Ethnobotanical importance and conservation status of *Citrullus colocynthis* (L.) Schrad in division Mirpur, Kashmir Himalaya.

Mubsher Mazher, Muhammad Ishtiaq, Bilqeesa Hamid, Shiekh Marifatul Haq, Mussaddaq Mazhar, Faiza Bashir, and Rainer W. Bussmann

Correspondence

Mubsher Mazher[1]*, Muhammad Ishtiaq[1], Bilqeesa Hamid[2], Shiekh Marifatul Haq[3], Mussaddaq Mazhar[1], Faiza Bashir[1], and Rainer W. Bussmann[3,4]

[1]Department of Botany, Mirpur University of Science and Technology (MUST), Mirpur 10250, Azad Jammu and Kashmir (AJK), Pakistan; mubashircheema60@gmail.com (M.M.); drishtiaqbotany@must.edu.pk (M.I.); mussaddaqbiology60@gmail.com (M.M.); scholar.faiza@gmail.com (F.B.)
[2]University of Kashmir Srinagar, Srinagar 190006, India bhatbilqees94@gmail.com (B.H)
[3]Department of Ethnobotany, Institute of Botany, Ilia State University, Tbilisi, Georgia; marifat.edu.17@gmail.com (S.M.H.); rainer.bussmann@iliauni.edu.ge (R.W.B.)
[4]Department of Botany, Institute of Life Sciences, State Museum of Natural History, Karlsruhe, Germany; rainer.bussmann@smnk.de (R.W.B.)

*Corresponding Author: mubashircheema60@gmail.com

Ethnobotany Research and Applications 25:33 (2023) - http://dx.doi.org/10.32859/era.25.33.1-14
Manuscript received: 08/02/2023 – Revised manuscript received: 26/02/2023 - Published: 02/03/2023

Research

Abstract

Background: Citrullus colocynthis (L.) Schrad has been used traditionally for curing ailments in humans and animals in different parts of the world. The current study was conducted to determine the ethnobotanical importance of *C. colocynthis* in division Mirpur, Kashmir Himalaya.

Methods: Twelve well-planned ethnobotanical surveys of the study area were arranged. A total of 118 respondents of varying educational backgrounds, professional affiliations, and age groups were interviewed. Visual appraisal assessment (VAA) and rapid rural appraisal (RRA) methods were used to collect the qualitative and quantitative data.

Results: The plant part value (PPV) indicated that fruit as a whole (PPV=90) and its parts, i.e., rind (PPV=83.33), pulp (PPV=80), and seeds (PPV=90) are mostly used for ethnomedicinal purposes. *C. colocynthis* was found to be most commonly used to treat microbial infections (FL=0.91), diabetes (FL=0.86) and obesity (FL=0.84). The informant agreement ratio (IAR) values indicate that *C. colocynthis* has antidiabetic (IAR=0.96), antilipidemic (IAR=0.91), and antimicrobial (IAR=0.88) potential. The conservation status was calculated to be 1.82, and it was stated that *C. colocynthis* is vulnerable in the study area.

Conclusion: It can be concluded that *C. colocynthis* has been an important ethnomedicinal plant in the study area. It is still in use by farmers, herbalists, nomadic people, and rural people for the treatment of microbial infections,

obesity, constipation, and blood purification. Due to its unchecked utilization, there is severe pressure on its survival, and its conservation is needed immediately.

Keywords: Traditional Ethnomedicines, Mirpur, Conservation Status, *Citrullus colocynthis*

Background

Plants have been used for medicinal purposes since ancient times (Petrovska 2012). Due to better understanding of side effects of synthetic medicines people have become more interested in plant-based medicines (Li *et al.* 2022). Demand for medicinal plants has increased manifold; hence, pressure on these plants has also increased (Caporale *et al.* 2020). Plants have a variety of chemical constituents with a variety of pharmaceutical properties (Amaral *et al.* 2006, Sultana *et al.* 2022). Phytoconstituents are being widely used for the production of pharmaceuticals. Recent research advancements have elaborated that there is no difference between medicine and nutrition (Bussmann *et al.* 2022). Some species of medicinal plants are considered very important for ethnomedicinal as well as commercial purposes; this poses severe pressure on these plant resources, and sustainable utilization of these ethnomedicinal resources is needed (Guo *et al.* 2022). Cattle farming is a common practice in rural areas (Varijakshapanicker *et al.* 2019). Cattle farming can alleviate poverty by providing milk, meat, manure, and lather (Banda & Tanganyika 2021). Healthy cattle give better yield and profits; that is why rural people care for their animals' health and rely mostly upon ethnomedicinal practices (Tabuti *et al.* 2003).

