Quantitative study on the trade and ecological aspect of spice plants in the markets of District Bannu, Khyber Pakhtunkhwa, Pakistan

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Databases and Inventories

Abstract

Background: This survey is the first extensive and large-scale spice plant assessment in four different spices marketplaces of district Bannu, Khyber Pakhtunkhwa, Pakistan. The study offers the first significant catalog of spice prices, the chain of collection, production, trade pattern and consumption.

Methods: Consultation, personal observations, and group discussions with 90 informants (10% women and 90% male) using semi-structured questionnaires were conducted.

Results: A total of 45 spice taxa belonging to 21 families were documented. The data were examined using various ethnoecological indices such as UV (Use Value), RFC (Relative Frequency of Citation), UR (Use Report), and CIV (Cultural Importance Value). Amongst all the taxa, the plant having the highest Use Value were *Coriandrum sativum* (0.783), used as Anti-cholesterol and carminative, *Ocimum basilicum* (0.742) for kidney problems, insomnia, and snake bites, and *Piper nigrum* (0.732) for cough. The UV ranged from 0.07 (*Mangifera indica*) to 0.78 (*Coriandrum sativum*). The most used spices plant parts were fruits (35.56%), trailed by seeds (28.89%), leaves (11.11%), bulb, bark, and rhizome (4.44%). RFC ranged from 0.16 (*Mangifera indica*) to (*Coriandrum sativum*) 0.82. The maximum RFC value was documented for *Coriandrum sativum* (0.822), trailed by *Papaver somniferum* (0.788), *Cuminum cyminum*, *Ocimum basilicum*, and *Piper nigrum* (0.777) each. *Curcuma longa* (0.65) had the maximum mCI (mean Cultural Importance) while the *Mangifera indica* (0.04) had the lowest. The majority off spice plants parts traded was imported (41 species, 91.11%) from India, China, Vietnam, Afghanistan, Iran, Brazil, and Nepal. Most of them were transported from Pakistan from different cities and provinces in Pakistan like Lahore, Karachi, Faisalabad, Gilgit, Peshawar, Quetta, and Multan into district Bannu. The minimum number of spice plants (8 species, 17.77%) were collected or cultivated locally. The spices plant having the highest trade price per kg (PKR 525000, US$ 3365) was *Crocus sativus* which is imported from Gilgit-Baltistan and China, while the lowest trade price was documented for *Allium sativum* (PKR 75, US$ 0.4) which is imported and also grown locally.

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Conclusions: The current study suggests that more detailed research would be highly interesting, as the district is well known for spices and medicinal plants.

Keywords: Quantitative study, spices plants, spices markets, Bannu, Khyber Pakhtunkhwa, Pakistan.

Background

Medicinal plants have been identified and used throughout human history (Shikov *et al.*, 2014; Süntar, 2020; Aziz *et al.*, 2015). The World Health Organization (WHO) estimates that up to 80% of the world's population in developing countries depend on locally available plant resources for their primary healthcare because western pharmaceuticals are often expensive and inaccessible (Tugume *et al.*, 2019; Shafi *et al.*, 2021; Borowy, 2020). Pakistan harbors a high diversity of medicinal and aromatic plants due to its unique phytogeography with diverse climatic conditions (Shaheen *et al.*, 2019; Jan *et al.*, 2020; Abdullah *et al.*, 2021). About 400-600 medicinal plant species out of a flora of 5700 are estimated to exist in Pakistan (Gulzar *et al.*, 2019; Abbas *et al.*, 2019; Rudov *et al.*, 2020). In the early 1950, almost 84% of the Pakistani population mainly depended on traditional medicines as a primary health care source (Rahman *et al.*, 2019; Zaman *et al.*, 2019). Nowadays this dependency is more limited, and only still prevalent in more remote areas due to rapid changes in lifestyle and modernization.

The term spice is derived from the word **espice** (old French word), which came from Latin "spec" which means kind or appearance (Beegum *et al.*, 2019). The term **spices** now includes all those plants and their parts (seeds, bark, roots and fruits) which are mainly used for flavoring and coloring in a wide variety of food substances (Liang *et al.*, 2021; Sabina *et al.*, 2020; Asif, & Mohd, 2019). Spices are plant products that frequently contain essential oils, which evaporate and give us characteristic smell and color of each spice species (Shalaby *et al.*, 2020; Ngan *et al.*, 2020; Calín-Sánchez *et al.*, 2020). Spices are thought to be a mixture of vegetable products that are free of impurities for imparting aroma to foods, seasoning and flavoring (Cascadden *et al.*, 2020). The dried leaves of aromatic plants are often traded separately from the leaf stalks and plant stems and gives odor and flavor to our food (Salehi *et al.*, 2019; Osuntokun, 2021), Spices may be comprised all the dried parts except the leaves of aromatic plants (Zinicovscaia *et al.*, 2020; Liang *et al.*, 2021). The history of spices dated back to at least 3500 BC, when the ancient Egyptians used them for preserving dead bodies, cosmetics and for flavoring of foods (Yildirim *et al.*, 2020; Byrd & Dunn, 2020). The use of spices became common and spread from the Middle East to the eastern Mediterranean and Europe (Tornero *et al.*, 2020; Pieroni *et al.*, 2019; Morton, 2020). Cinnamon is thought to be the oldest spice traded long before the 1500s to the east coast of Africa and Madagascar by Indonesian sailors (Horton *et al.*, 2021; Yaapar, 2019; van Rossum, 2021). Asia is known for the highest production of spices especially India which is contributing 86% of spices production globally followed by China, Bangladesh, Turkey, and Nepal contributing 4, 3, 2, and 1% respectively (Pickova *et al.*, 2020; Pickova *et al.*, 2021; Ozdal *et al.*, 2021). Pakistan is also contributing 2% of global spice production (Ur Rahman & Mohsin, 2019; Khan *et al.*, 2020). Spices are used throughout the world but in each country, the pattern and proportion of spices preparation are quite different (Yilmaz & Demirci, 2021; Silvis *et al.*, 2019). Different thoughts exist about spices, ranging from that, they contain macronutrients, clean foods from pathogens and thereby contribute to health and longevity, to reproductive success of people who use spices in their foods. The absence of documentation, time-consuming processes, and the transfer of insufficient intergenerational knowledge amongst people have created a lot of problems related to traditional foods all over the world. For the preparation of many traditional foods, many different species of edible plants are needed. As such, the mastering of components and processing methods constitute limitations to the valorization of this category of foods. To promote the consumption of traditional foods we need to go for the documentation of culinary information which is functional in the preparation to uphold the home-grown or outdated practices. The research work was designed to,

- Identify and document the spices plants for their traditional uses along with price patterns in four selected markets (Chuk, Laki gate, Masala mandi and Tanchi market) of district Bannu.
- Elucidating all the routes and channels through which these plants are produced, imported and exported.
- Compare the identified spice plants and their cross-markets commonalities and differences among four considered markets.

