract, Root bark powder	Both oral & topical	2.07	0.97
Boraginaceae	*Arnebia benthamii* (Wall. ex G.Don) I.M.Johnst.	G.H.No: 9823	Kazban	Herb	Root	Intestinal problem	Decoction	Oral	1.67	0.80
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	G.H.No: 9824	Bun Painncha	Herb	Shoot, leaves, and seed	Diarrhea, blood pressure	Aerial parts are cooked and used in diarrhea; Seeds powder is taken with water to cure high blood pressure	Oral	2.11	0.76
Cannabaceae	*Cannabis sativa* L.	G.H.No: 9826	Bhang	Herb	Leaves	Diarrhea and stomach disorder	Leaves cooked and used as vegetable	Oral	1.50	0.40
Convolvulaceae	*Convolvulus arvensis* L.	G.H.No: 9827	Sonchal	Herb	Leaves and shoot	Constipation	Powder	Oral	1.83	0.60
Caryophyllaceae	*Silene vulgaris* (Moench) Garcke	G.H.No:9828	Murkan	Herb	Leaves	Constipation	Leaves and shoots cooked and taken as vegetable	Oral	2.31	0.62
Chenopodiaceae	*Chenopodium album* L.	G.H.No: 9834	Bathwa	Herb	Leaves and shoot	Constipation, flatworms	Leaves and shoots cooked and taken as vegetable	Oral	2.14	0.70
Cupressaceae	*Juniperus communis* L.	G.H.No: 9839	Bhenthri	Shrub	Cone/ Berries	Asthma	The cone is chewed to cure asthma	Oral	1.04	0.41
Cuscutaceae	*Cuscuta reflexa* Roxb..	G.H.No: 9840	Neela Dahari	Herb	Whole plant	External wound infection	A cold aqueous extract is used externally for washing wound	Topical	1.07	0.49
Equisetaceae	*Equisetum arvense* L.	G.H.No: 9677	Banda Kaya	Herb	Whole plant	Acidity, weakness, kidney infection	Grind and keep in water during night in an open place. Then add molasses and use	Oral	1.40	0.88
Equisetaceae	*Equisetum ramosissimum* Desf.	G.H.No: 9678	Banda Kaya	Herb	Whole plant	Acidity, kidney infection	Plant extract	Oral	1.34	0.80
Fabaceae	*Astragalus himalayanus* Klotzsch	G.H.No: 9863	Maswak	Herb	Root	Toothache	Chewed and used as toothbrush (Miswak)	Oral	1.26	0.70
Fabaceae	*Indigofera heterantha* Brandis	G.H.No: 9864	Kainthi	Shrub	Leaves, Root	Wounds, allergy, flatworms	Leaves extract is applied on bleeding wounds. Mussel fresh leaves on allergic body parts. Boiled root extract taken orally.	Oral	1.52	0.60