Local communities in Pakistan retain sufficient ethnomedicinal knowledge of local medicinal plants. The people are well aware of the ethnomedicinal uses of a large number of medicinal plants for curing basic ailments (Bibi *et al.* 2022). Indigenous medicinal plants in Kashmir are rich source of medicines, flavor, perfumes, foot, and oils (Haq *et al.,* 2021). The state of Azad Jammu and Kashmir (AJK) has an 82.57% rural population. The rural people of AJK largely depend upon agriculture and small-scale farming of animals (AJK Bureau of Statistics 2021). Rural people in AJK use a large number of medicinal plants for curing asthma, fever, dermatitis, dysentery, constipation, infections, wound healing, epilepsy, diabetes, arthritis, jaundice, cardiovascular disorders, and cancer (Ishtiaq *et al.* 2021, Shaheen *et al.* 2017). Climate change, population explosion, and the growing demand for plants for commercial purposes have caused severe stress on the flora of AJK. If conservation measures are not taken, important medicinal plants will become threatened in this area (Khanam *et al.* 2022).

Citrullus colocynthis (L.) Schrad is a medicinal plant that has been used for numerous medicinal purposes (Hussain *et al.* 2014). *C. colocynthis* is widely distributed in Pakistan (Sultan *et al.* 2010). Different parts of *C. colocynthis* are used for the treatment of diabetes (Drissi *et al.* 2021, Ghauri *et al.* 2020, Lahfa *et al.* 2017), insulinotropic (Nmila *et al.* 2000), hyperglycemia (Amamou *et al.* 2011), constipation (Qureshi *et al.* 2010, Upadhyay *et al.* 2007), hypertension (Eddouks *et al.* 2002), arthritis (Aburjai *et al.* 2007, Marzouk *et al.* 2010), cancer (Chawech *et al.* 2015, Saeed *et al.* 2019), microbial infections (Bourhia *et al.* 2021, Degola *et al.* 2019, Hameed *et al.* 2020), baldness (Qureshi *et al.* 2010), reactive oxygen species (Al-Nablsi *et al.* 2022, Bourhia *et al.* 2021), anti-inflammatory (Bourhia *et al.* 2021, Marzouk *et al.* 2010), and hyperlipidemia (Dallak *et al.* 2011, Daradka *et al.* 2007, Rahbar & Nabipour 2010). Its extracts are given to domestic animals for blood purification (Galván *et al.* 2021), as an antiparasitic medicine (Ahmad *et al.* 2020). Inclusion of its seed can lower blood fat and improve the yield of eggs in commercial layer hens (Alzarah *et al.* 2021). Its fruits are useful to protect the cows from *Fasciola hepatica* (Chawech *et al.* 2017). Extracts of *C. colocynthis* have antiandrogenic ability (Chaturvedi *et al.* 2003). Recently a pesticidal and nematicidal product (NNRC-82) obtained from *C. colocynthis* is registered as a patent (Khatri *et al.* 2021). Medicinal plants in the region of Kashmir also have antidepressant potential (Yousuf *et al.* 2020).

It is important to conserve ethnobotanical knowledge of medicinal plants (Haq & Singh 2020). The study area is a rural area, and most of its population depends on agriculture and cattle farming. In the study area, *C. colocynthis is a* prevalently important medicinal plant, used by farmers, rural people, and herbalists for numerous medicinal purposes. It is being utilized without any conservative measures, due to which this medicinal treasure is under severe threat. The current study sought to determine the ethnomedicinal significance of *C. colocynthis* in three districts of Division Mirpur, AJK, namely Bhimber, Mirpur, and Kotli. It will also find out the conservation status of *C. colocynthis in the* study area. This study is important to highlight the importance of *C. colocynthis* and its conservation.