Materials and Methods

Study area and topography

Bannu is considered one of the important and ancient districts of Khyber Pakhtunkhwa (province) Pakistan, founded by S, H. Edward in 1848 (Shah *et al.*, 2020). Bannu shares boundaries with North Waziristan in the northwest, the

district Karak in the northeast, and Laki Marwat and South Waziristan in the southeast and southwest respectively. It lies at (70.22° - 70.57° E) and (32.43° - 33.06° N) at an average altitude of 371m above the sea level and cover 1,227 km^2 (Kamran *et al.*, 2020; Ahmad *et al.*, 2020) (Figure 1). Entry into the main city of Bannu used several gates (Mandan, Hinjal, Meryan, Lakki, Railway, Pori, Sokari, Qasaban, Paredi, and Hwand gate, etc.), because the whole city is surrounded by a big wall constructed under British rule (Ali & Perveen 1848). Most of the population can speak and understand English and Urdu but the native language of Bannu is Banisee (Pashto language). Most the population is living in rural communities around the main city. The area has a semi-arid climate and is very dry and hot in summer, and in winter the weather remains moderate to cool. The highest registered temperature was 33.6°C in June, while January has the lowest average temperature of 11.7°C. The area is bisected by two major rivers i.e., Gambila/Tochi and Khurram which come from the hills of Waziristan and the main source of irrigation water (Ali & Perveen 1848). The current study was carried out on four main markets of district Bannu known for spices are discuss below.

Chuk Market.

Chuk Market is known to be the most ancient and largest market of district Bannu. It comprises hundreds of shops belongs to different fields such as ornamental, weeding, educational, clothes, foods materials but most shops belong to spice sellers (60%) and herbalist.

Laki Gate Market.

Laki Gate Market is the second-largest market in district Bannu. The market is known for medicines and herbalists. The best herbalists of district Bannu resides here and nearly 90% of shops belong to herbalist.

Masala Mandi Market.

Masala Mandi Market is a relatively small but important spice market. The individuals who belong to this market have the broadest experience spice trade all over the district.

Tanchi Market.

Tanchi Market is known for many foods famous for district Bannu. The number of spice and herbalist shops is approximately 20-30%.

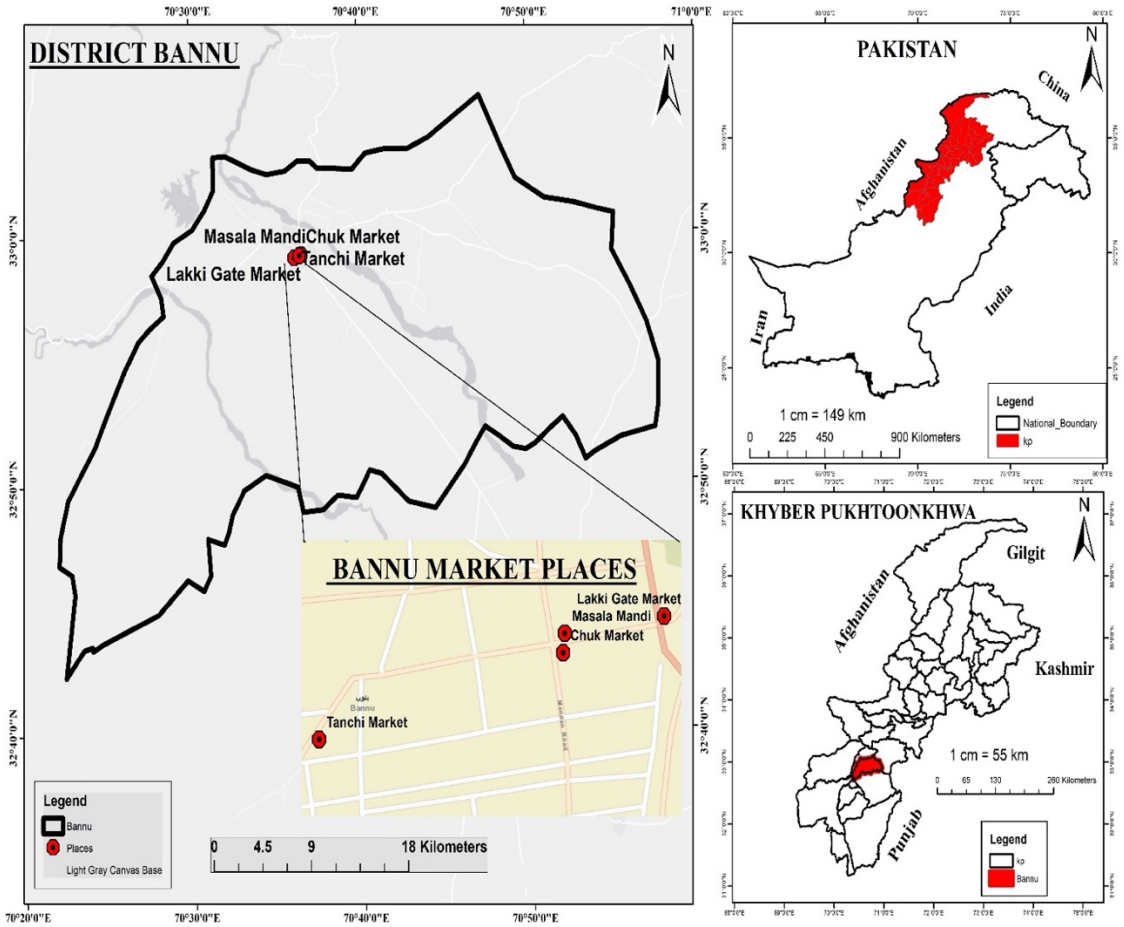

Figure 1. Study area map

Study Design

Based on therapeutic values, harvesting, and trade of plants used in spices the data were collected from different markets of district Bannu of province Khyber Pakhtunkhwa, Pakistan. The market selection was done based on herbal plant production, diversity of plants, utilization, and large markets with more than 40 species traded.

Markets survey and data collection

By using open-ended questionnaires and a purposive sampling method, the price pattern, ethnomedicinal data, and trade data were collected from April 2020 to May 2021. Group discussions and face-to-face interviews were conducted with various individuals like healers, traders, local dealers, and collectors of various communities. During the research, each herbal and spice market was visited several (3-5) times. The work followed the International Society of Ethnobiology Code of Ethics (International Society of Ethnobiology. International Society of Ethnobiology Code of Ethics (with 2008 additions). 2006; http://www.ethnobiology.net/what-wedo/core-programs/ise-ethics-prog.The information was collected from all those participants who gave their prior informed consent (Bussmann *et al.*, 2007). Collected data including information regarding disease treated, uses, trade name, utilization, export and import, local name, demand and supply, market prices, parts traded, sales, and Spice plants production sites. The demographics of participants are given in Table 1.

Plant identification

For identification purpose, the spice plants were collected from different markets, and with help of the flora of Pakistan and available literature, each taxon was identified, and photographed at the herbarium of the Department of Botany, University of Peshawar (Ali & Perveen, 1848; Ullah *et al.*, 2006; Ahmad, 2001). Names were verified using The Plant List (http://www.theplantlist.org and www.tropicos.org).