Fabaceae	*Oxytropis cachemiriana* Cambesss.	G.H.No: 9865	Kathra	Herb	Rhizome	Toothache	Rhizome used as a toothbrush	Topical	1.30	0.61
Fabaceae	*Trifolium repens* L.	G.H.No: 9866	Sinja	Herb	Seed	Abdominal pain	Seeds are chewed and swallowed with water	Oral	1.09	0.85
Fumariaceae	*Corydalis crithmifolia* Royle	G.H.No: 9881	Pat-papra	Herb	Whole plant	Eye infection	Flower powder	Topical	1.00	0.05
Gentianaceae	*Swertia petiolata* D.Don	G.H.No: 9885	Nil	Herb	Flower	Skin infection	Flower powder	Topical	1.02	0.50
Geraniaceae	*Geranium collinum* Stephan ex Willd.	G.H.No: 9891	Ratan Jog	Herb	Root	Rheumatism, backache	Decoction	Oral	1.92	0.65
Geraniaceae	*Geranium nepalensis* Sweet	G.H.No: 9892	Ratan Jog	Herb	Whole plant	Renal infection	Rhizome powder and decoction of aerial parts	Oral	1.50	0.80
Geraniaceae	*Geranium wallichianum* D.Don ex Sweet	G.H.No: 9893	Ratan Jog	Herb	Root	Wound, toothache, backache	Root powder	Both oral & topical	1.37	0.75
Juglandaceae	*Juglans regia* L.	G.H.No: 9894	Akhroot	Tree	Fruit, Bark	Toothache	Nuts are believed to be used as brain tonic and bark in toothache	Oral	3.65	0.89
Lamiaceae	*Mentha longifolia* (L.) L.	G.H.No: 9905	Poodna	Herb	Leaves	Asthma, Gastric problem	Decoction	Oral	1.84	0.78
Lamiaceae	*Mentha royleana* Wall.ex Benth.	G.H.No: 9906	Poodna	Herb	Whole Plant	Gastric problem	Extract	Oral	1.69	0.70
Lamiaceae	*Thymus linearis* Benth.	G.H.No: 9908	Ban-Ajwain/ Bunrjuain	Herb	Flower, Leaves	Pneumonia, throat sour, menstrual disorders	Decoction	Oral	2.27	0.70
Lilliaceae	*Fritillaria pallidiflora* Schrenk	G.H.No: 9799	Rech-Eend	Herb	Bulb	Broncho-asthma, Tuberculosis	Powder	Oral	1.38	0.24
Malvaceae	*Lavatera cachemiriana* Mast.	G.H.No: 9932	Dang Sonchal	Herb	Root	Constipation	Root Powder	Oral	1.41	0.20
Orchidaceae	*Dactylorhiza hatagirea* (D.Don) Soo	G.H.No:9773	Nar Mada	Herb	Tuber	Aphrodisiac, depression	Tuber powder is used as a sex stimulant & nerve tonic.	Oral	1.00	0.14
Parnassiaceae	*Parnassia nubicola* Wall. ex Royle	G.H.No: 9941	Nil	Herb	Whole plant	Indigestion	The whole plant is cooked as a vegetable (pot herb)	Oral	1.00	0.05
Pinaceae	*Pinus wallichiana* A.B. Jacks.	G.H.No: 9942	Kail/ Bayar	Tree	Stem resin	Wound & skin infection	Stem resin for wound healing and avoid infection.	Topical	2.35	0.99
Plantaginaceae	*Plantago lanceolata* L.	G.H.No: 9945	Chamchi Patar	Herb	Leaves, Root, Seed	Dysentery, Constipation	Leaves and tonic are stimulants and used in dysentery. Seeds are taken with milk as purgative	Oral	1.39	0.79
Plantaginaceae	*Plantago major* L.	G.H.No: 9949	Chamchi Patar	Herb	Leaves, Root, Seed	Toothache, Constipation	Powder	Oral	1.41	0.79
Podophyllaceae	*Sinopodophyllum hexandrum* (Royle) T.S.Ying	G.H.No: 9950	Ban-Kakhri	Herb	Rhizome, Seed	Infection, stomach & liver disorder	Root and seed Powder	Oral	1.79	0.53

Polygonaceae	*Aconogonon rumicifolium* (Royle ex Bab.) Hara	G.H.No: 9954	Pnchoola	Herb	Root	Backache	Root boiled in water then prepared its pudding and eaten to get relief from backache.	Oral	1.45	0.79
Polygonaceae	*Bistorta affinis* (D.Don) Green	G.H.No: 9955	Masloon	Herb	Root	Body pain, muscle contraction	Root powder taken with milk	Oral	1.63	0.88
Polygonaceae	*Oxyria digyna* (L.) Hill	G.H.No: 9956	Khatkara	Herb	Whole plant	Dysentery	Cooked and taken to cure dysentery	Oral	1.31	0.70
Polygonaceae	*Bistorta amplexicaulis* (D.Don) Green.	G.H.No: 9959	Masloon	Herb	Root	Throat infection,	Root Powder	Oral	1.79	0.51
Polygonaceae	*Polygonum aviculare* L.	G.H.No: 9962	Dhrubra	Herb	Whole plant	Constipation	Cooked as a pot herb	Oral	2.24	0.71
Polygonaceae	*Rheum webbianum* Royle	G.H.No: 9963	Chotyeal	Herb	Rhizome, Shoot	Wounds, urinary tract infection, constipation	Rhizome paste, Shoots chewed due to its purgative nature its juice cures constipation.	Both oral & topical	1.53	0.70
Polygonaceae	*Rumex nepalensis* Spreng.	G.H.No: 9964	Hoola	Herb	Root, leaves	Allergy, constipation disorder in the menstrual cycle	Decoction is used to regulate the menstrual cycle. Leaves used as vegetables and are believed to ease bowel evacuation. Leaves rubbed on the affected parts for relief from irritation caused by *Urtica dioica*.	Both oral & topical	1.52	0.72
Primulaceae	*Primula denticulata* Sm.	G.H.No: 9971		Herb	Rhizome	Eye disorder	Powdered mixed with honey used to cure various eye disorders.	Both oral & topical	1.00	0.11
Primulaceae	*Primula involucrata* Wall. ex Duby	G.H.No: 9972	Mamera	Herb	Leaves	Eye infection	Powder on leaves is used to cure eye pain	Topical	1.00	0.09
Ranunculaceae	*Caltha alba* Cambess.	G.H.No: 0074	Kalari Patra	Herb	Leaves	Boils	Fried leaves in ghee applied on boils	Topical	1.00	0.11
Ranunculaceae	*Aconitum chasmanthum* Stapf. ex Holmes	G.H.No: 9975	Mohri	Herb	Flower	Asthma, cough, respiratory tract infection, skin issues (Chamal)	Dry and grind the flower, then mix it with honey and *Arnebia benthamii* flowers, keep at worm place for 40 days (to kill its poison), then use small amount equal to maize grain with tea at night. Grind the dry root quite fine and the use along with vaseline is very effective	Both oral & topical	1.00	0.16