Materials and Methods

Study area

The state of Azad Jammu and Kashmir comprises only six percent of the state of Jammu and Kashmir. It is located between 73° and 75° N and 32°and 36° E. The total population of the state of AJK is 4.045 million according to the 2017 census (AJK Bureau of Statistics 2021). The total area of Azad Jammu and Kashmir is 13297 km^2. The altitude of the state varies from 360 m to 6325 m above sea level (ASL) in the north. The study area is the plain region, including three southern districts, viz., Bhimber, Mirpur, and Kotli (Akbar 2016). The district of Bhimber is 459 meters above sea level. It is mainly a plain area (Ishtiaq *et al.* 2007). Topography of district Mirpur comprises partly plain and partly hilly areas. It's hot climate and other geographical conditions are ideally suited for agriculture (AJK Bureau of Statistics 2015). District Kotli district is partly plain and partly hilly territory. Its climate is milder than that of Mirpur due to its sub-mountainous terrain (AJK Bureau of Statistics 2015). The study area is rich in floral diversity. Its soil is generally sandy-clay and acidic in nature (Khanum *et al.* 2022).

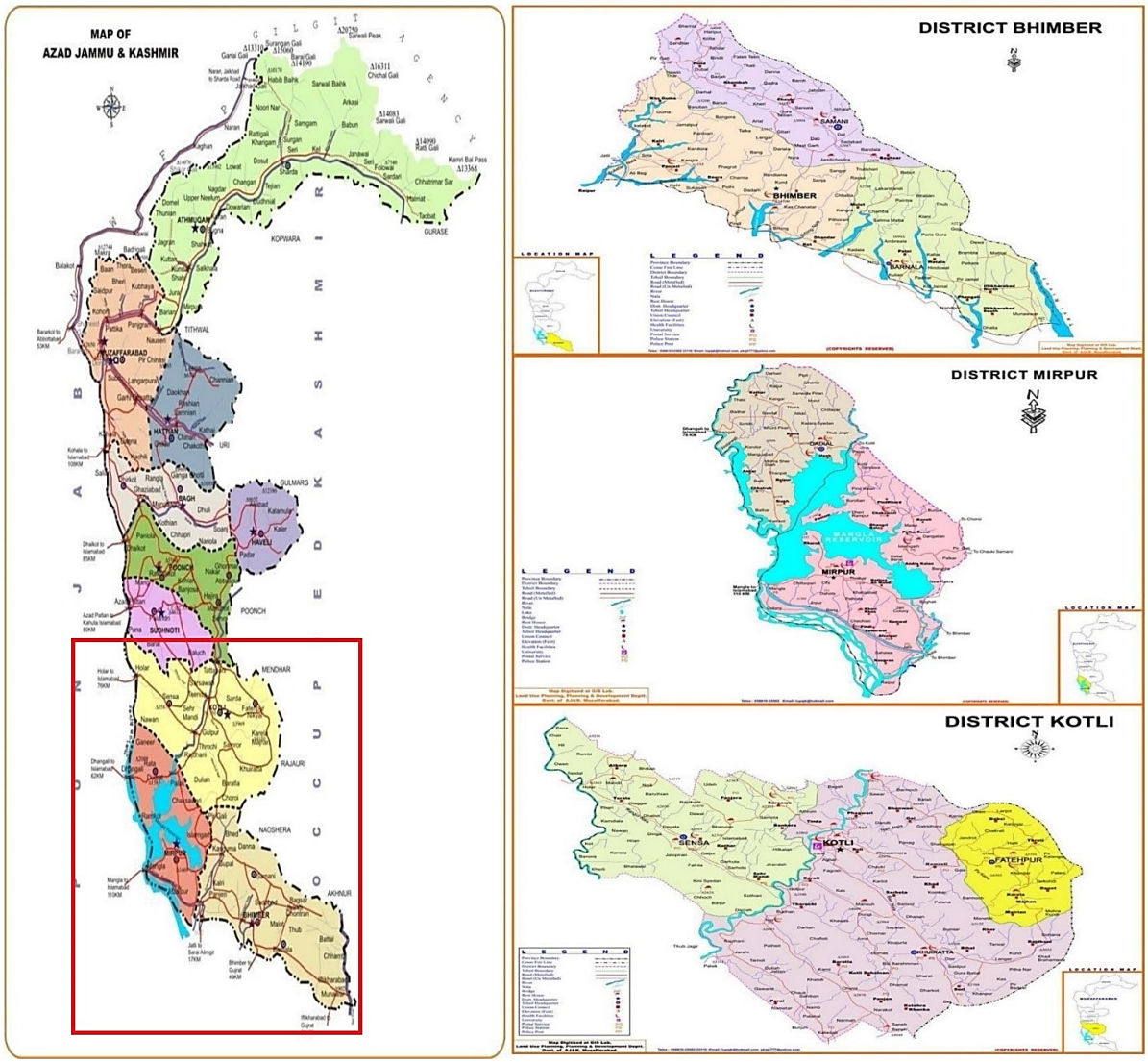

Figure 1. Map of the study area; district Bhimber, Mirpur, and Kotli of Division Mirpur AJK, Pakistan (www.pndajk.gov.pk)

Collection of ethnobotanical data and validation

To collect ethnobotanical data, several field visits were organized. Data were collected by visual appraisal assessment (VAA) and rapid rural appraisal (RRA) methods from August to December 2021. In VAA, researchers visited local herbalists, homeopathic stores, and local farms. Data were collected based on observations and personal evaluation through questionnaire (Haq *et al.* 2022). In the RRA method of data collection, a questionnaire was prepared about the ethnobotanical use of *C. colocynthis* for different ailments. Mostly open-ended questions

were included in the questionnaire. Data were collected from 118 inhabitants. Among the respondents' older people, farmers, teachers, herbalists, herb vendors, nomadic tribes, and shepherds were approached.

Ethical approval for data collection