Quantitative Statistical Analysis

To evaluate the medicinal importance of each taxon UV (Use Value), RFC (Relative Frequency Citation), UR (Use Report), and CI (Cultural Importance Index).

Use Value

The Use-value (UV) is used to demonstrate the comparative significance of each plant taxon. The standard formula shown below was used to calculate the use-value.

$$UV = {}^{UVi}/_{Ni}$$

where UVi is the number of uses for given taxa cited by each informant while the total number of informants mentioning the species will be represented by Ni (Thomas *et al.*, 2009; Phillips, & Gentry, 1993; Quave & Pieroni, 2015).

Use Reports and Relative Frequency of Citation

By using an index RFC (Relative Frequency of Citation) the quantitative analysis of collected ethnomedicinal information was carried out, demonstrating the local significance of given taxa: following

$$RFC = {}^{FC}/_{N} \, (0 < RFC < 1)$$

where FC (total number of individual citing taxa) were divided by the total number of informants represented by (N) (Vitalini *et al.*, 2013; Sargin, 2015; Asharaf & Sundaramari, 2016).

Cultural Importance Index

To demonstrate the cultural importance of each one species in every market an index CI (Culture Importance Index) was used:

$$CI = URi \, / \, Ni$$

where UR (Use Report for each taxon in every market) was divided by the total number of an informant in every market (Ni). By calculating the culture importance value for each species, the mCI (mean culture significance) was demonstrated (Kaur *et al.*, 2019; Shah *et al.*, 2020)

Jaccard Similarity Index

Jaccard index was used to analyze the differences and similarities amongst the four major markets of district Bannu. The standard formula for the Jaccard index (JI) reveals that the number present in both markets will be divided by the number present in either or both and multiply by 100 (Abbas *at el.*, 2020).

$$J(A,B) = \frac{(A \cap B)}{(A \cup B)} \times 100$$

Informant consensus factor (ICF)

To check the consent of the informant and homogeneity of the information, concern with the usage of plant taxa for the treatment of different ailments groups, the index (Informant consensus factor) was used. The ICF value ranges from 0 to 1. Normally medicinal taxa have a higher value of ICF (1) that is supposed to be active in treating definite ailments while the lowest value of ICP will be zero. The formula of ICP is

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

where Nur represents the number of a citation for an ailments group treated by a plant taxon while the total number of plant taxa used for that particular disease category will be represented by Nt (Bussmann *et al.*, 2021; Najem *at el.*, 2019).

Results

Demographic details of respondents

In the current research work, an overall of 90 participants from different cultural backgrounds and professions were interviewed. These included dealers (large scale) (3.33%), collectors (6.66%), farmers (10.0%), local dealers (16.66%), herbalists (20.0%) and shopkeepers (43.33%) (Table 1). Amongst the informants, 90% were men while 10% were women. The participation of women was limited (9) due to cultural restriction (prohibiting women from talking to strangers). The data was collected from informants of various age categories: 3.33% from less than 20 years, 23.33% from 21-40 years, 33.33% from 41-60 years, and 40.0% of the respondents were older than 60 years. Most of the informants were matriculated (40.0%) and few postgraduates (3.33%). Most of the respondents had more than 20 years of spice trade experience (60.0%), 23.33% 16-20 years, 10.0% 11-15 years, and 6.66% had 5-10 years of experience.

Table 1. Demographic statistics of informants of Districts Bannu.

Parameter	Classes	Frequency of respondent in each class	Percentage
Gender	Male	81	90
	Female	9	10
Age classes	Less than 20 years	3	3.33
	21-40 years	21	23.33
	41-60 years	30	33.33
	Above 60	36	40
Educational background	Illiterate	24	26.66
	Matriculate	36	40
	Intermediate	15	16.66
	Graduate	12	13.33
	Postgraduate	3	3.33
Respondent Profession	Farmers	9	10
	Collectors	6	6.66
	Herbalists	18	20
	Shopkeepers	39	43.33
	Local dealers	15	16.66
	Main dealers (large scale)	3	3.33
Experience in relevant field	5-10 years	6	6.66
	11-15 years	9	10
	16-20 years	21	23.33
	Above 20 years	54	60

Availability, trade, and price patterns of spice plants

The average price and availability of each spice plant in each market were documented during data collection. Masala mandi Market is known to be the most leading market of district Bannu where a total of 35 Spices plants were being traded, followed by Tanchi Market, Laki Gate Market, and Chuk Market where 34, 33 and 31 Spice plants were being traded. Chuk Market had the lowest number of spice plants because the market is not only famous for spices but rather other products. The spice plant with the highest trade price per kg (PKR 525000, US$ 3365 in Masala Mandi) was *Crocus sativus* which was imported from Gilgit-Baltistan and China, followed by *Papaver somniferum* (imported from Dir and India) and *Syzygium aromaticum* (imported from India and China) with (PKR 2350, US$ 15.1) and (PKR 2200, US$ 14.1) respectively. These spice plants were not commonly or locally utilized especially *Crocus sativus*. The lowest trade price was documented for *Allium sativum* (PKR 75, US$ 0.4) (Table 2). The trade and utilization of *Curcuma longa* and *Ocimum basilicum* have currently increased due to their use against many diseases. According to the participants, most of their income came from the sale of *Allium cepa*, *Allium sativum, Trachyspermum ammi, Coriandrum sativum, Foeniculum vulgare, Cuminum cyminum, Trigonella foenum-graecum, Ocimum basilicum, Mentha piperita, Cinnamomum verum, Laurus nobilis, Myristica fragrans, Syzygium aromaticum, Piper nigrum, Illicium verum, Elettaria cardamomum, Curcuma longa,* and *Zingiber officinale*. *These spice plants were utilized and traded throughout the district because of high medicinal values, easy availability, daily life uses, and low prices.* The highest Jaccard Index values of 50.00 occurred between Chuk Market and Masala Mandi Market, 47.62 between Chuk Market and Laki Gate Market, and 45.45 between Masala Mandi Market and Laki Gate Market demonstrated that many traded spice plants were similar between two markets.

Therapeutic uses of spices plants

The current study showed that throughout the district spice plants were widely utilized by the inhabitants. The plant taxa with the highest RFC and UV values had everyday use, e.g., *Allium sativum* (Bulb) was utilized to control blood pressure and intestinal worms. The seeds of *Trachyspermum ammi* were used as antiseptic and nasal obstruction, seeds of *Coriandrum sativum* as anti-cholesterol and carminative, seeds of *Foeniculum vulgare* for colic pain and flatulence, seeds of *Cuminum cyminum* for hypogalactia and colic problems. The seeds of *Ocimum tenuiflorum* were used against bronchial asthma, skin diseases, arthritis, and insect bite, seed of *Ocimum basilicum* for kidney problems, insomnia, and snake bites. The leaves of *Mentha piperita* were used for acid reflux, flatulence, fever, and urinary tract infections. The bark of *Cinnamomum verum* was used to treat anorexia as carminative and antiseptic. The seed of *Myristica dactyloides* served to remedy bronchitis, inflammation of joints, skin disorders, and liver disorders. The fruit of *Syzygium aromaticum* was used in toothache and as flavoring agent. The *Papaver somniferum* was used for cough, sleep disorders, and as anodyne, *Piper nigrum* was used to treat cough, *Capsicum frutescens* to increase immunity, pain reliever and taste purpose, *Elettaria cardamomum* for bad breath, Indigestion, heartburn, and for its cooling effect, *Curcuma longa* for anti-cholesterol and analgesic, *Amomum subulatum* as antimalarial and brain enhancer and *Zingiber officinale* for allergies, nausea, fever, and vomiting (Table 2).