							against skin irritation (Chambal).			
Ranunculaceae	*Aconitum heterophyllum* Wall. ex Royle	G.H.No: 9976	Patrees	Herb	Root	Cough, pneumonia, abdominal pain, sugar, blood pressure	Root powder	Oral	1.00	0.93
Rosaceae	*Potentilla kashmirica* Hook. f.	G.H.No: 9980	Malyan di chah	Herb	Root	Pneumonia, intestinal infection	Decoction	Topical	1.85	0.43
Rosaceae	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	G.H.No: 9981	Khanmarch	Herb	Whole plant	Jaundice, fever, cholera	Extract	Topical	2.40	0.74
Rosaceae	*Sambucus wightiana* Wall. ex Wight & Arn.	G.H.No: 9982	Ghanola	Herb	Root	Stomach worms, skin infection	Decoction, Powder	Topical	1.00	0.05
Rubiaceae	*Galium asperuloides* Edgew.	G.H.No: 9983		Herb	Whole Plant	Urinary tract infection	Decoction	Oral	1.19	0.25
Rubiaceae	*Skimmia laureola* Franch.	G.H.No: 9984	Nera	Shrub	Leaves	Abdominal pain, urinary tract infection, kidney stone, sugar	Leaves powder is used in cough. Boil dry leaves in water, and keep the pot in open air on the roof for dew. Then use it early in the morning in a fastening condition.	Oral	1.00	0.29
Saxifragaceae	*Bergenia ciliata* (Haw.) Sternb.	G.H.No: 9985	Batbewa	Herb	Root	Wound healing, stomach ulcer, urinary tract infection	Used as tea and is effective in curing urogenital disorders. The dried powder is applied to the pusy wound tumor.	Both oral & topical	1.81	0.49
Solanaceae	*Hyoscyamus niger* L.	G.H.No: 9988		Herb	Leaves, seed	Anxiety, cough	Decoction, seed powder	Oral	1.00	0.02
Scrophulariaceae	*Picrorhiza kurroa* Royle	G.H.No: 9989	Kaur	Herb	Root	Abdominal pain, Sugar, Blood Pressure	Root powder is taken orally (Phaki) with hot water.	Oral	1.00	0.23
Scrophulariaceae	*Verbascum thapsus* L.	G.H.No: 9991	Gadi Kan	Herb	Leaves, Flower, Root	Swollen wounds, boils, jaundice, respiratory tract infection	The leaves are hot and dry and used in chest complaints. Leaves and flowers are useful in pulmonary diseases and bleeding of the lungs. Leaves are also smoked to induce sedation by reducing irritability or excitement. Paste of the roots is also applied to swelling wounds that release pus from boils.	Both oral & topical	1.00	0.09

Melanthiaceae	*Trillium govanianum* Wall. ex D.Don	G.H.No: 9992	Tray Patra	Herb	Root	Stomach ulcer	Root powder	Oral	1.00	0.16
Taxaceae	*Taxus baccata* L.	G.H.No: 9993	Thooni	Tree	Bark	Stomach ulcer, asthma	Decoction	Oral	3.59	0.25
Valerianaceae	*Valeriana pyrolifolia* Decne.	G.H.No: 9994	Mushk Bala	Herb	Rhizome	Constipation,	Rhizome powder	Oral	1.00	0.29
Violaceae	*Viola fedtschenkoana* W. Becker	G.H.No: 9997	Bnafsha	Herb	Flower, Leaves	Stomach acidity, throat infection	Extract, Decoction	Both oral & topical	1.00	0.19

Ad: Administration, **UV**: Use Value, **RFC**: Relative Frequency of Citation

Informant Consensus factor (ICF)

The ICF was calculated on the base of use reports against each disease category, inferring a high consensus value among the informants (Table 3). The inhabitants of the study area used medicinal plant species to treat 30 different ailments grouped into 10 major disease categories and the maximum ICF value is for digestive system problems (0.98) followed by respiratory system and skeletomuscular system problems having ICF (0.97) each. Least ICF value was recorded for the problem of the nervous system (0.92).