To collect ethnobotanical data, local and native people were selected. All informants were given a detailed explanation of the interview's purpose and intentions, and their permission was obtained. The principle of "prior informed consent" (PIC) was strictly followed during the interview. Permission for data collection was accorded by the departmental ethical committee (DEC), vide letter no. 137/DEC/BOT/2021 dated July 25, 2021.

Plant collection and identification

Plants were collected in the month of July 2021 from Bhimber 32° 28′ 0″ N (latitude) and 75 ° 6′ 0″ E (longitude), AJK, Pakistan. Plants were identified by Dr. Muhammad Ishtiaq (Ph. D.), Professor, Department of Botany, Mirpur University of Science and Technology (MUST), Mirpur (AJK), Pakistan. Identified herbarium was submitted to herbarium of botany department under reference no. MUST-Bot-MUH-517.

Demographic information of respondents

Overall 34.75% women and 65.25% men were interviewed. The 41 females that were interviewed were also elderly. Our focus was educated and elderly people that have vast experience of traditional uses of medicinal plants. The highest percentage of 51% of respondents was from the age group of 51-60 years. Among the respondents herbalists, herb-vendors, teachers, farmers, shepherds, and nomadic people were approached. Respondents were having varying educational background ranging from illiterate to Masters Level.

Authentication of ethnobotanical data

The data was arranged in tabular form to carry out quantitative ethnobotanical analysis. To validate the gathered data, following ethnobotanical indices were applied.

Plant part value (PPV)

To calculate the importance of different parts of a particular medicinal plant (Chaachouay *et al.* 2019) method was followed. Plant part value (PPV) was calculated by the following formula:

$$PPV = RU/RU_{pp}$$

Here, "RU" represents the total number of uses of a medicinal plant (all of its parts) mentioned by the respondent, and "RU_{pp}" represents the total number of uses of any specific part of the medicinal plant.

Fidelity Level (FL)

From the gathered data, the fidelity level (FL) of *C. colocynthis* for different ailments was calculated following the procedure published by (Friedman *et al.* 1986).

$$FL = I_p / I_u \times 100$$

Here, "I_p" represents the number of respondents who reported specific use of a particular plant, and "I_u" represents the total number of respondents who mentioned the plant for any use.