Trade routes identified

The results show that in selected markets of district Bannu most of spice plants traded were imported from India, China, Vietnam, Afghanistan, Iran, Brazil, and Nepal (41 spp., 91.11%). The imported spice plants were primarily received by some of the big cities of Pakistan e.g., from China into Quetta, India into Lahore, Iran into Karachi, and from Afghanistan into Peshawar (Figure 2). Lahore and Faisalabad are known to be the primary trade center getting the maximum amount of Spices plants imported from foreign countries. Karachi was the chief center for exporting spices and natural products abroad. Few spice plants (8 spp., 17.77%) (Figure 3) were collected or cultivated locally. Masala Mandi Market turned out as the central business hub where the import and export of spice plants were maximum.

Taxonomic classification of spice plants

In the current survey, 45 spice plants belong to 21 families were documented. The leading family was Solanaceae (6 spp., 13.33%), followed by Apiaceae (5 spp., 11.11%), Rosaceae and Zingiberaceae (4 spp., 8.89%), Rutaceae and Lamiaceae (3 spp., 6.67%), Amaryllidaceae, Anacardiaceae, Fabaceae, Lauraceae and Myristicaceae (2 spp., 4.44%) while the remaining 10 families contained (1spp., 2.22%) each (Figure 5). For every single spice plant uses, trade number (CGP), market price (US dollars), and status (local, imported) were documented (Table 2). Herbs were the most common life form traded in markets (27 spp., 60%) trailed by trees having (14 spp., 31.11%) and shrubs having (4 spp., 8.89%).

Table 2. Spice plants traded in the selected spices Markets of district Bannu.

Families	Plant Name Local Name Sample Trade Number	Habit	Part used	Plant status	Price of each plant in US $/Kg				Ethnomedicinal uses	FC	RFC	U_R	Uv	mCI
					Chuk Market	Tanchi Market	Masala Mandy Market	Laki Gate Market						
Amaryllidaceae	*Allium cepa* L. Pyaz AAB-01	H	Bulb	L	0.4	-	0.5	0.5	Parasiticidal, carminative and cure of irritation	43	0.48	18	0.41	0.25
	Allium sativum L. Ezza AAB-02	H	Bulb	L	2.7	2.5	2.7	2.3	Intestinal worms and hypertension	57	0.63	33	0.57	0.47
Anacardiaceae	*Mangifera indica* L. Aam AMP-03	T	Powder	I	0.5	-	0.6	-	Candidiasis, digestive agent, rheumatism, and diarrhea	14	0.16	1	0.07	0.04
	Anacardium occidentale L. Kaju AABL-04	T	Bark, Leaves	I	-	-	11.9	12.3	Reduce blood sugar levels and detoxify snake bites	47	0.52	23	0.49	0.26
Apiaceae	*Trachyspermum ammi* (L.) Sprague Ajwain ATS-05	H	Seeds	I	-	1.1	1.3	-	Nasal obstruction and antiseptic	65	0.72	44	0.68	0.47
	Coriandrum sativum L. Danya ACF-06	H	Fruit	L, I	1.4	1.7	1.1	1.5	Anti-cholesterol and carminative	74	0.82	58	0.78	0.63
	Foeniculum vulgare Mill. Saunf AFS-07	H	Seed	I	-	-	1.3	1.5	Colic pain and flatulence	66	0.73	46	0.70	0.50
	Anethum graveolens L. Soya AAL-08	H	Leaves	I	5.8	6.3	5.9	-	Bone fracture	41	0.45	16	0.39	0.25

	Cuminum cyminum L. Zeera ACS-09	H	Seed	I	4.6	3.5	4.6	5.1	Hypogalactia and colic problems	70	0.78	52	0.74	0.57
Aracaceae	Phoenix dactylifera L. Khajira APF-10	T	Fruit	L	-	7.1	5.1	8.1	Astringent for intestine, diarrhea, and sexual disorders	22	0.25	4	0.18	0.06
Brassicaceae	Brassica compestris L. Woyrayi ABO-11	H	Oil	L	1.2	-	1.4	1.3	Hair fall, angina, chest pain, and oil is used as tonic	26	0.29	6	0.23	0.09
Fabaceae	*Trigonella foenum-graecum* L. Methi Dana ATS-12	H	Seed	I	1.3	1.2	1.0	1.5	Allergy, fever, and child urination	45	0.50	21	0.47	0.22
	Tamarindus indica L. Imli ATF-13	H	Fruit	I	2.9	3.4	3.0	-	Constipation, abscess and carminative	23	0.26	5	0.22	0.07
Iridaceae	*Crocus sativus* L. Zaafraan ACS-14	H	Stigma	I	-	-	3365.4	-	Infertility, azoospermia and brain tonic	15	0.17	2	0.13	0.08
Lamiaceae	*Ocimum tenuiflorum* L. Tulsi AOS-15	H	Seed	I	1.3	1.5	-	1.8	Bronchial asthma, skin diseases, arthritis and insect bite	56	0.62	33	0.59	0.38
	Ocimum basilicum L. Tukhm-e-Malanga AOS-16	H	Seed	I	3.0	3.4	-	3.7	Kidney problems, insomnia, and snake bites	70	0.78	52	0.74	0.57
	Mentha piperita L. Wellena AML-17	H	Leaves	L, I	1.2	1.4	1.6	1.3	Acid reflux, flatulence, fever, and urinary tract infections	63	0.70	42	0.67	0.47

Lauraceae	*Cinnamomum verum* J. Presl Darchini ACB-18	T	Bark	I	-	4.1	4.3	4.4	Anorexia, carminative, and antiseptic	49	0.54	24	0.49	0.27
	Laurus nobilis L. Tez Paat ALL-19	T	Leaf	I	2.9	3.0	-	3.1	Astringent, narcotic, rheumatic pains and dropsy	36	0.40	12	0.33	0.18
Lythraceae	*Punica granatum* L. Anar APS-20	T	Seed	I	-	3.0	2.8	2.5	Cancer, digestive disorders and to expel tapeworms.	39	0.44	15	0.38	0.22
Myristicaceae	*Myristica fragrans* Houtt. Jaifal AMS-21	T	Seed	I	6.4	6.5	7.4	7.1	Drowsiness, dry mouth, and carminative in children	51	0.57	26	0.51	0.39
	Myristica dactyloides Javitri AMS-22	T	Seed	I	7.5	6.9	7.1	-	Bronchitis, inflammation of joints, skin disorders and liver disorders	62	0.69	40	0.65	0.44
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry Lawang ASF-23	T	Fruit	I	10.6	12.2	14.1	13.5	Toothache and flavoring agent	67	0.74	46	0.69	0.51
Papaveraceae	*Papaver somniferum* L. Khash Khash APS-24	H	Seed	I	11.2	11.5	13.8	15.1	Coughing, sleep disorders and anodyne	71	0.79	52	0.73	0.57
Phyllanthaceae	*Phyllanthus emblica* L. Aamla APF-25	T	Fruit	I	2.1	-	-	-	Eye diseases	42	0.47	16	0.38	0.25
Piperaceae	*Piper nigrum* L. Ter Mirch APF-26	S	Fruit	L, I	6.3	7.4	5.8	8.7	Cough	70	0.78	50	0.71	0.55