Table 3. Disease (s) categories and informant consensus factor (IFC) for each category for data from the study area

Disease Categories	Ntax	Nur	ICF	Most commonly used plants
Digestive system problems, Constipation, Dysentery	44	2188	0.98	*Allium humile, Heracleum cachemiricum, Arnebia benthamii, Aconitum heterophyllum, Bergenia ciliata, Rheum webbianum, Picrorhiza kurroa, Taxus baccata/ Taxus wallichiana, Aesculus indica, Impatiens edgeworthii, Cannabis sativa, Convolvulus arvensis, Silene vulgaris, Trifolium repens, Parnassia nubicola, Plantago lanceolata, Plantago major, Oxyria digyna, Polygonum aviculare, Rumex nepalensis, Valeriana pyrolifolia*
Respiratory system problem	28	953	0.97	*Aconitum chasmanthum, Heracleum cachemiricum, Inula royleana, Mentha royleana, Impatiens edgeworthii, Bistorta affinis, Aconitum heterophyllum ,Taxus baccata, Picrorhiza kurroa, Thymus linearis, Angelica cyclocarpa, Mentha longifolia, Fritillaria pallidiflora, Bistorta amplexicaulis, Potentilla kashmirica*
Skeletomuscular System problems	11	299	0.97	*Jurinea himalaica, Amaranthus spinosus, Saussurea costus, Berberis lycium, Geranium collinum, Aconogonon rumicifolium*
Urinogenital System Disorder	14	264	0.95	*Taraxacum officinale, Artemisia vulgaris, Jurinea himalaica, Equisetum ramosissimum, Thymus linearis, Skimmia laureola, Bergenia ciliata, Equisetum arvense, Geranium nepalensis, Galium asperuloides*
Hepatic Disorder	5	45	0.91	*Senecio analogus, Taraxacum officinale, Betula utilis, Sinopodophyllum hexandrum*
Hyperglycaemia	4	46	0.93	*Capsella bursa-pastoris , Picrorhiza kurroa, Skimmia laureola*
Skin and subcutaneous tissues	21	477	0.96	*Verbascum thapsus, Aconitum chasmanthum, Rheum webbianum, Sinopodophyllum hexandrum, Geranium wallichianum, Pinus wallichiana, Arctium lappa, Anaphalis nepalensis, Heracleum canescens, Senecio nudicaulis, Corydalis crithmifolia, Swertia petiolata, Rumex nepalensis*
Infectious and parasite-related diseases	6	101	0.95	*Chenopodium album, Saussurea costus, Artemisia vulgaris, Sambucus wightiana, Indigofera heterantha, Artemisia incisa*
Problem of the nervous system	7	81	0.92	*Hyoscyamus niger, Primula denticulata, Dactylorhiza hatagirea, Artemisia elagantissima, Cuscuta reflexa*
Obesity	2	20	0.95	*Heracleum cachemiricum, Saussurea costus*

The majority of the medicinal plant species identified in the study area are reportedly utilized to treat digestive system problems followed by respiratory, skeletomuscular system problems, skin and other infirmities. Digestive system problems were prevalent in the study area which can be attributed to the limited availability of hygienic food and drinking water(Wali *et al*.2019; Ishtiaq *et al*.2021; Mahmood &Tabassum 2011d; Kumar *et al.*2010). The prevalence of respiratory diseases in the study area due to the high altitude combined with low barometric pressure which limits the supply of oxygen (O_2) thereby impacting lung function (Hussain *et al*. 2012; Kayani *et al.*2014). The plants frequently used to treat these disorders might contain active ingredients and are thus well-known by locals. This result is also in agreement with previous studies conducted by other researchers to document traditional uses of wild medicinal plants (Amjad *et al*.2017; Hussain *et al*.2012; Kayani *et al* .2014; Schlage *et al*.2000). Skeletomuscular system problems might be due to carrying of heavy luggage by inhabitants in

form of woods and grasses to cope their daily life necessities and continuous walking on mountains slopes (Kumar *et al*. 2005; Kaval *et al*.2014). The high ICF values recorded reflected the high reliability of local flora (Adzu. *et al* .2003), especially for digestive system problems, skeletomuscular system, and respiratory system problems. The least ICF value was recorded for the problem of the nervous system (0.92), which indicates that there is less consistency in the informant's knowledge about the use of plants to cure this ailment Recorded ICF values of the dominant diseases were similar with studies conducted in other parts of Kashmir and Pakistan (Bano *et al*.2014; Schlage *et al*.2000) .