Ranunculaceae	*Nigella sativa* L. Tera zeera ANS-27	H	Seed	I	-	13.8	11.2	12.5	Cardiovascular disease and chest pain	39	0.44	15	0.38	0.24
Rosaceae	*Prunus armeniaca* L. Shawtuli APF-28	T	Fruit	I	2.4	-	-	2.6	Analgesic and antispasmodic,	27	0.30	7	0.26	0.10
	Prunus domestica L. Alocha APF-29	T	Fruit	I	-	2.8	3.0	-	Relieve constipation and improve digestion	25	0.28	5	0.20	0.07
	Rosa indica L. Gulab ARP-30	S	Leaves oil	I	1.3	1.7	1.8	-	Ant constipation	33	0.37	10	0.30	0.12
	Rosa damascenae L. Zingali Gulab ARP-31	S	Petals	I	3.4	3.1	-	3.0	Skin treatment and diabetes	38	0.42	14	0.37	0.21
Rutaceae	*Citrus limon* (L.) Osbeck Nimbo ACF-32	H	Fruit	I	-	0.7	0.9	0.6	Smooth digestion and antiseptic	44	0.49	19	0.43	0.29
	Citrus aurantium L. Narang ACF-33	H	Fruit	I	0.9	0.7	-	0.8	Laxative and stomachic	32	0.36	9	0.28	0.14
	Murraya koenigii (L.) Sprenge Kari Pata AML-34	T	Leaf	I	11.2	9.6	9.0	-	Inflammation, itching, dysentery and snakebites	34	0.38	11	0.32	0.15
Schisandraceae	*Illicium verum* Hook.f. Badyan AIF-35	T	Fruit	I	-	10.6	9.6	9.9	Stomachache and intestinal gases	41	0.45	16	0.39	0.17
Solanaceae	*Capsicum annuum* L. Shimla mirch ACF-36	H	Fruit	I	4.8	-	5.1	5.6	Increase immunity and pain reliever	37	0.42	13	0.35	0.15
	Capsicum annuum var. abbreviatum Fingerh Shimla mirch ACF-37	H	Fruit	I	4.2	5.1	-	5.9	Pain reliever	39	0.43	15	0.38	0.17

	Capsicum annuum var. acuminatum L. Shimla mirch ACF-38	H	Fruit	I	-	5.8	4.1	4.8	Increase immunity and taste purpose	41	0.46	17	0.41	0.20
	Capsicum annuum var. grossum L. Shimla mirch ACF-39	H	Fruit	I	5.3	-	4.8	-	For taste	35	0.39	12	0.34	0.18
	Capsicum frutescens var. baccatum L. Shin Mirch ACF-40	H	Fruit	I	4.2	5.4	-	5.2	Increase immunity, pain reliever and taste purpose	40	0.44	15	0.38	0.23
	Capsicum frutescens L. Shin Mirch ACF-41	S	Fruit	I	3.5	5.8	4.8	5.4	For taste	56	0.62	32	0.57	0.36
Zingiberaceae	*Elettaria cardamomum* (L.) Maton Sheen lochi AES-42	H	Seed	I	-	12.5	13.5	10.9	Bad breath, Indigestion, heartburn, cooling effect	57	0.63	33	0.58	0.38
	Curcuma longa L. Kurkaman ACR-43	H	Rhizome	L	1.4	1.5	1.1	1.8	Anti-cholesterol and analgesic	64	0.71	43	0.67	0.65
	Amomum subulatum Roxb. Ter lochi AAS-44	H	Seed	I	10.2	11.5	11.2	-	Antimalarial and brain enhancer	44	0.49	19	0.43	0.27
	Zingiber officinale Roscoe. Adrak AZR-45	H	Rhizome	I	5.4	4.5	6.7	8.0	Allergy, nausea, fever, and vomiting	65	0.72	43	0.66	0.66

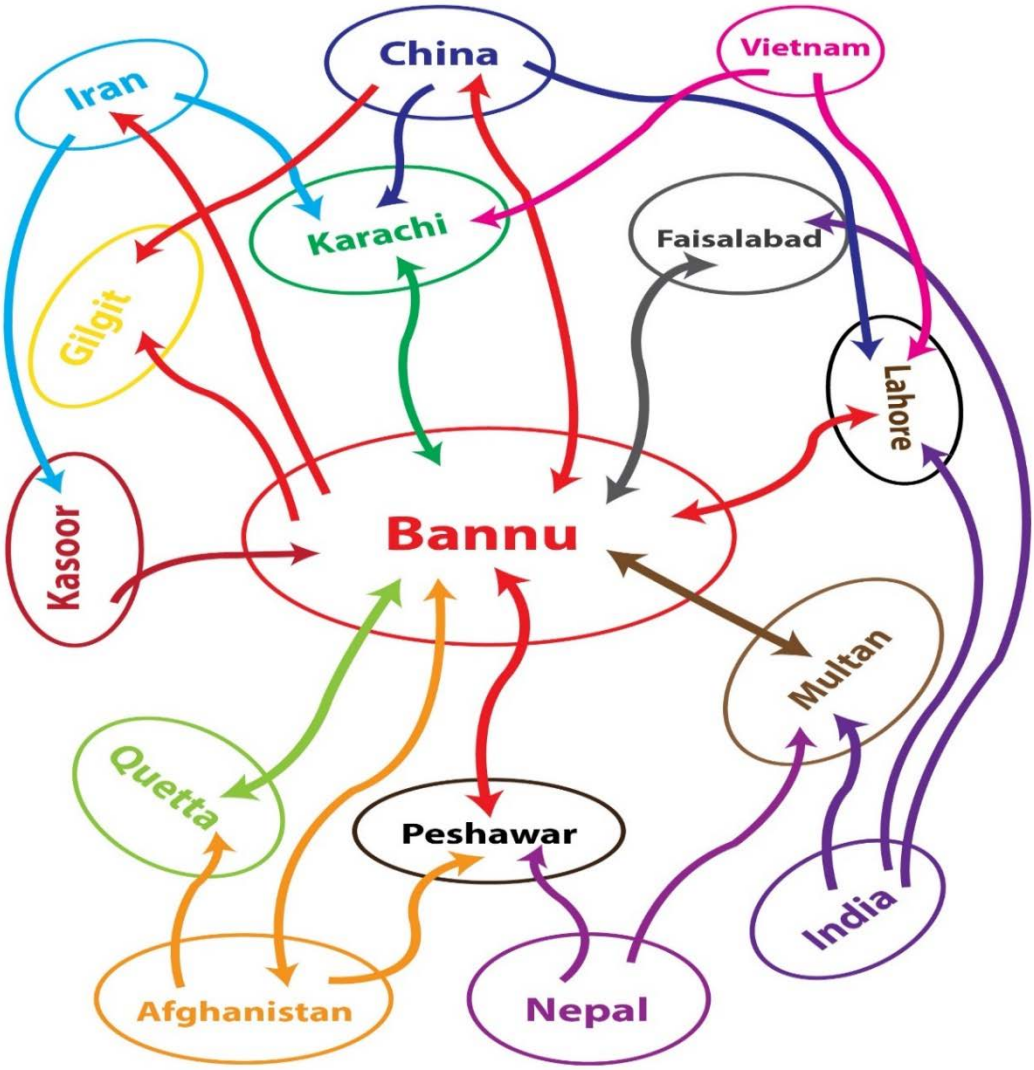

Figure 2. Routes identified for spice plants trade and commercialization

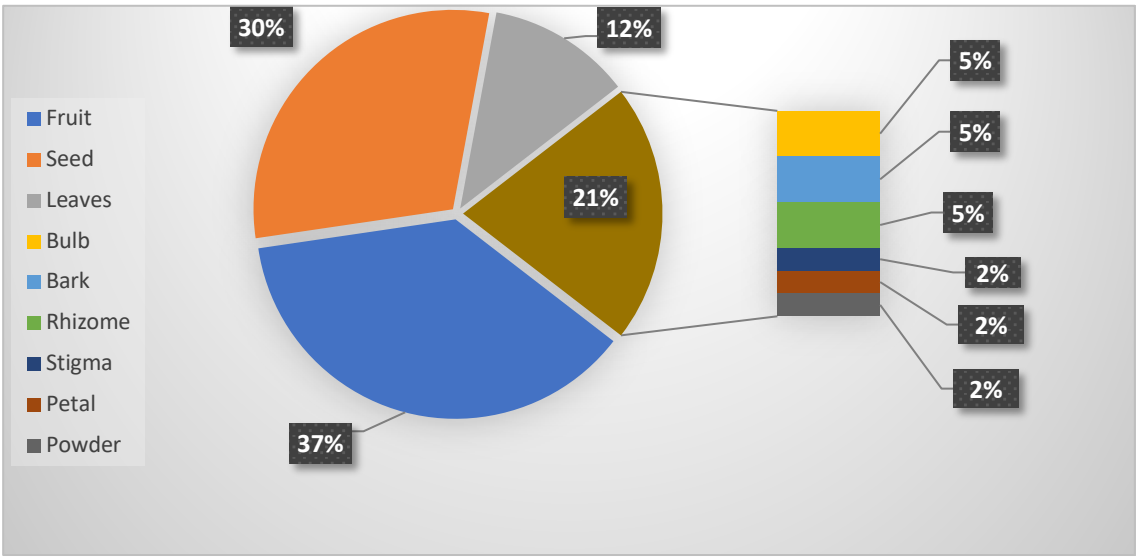

Figure 3. Plants status in different spice markets of district Bannu

Plants parts traded

In four major markets of Bannu, the most traded spice plants parts were fruits (35.56%), trailed by seeds (28.89%), leaves (11.11%), bulb, bark, and rhizome (4.44%). Stigma, petals, and powder (2.22%) respectively are the minor used part traded and utilized in the markets (Figure 4).

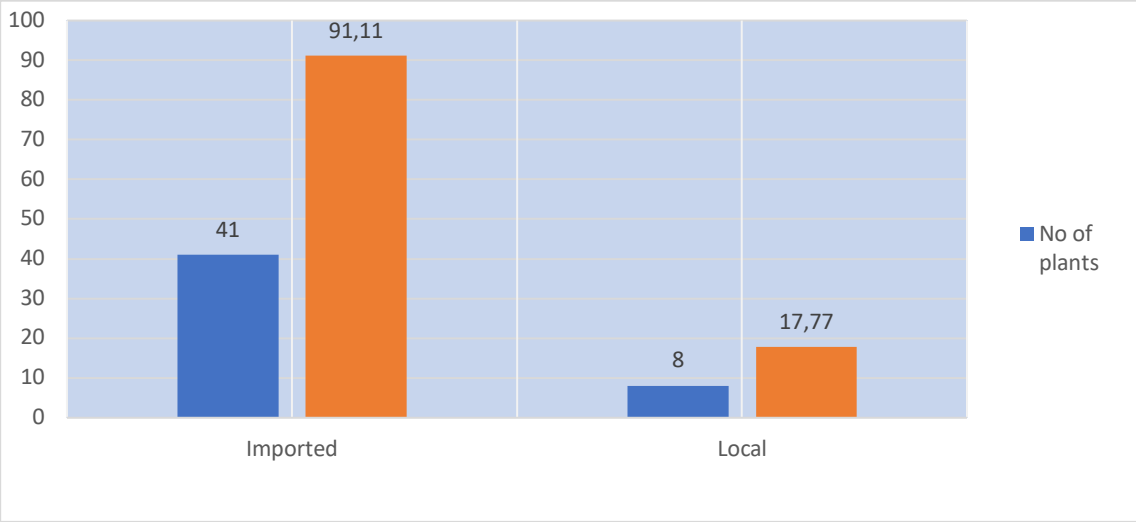

Figure 4. Part used of spice plants in different markets of district Bannu.