Relative frequency of citation

Homogeneity in the traditional knowledge of medicinal plants was quantitatively evaluated by using RFC index. The RFC of medicinal taxon ranged from 0.88 to 0.99 (Table 2). The highest RFC was recorded for *Pinus wallichiana* (0.99 followed by Berberis *lycium* and *Heracleum canescens* (0.97) each, *Saussurea costus* (0.95), *Aconitum heterophyllum* (0.93), *Juglans regia* (0.93) *Bistorta affinis* and *Taraxacum officinale* having RFC (0.88) each. The RFC shows the local importance of every species with reference to the informants who cited uses of these plant species (Lin *et al*.2002).Plants with high RFC value are very famous among the local people and their specific properties for curing different diseases have become popularized and well established among the indigenous people, these could be used for subsequent assessment of phytochemical profiling, and in future drug discoveries (Vitalini *et al*. 2012; Mukherjee &Wahile 2006).

Use Value

Medicinal plants that are used commonly showed higher use value than the least used plants. In the present study, the use values of medicinal taxon ranged from 1 – 3.65 (Table 2). The results showed that *Juglans regia* reported the highest use value of (3.65), followed by Taxus *baccata* (3.59), *Fragaria nubicola* (2.40), *Thymus linearis(*2.27), *Allium humile (*2.26) and *Polygonum aviculare* (2.24) respectively.

The use value (UV) is a numerical method for data inquiry that measures types of uses associated with particular species (Mukherjee *et al.* 2012). High use values of a species show its consistent use for the treatment of various diseases and high usage reported by the number of informants shows that the plant is well recognized by the local inhabitants and is well utilized in ethnomedicinal purposes (Bieski *et al.* 2012; Kayani *et al.*2015).

Plants with low UV and RFC values may reflect a lack of awareness of the proper use of medicinal flora among the young generation (Abbas et al. 2017b). Hence traditional knowledge about the medicinal flora is at risk of not being transmitted to future generations.

This was the first quantitative ethnobotanical investigation to be carried out in the study area; therefore we compared our results with similar quantitative studies carried out in other parts of the country (Kaval *et al* .2014 Mahmood *et al*.2012; Schlage *et al*.2000; Lin et al.2002).

In most Himalayan regions native people use medicinal plants as their own assets (Nautiyal *et al.*2001). *Bergenia cilliata*, *Valeriana pyrolifolia*, *Fritillaria pallidiflora*, *Picrorhiza kurrooa*, *Aconitum heterophyllum Synopodoplyllum haxandrum*, *Fritilla royleoi*, *Trillium govanianum* and *Valiriana wallichiaii* are extracted on large scale. Local poor people are reported to sell up to 10 kg - 15 kg roots / HH/ year from the area of Musk Deer National Park. Considering this increasing demand for herbal drugs and medicinal plants and the consequent depletion of several species, it is imperative to initiate urgent steps for the conservation of medicinal flora (Singh *et al.* 2006)

Conclusion

Current study recorded the diverse medicinal flora of Musk Deer National Park. The documentation of this rich traditional ethnomedicinal knowledge has furnished us with novel information that will provide recognition of this undocumented knowledge. Plants are still a vital source of medicines for the remote mountainous community of the area, but infusion of allopathic drugs could erode traditional knowledge. therefore, an ethnobotanical investigation is suggested to underpin the comprehensive documentation of traditional ethnomedicinal knowledge before the disappearance of the biocultural heritage of the area. This is first ever ethnomedical investigation in the MDNP that could serve as a useful baseline for future conservation and management of park resources and will encourage policymakers and conservation planners to endorse the importance of medicinal flora in the traditional healthcare system and will plan for its conservation and utilization on a sustainable basis.

Declarations

List of abbreviations: RFC= relative frequency of citation, UV= use value, Ad = Administration, MDNP = Musk Deer National Park

Ethics approval and consent to participate: Prior to the survey, we obtained oral informed consent from each informant.

Consent for publication: Not applicable

Availability of data and materials: All data generated or analyzed during this study are included in this published article

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Contributions: MH, and JA designed the study; MH and SMR conducted the fieldwork, GMS, AM, NS, AG conducted the main statistical analysis; MH, and AG wrote the manuscript, JA and AM revised the data analysis and the manuscript; all authors read, corrected, and approved the manuscript.

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