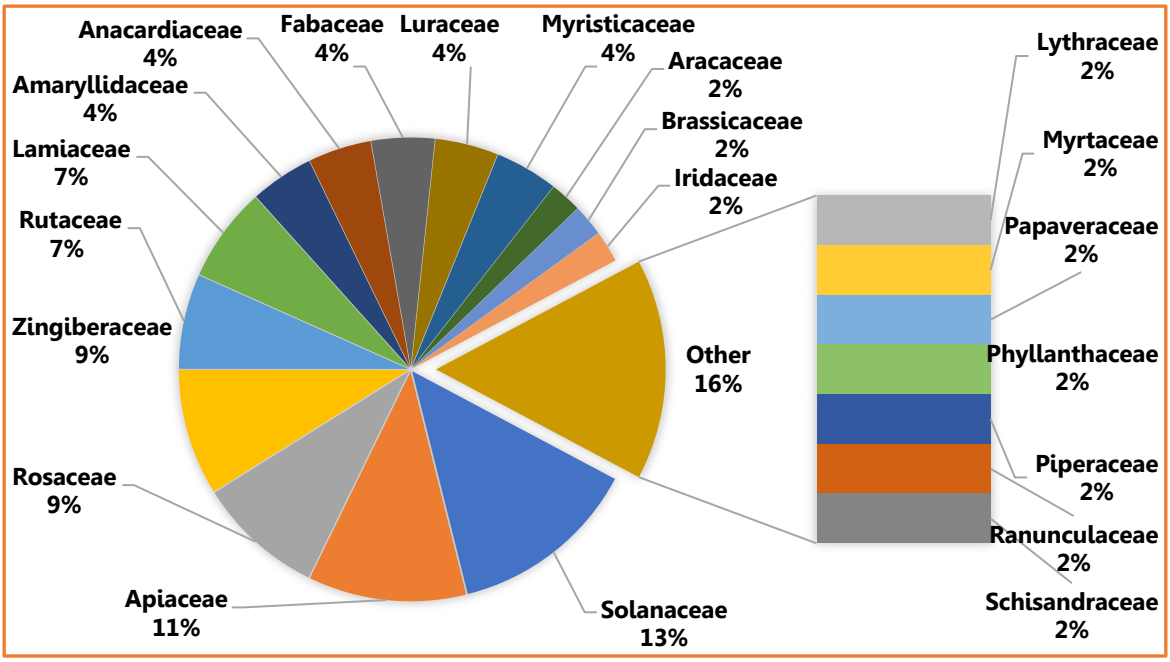

Figure 5. Family distribution of spice plants in different markets of district Bannu.

Quantitative appraisal of medicinal plants

The local uses and importance of spice plants were determined by applying various analytical/statistical techniques such as Relative Frequency of Citation (RFC), Use Report (U_R), Use Value (UV), Cultural Importance Index (CI), Jaccard similarity index (JI) and Informant Consensus Factor (ICF).

Relative Frequency of Citation and Use Report

RFC ranged from 0.16 to 0.82. The maximum RFC value was documented for *Coriandrum sativum* (0.822), trailed by *Papaver somniferum* (0.788) and *Cuminum cyminum, Ocimum basilicum,* and *Piper nigrum* (0.777) each. The lowest value of RFC was documented for *Mangifera indica, Phoenix dactylifera, Tamarindus indica, Crocus sativus,* and *Prunus domestica*. The highest RFC values indicate that amongst the local inhabitants and healers of that area the plants are commonly used. *Coriandrum sativum* (74) had the highest number of use reports, followed by

Papaver somniferum (71), *Cuminum cyminum, Ocimum basilicum,* and *Piper nigrum* (70) each, *Syzygium aromaticum* (67), *Foeniculum vulgare* (66), and *Trachyspermum ammi* (65). The species with least use reports was *Mangifera indica* (14) (Table 2, Figure 6).

Figure 6. Spice taxa commonly utilized in the various markets of district Bannu. **A** and **B**: An interviewing shopkeeper at a spice shop in Masala mandi market. **C**: interviewing herbalist to know about the therapeutic value of spice plants. **D**: Interviewing local dealers about spice marketing. **E**, **F** and **G**: The powdering of various species in the factory for various spice preparation at Laki gate market.

Use Value

UV is used to enumerate or estimate the relative significance of Medicinal plants. In the present work the UV ranged from 0.07-0.78. The maximum UV value was documented for *Coriandrum sativum* (0.783), followed by *Cuminum cyminum* and *Ocimum basilicum* (0.742) each, *Papaver somniferum*, and *Piper nigrum* having (0.732) and (0.712) respectively while the lowest value of UV was documented for *Mangifera indica* (0.07). Other spice plants having high UV involved *Syzygium aromaticum* (0.69), *Foeniculum vulgare* (0.70), and *Trachyspermum ammi* (0.68). The plants having maximum citation have high use report which results in the highest use-value. The use value of plant

species also depends on easy availability, average price, local collection, and ethnopharmacological knowledge (Table 2).

Cultural Importance index

Culture importance index (CI) is used to determine the quality, exclusivity, and intensity of taxa for an ailment, and calculate the amount of consensus amongst participants. In the present work, Cultural Importance (CI) and mean cultural Importance (mCI) of spice plants traded in various markets of district Bannu were calculated. The highest mCI value was documented for Curcuma longa (0.65) trailed by *Coriandrum sativum* (0.63), *Cuminum cyminum, Ocimum basilicum,* and *Papaver somniferum* have (0.57), *Piper nigrum* (0.55) and *Syzygium aromaticum* have (0.51). Plants having the lowest mCI values were *Mangifera indica* (0.04), *Phoenix dactylifera* (0.06), and *Tamarindus indica* (0.07). Few plants are thought to be sacred and are mentioned in holy books such as in Quran (*Allium cepa*, *Ocimum basilicum,* and *Brassica campestris*), and in Bible (*Coriandrum sativum*). Nearly all the spice plants with high CI values were imported except for few species *Curcuma longa* and *Coriandrum sativum* which were also cultivated locally (Table 2).

Cross market assessment

The similarity amongst the four selected markets of district Bannu was calculated by using the Jaccard index (JI). The maximum similarity was 50.00 between Chuk and Masala Mandi markets, followed by Chuk and Laki Gate markets (47.62) and Masala Mandi and Laki Gate markets (45.45). The least Jaccard similarity values were amongst Tanchi and Masala Mandi markets (35.71) (figure 7).

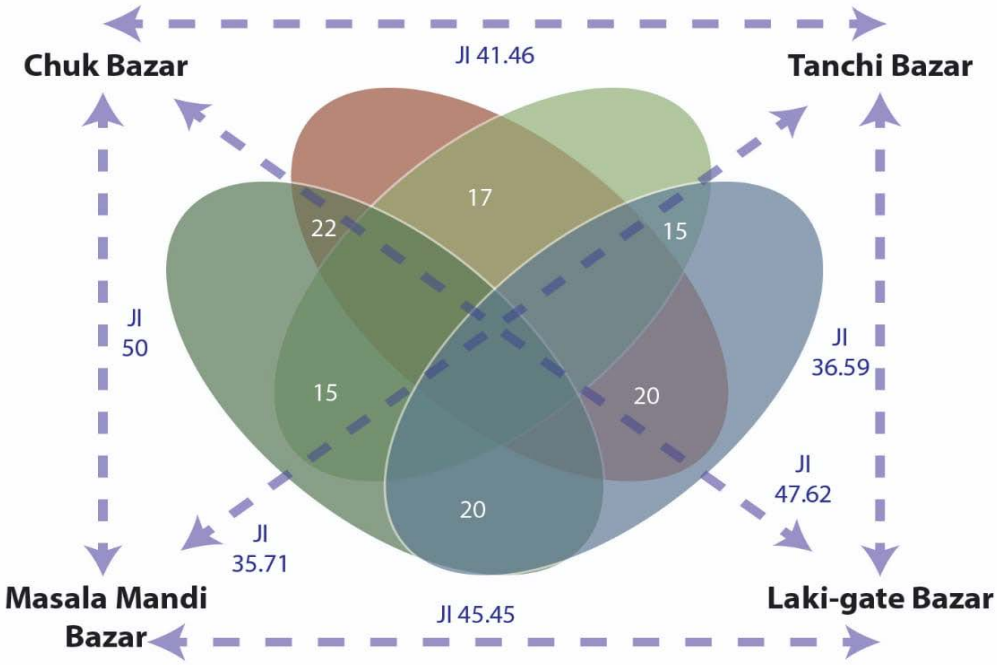

Figure 7. Venn diagram of similarity amongst the selected markets of Bannu.

Informant consensus factor (ICF)

The current study shows that the people of an area used spice plants for many ailments (a total of 87 diseases). An analysis of all ailment groups (13 disease categories) demonstrated high ICF values (0.916-0.989). These high values of ICF indicate that the inhabitants agreed on the usage of species to treat each ailment. Based on the highest Nur (use-report) and Nt (spice taxa) all the ailments were categorized into notable classes or groups. The most important disorders were diabetes, hypertension, infertility, anemia, cough, arthritis, colic pain, sleep disorder, stomachache, hair fall, bone fracture, dermatological and inflammation of joints. The highest ICF value was reported for muscular diseases (ICF-0.989, Nur-98, Nt-2), followed by mouth disorder (ICF-0.985, Nur-72, Nt-2), urinary disorders (ICF-0.982, Nur-115, Nt-3), endocrine disorders (ICF-0.981, Nur-54, Nt-2) and respiratory disorders (ICF-0.980, Nur-252, Nt-6). About 49.0% of all spice plants were used for digestive disorder, followed by general disorder (33.3%), circulatory disorder (16.0%), respiratory disorder (13.3%), skin disorder (11.1%) and skeleton disorder

(9.0%). The research shows that majority of spice plants are used against digestive, general, and circulatory diseases (Table 3).

Table 3. Disease categorization of ailments in a study area by Informant consensus factor (ICF)

Disease category	Reported symptoms or uses	Nur.	% of U_R	Nt.	% of species	Nur - Nt	Nur -1	ICF
Digestive disorders	Carminative, parasiticidal, intestinal worm, diarrhea, flatulence, astringent, astringent, expel tapeworm, flavoring agent, smooth digestion, vomiting, stomachache, and antispasmodic.	483	23.55	22	49.00	461	482	0.956
General disorders	Rheumatism, allergy, fever, insomnia, antiseptic, narcotic, drowsiness, sleep disorder, anodyne, analgesic, antiseptic, inflammation, increase immunity, and pain killer.	414	20.19	15	33.33	399	413	0.966
Circulatory disorders	Hypertension, reduce blood sugar level, anti-cholesterol, chest pain, cardiovascular and heartburn	187	9.12	7	16.00	180	186	0.967
Respiratory disorders	Nasal obstruction, asthma, bronchitis, coughing and bad breath.	252	12.29	6	13.33	246	251	0.980
Skin disorders	Dermatological, irritation, and itching.	116	5.66	5	11.11	111	115	0.965
Skeleton disorders	Bone fracture, hair fall, arthritis, and inflammation of joints.	95	4.63	4	9.00	91	94	0.968
Urinary disorders	Child urination and urinary tract infections.	115	5.61	3	7.00	112	114	0.982
Antimicrobial diseases	Candidiasis, abscess and anti-malarial.	25	1.22	3	7.00	22	24	0.916
Muscular ailments	Colic pain and colic problems.	98	4.78	2	4.44	96	97	0.989
Mouth disorders	Dry mouth and toothache.	72	3.51	2	4.44	70	71	0.985
Nervous disorders	Brain enhancer and brain tonic.	21	1.02	2	4.44	19	20	0.950
Endocrine disorders	Liver disorder and diabetes.	54	2.63	2	4.44	52	53	0.981
Other	Eye problems, reproductive infertility, and azoospermia, anorexia, antitumor and anti-cancer, hypogalactia, sexual failure, and tonic.	119	5.80	7	16.00	112	118	0.950

Discussion

The knowledge about spice plants and medicinal plants is transferred from generation to generation by mutual discussion of local inhabitants of an area which in a time-dependent process (Mahady, 2009; Bond, 2012; Perlin *et al.*, 2020). Nowadays this knowledge is often diminishing due to a declining interest in the younger generation (Carvalho & Morales, 2010; Leonti, 2013; Singh *et al.*, 2017). The current study found that a large quantity of spice plants was consumed in the markets of Bannu for medicinal and food purposes. A total of 45 spice plants were traded in Bannu out of which 35 species were traded in Masala Mandi market, followed by Tanchi Market 34 spice,

Laki Gate market 33 spice plants, and Chuk market with 31 spice plants. In Pakistan, data on the (trade of spice plants) are still very limited. A similar study was carried out in the Swat valley (Khyber Pakhtunkhwa) where a total of twenty medicinal and aromatic plants (MAPs) were traded at the local level and exported to different markets of Pakistan for domestic food consumption and local medicinal purposes (Hussain *et al.*, 2021). (Shah *et al.*, 2020) reported 161 herbal and 3 fungal species traded in various markets of seven districts of Khyber Pakhtunkhwa. (Javed *et al.*, 2020) reported 92 herbal plants traded in various herbal markets of district Rawalpindi (Punjab). (Zougagh *et al.*, 2019) reported 44 medicinal plants traded in various markets of Gulla Khel and Makerwal herbal. In Gilgit-Baltistan 103 herbal plants were traded in various markets (Yebouk *et al.*, 2020). (Salim *et al.*, 2019) reported 231 medicinal plants traded in Gilgit-Baltistan which were used against 208 diseases. In our current study Masala, Mandi market was the whole center/hub for all other markets.

Men showed more knowledge as compared to women, which has its roots in the restrictions imposed on women especially in our society (Muslim society) where women are kept inside specific boundaries (Alqethami *et al.*, 2017; Abbas *et al.*, 2020; Sher *et al.*, 2016). In our study the fruit was the most traded part in contrast to (Shah *et al.*, 2020) who found seeds and leaves were the most traded parts respectively.

Novelty and future perspective

The current study is the first-ever cross markets study on plant utilization for spices and commercialization in four markets of district Bannu, Khyber Pakhtunkhwa as well as the first large scale study focusing on spice plants in Pakistan. The current study showed that the trade and price patterns of spice were found different in the markets of district Bannu.

Conclusion

The current study concluded that the traded spice plants had high therapeutic values and the local people (collectors, healers, local dealers, herbalists, and large-scale dealers) used them for various purposes. In all markets the participants had an average age of over 60 years, while the younger generation showed little interest in traditional practices. The current investigation demonstrates that most spices plants were imported into local markets of Bannu and into Pakistan. As the spice plants are needed in large quantity efforts should be made to increase local cultivation. Preservation and better management of spice plants would be important.

Declarations

Ethics approval and consent to participate: All the participants provided prior informed consent before the interviews.

Consent for publication: All persons shown in Figures agreed to have their pictures taken and published.

Availability of data and materials: Data is available from the first author.

Competing interests: The authors declare that they have no competing interests.

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Author contributions: AAS, LB, MM, SK, MA, AJ and NK conceived the research idea, collected data, analyzed and interpreted the data and drafted the initial manuscript, RWB revised the data analysis, and revised and expanded the manuscript. All authors read and approved the final manuscript.

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