Informant Agreement Ratio (IAR)

The informant agreement ratio (IAR) was calculated following (Heinrich *et al.* 1998) by the following formula:

$$IAR = N_{ur} - N_t / N_{ur} - 1$$

Here, "N_{ur}" represents the number of uses of a particular medicinal plant for a particular purpose, and "N_t" represents the total number of plants used for a particular purpose.

Assessment of conservation status (CS)

To assess the conservation status (CS) of *C. colocynthis,* questions were asked to respondents about the availability status of this medicinal plant. The CS was calculated using the following formula (Shah *et al.* 2019):

$$CS = K (OC + AV + CE) / TF \times RP$$

Here, "CS" represents conservation status, "K" is a constant valued at one, "OC" is occurrence in a particular site, "AV" is availability, "CE" is conservation efforts, "TF" is threatening factors, and "RP" is reproductive potential. The frequency of occurrence of a particular plant is quantified as one for rare, two for moderate, and three for abundant. Availability is quantified as one for decreasing, two for no change, and three for increasing. Conservation efforts (cultivation, protection from fire, grazing, cutting, fencing, etc.) are quantified as one for each effort made for the conservation of a particular plant. Threatening factors are quantified as zero for no threat, one for negligible, two for moderate, and three for extreme. Reproductive potential is quantified as one for low, two for moderate, and three for extreme.

The result of the conservation equation was used to predict the CS according to the IUCN table. The CS value of 0.1 to 1 is considered critically endangered, 1.1 to 1.5 is considered endangered, 1.6 to 2.0 is considered vulnerable, 2.1 to 2.5 is considered rare, and 2.6 and above is considered least concerning.

Statistical analysis

The demographic data of respondents is expressed as mean ± standard error, calculated by statistical package for social sciences (SSPS 16.0). The data collected by ethnobotanical surveys were analyzed by plant part value (PPV), fidelity level (FL), and informant agreement ratio (IAR). To determine conservation status (CS), means (n = 118) of occurrence (OC), availability (AV), conservation efforts (CE), threatening factors (TF), and reproductive potential (RP) were used.

Results and Discussion

Demographic information about respondents and frequency of citation

Following PIC, 118 respondents were interviewed, and on the basis of the collected data, it was found that male respondents had more information about traditional ethnomedicinal use of *C. colocynthis* as compared to women. Male respondents cited an average of 2.44±0.37 parts and 3.67±0.86 uses of *C. colocynthis,* whereas female respondents cited an average of 1.96±0.26 parts and 2.54±1.12 uses of *C. colocynthis* (Table 1). It was discovered that older people know more about TEMs than younger people. It might be due to advancements in technology and less dependence on traditional medicinal cultures. Herbalists cited the most plant parts (3.51±1.68) and medicinal uses (3.73±1.16) in their profession. Educated people cited fewer TEMs as compared to the illiterate.

Table 1. Demographic information of respondents' and frequency of citation

Indicator	**Distribution of Respondents**		**Frequency of Citation**	
	Number	Percentage	Plant Parts	No. of Uses
Gender				
Female	41	34.75	1.96±0.26	2.54±1.12
Male	77	65.25	2.44±0.37	3.67±0.86
Age in years				
31-40	13	11.02	0.86±0.17	1.34±0.22
41-50	21	17.8	1.58±0.49	2.86±0.71
51-60	68	57.62	2.12±0.45	3.69±1.04
Above 60	16	13.56	2.73±1.28	3.11±0.77
Profession				
Farmer	42	35.59	1.63±0.54	1.92±0.78
Herb Vendor	11	9.32	3.47±1.23	3.26±0.56
Herbalists/Hakeem	6	5.08	3.51±1.68	3.73±1.16
Nomadic	8	6.78	2.27±1.36	3.08±1.3
Shepherd	27	22.88	1.75±0.43	3.19±1.42
Teacher	24	20.34	0.72±0.17	1.55±0.24
Education				

Illiterate	23	19.49	2.41±0.93	4.02±1.71
Primary (1-5)	18	15.25	2.46±1.06	3.83±0.55
Secondary (6-10)	21	17.8	2.01±0.58	3.23±1.12
Intermediate (11-12)	35	29.66	1.96±0.77	2.54±0.19
Bachelors (13-16)	12	10.17	1.29±0.16	1.88±0.37
Higher Education	9	7.63	1.51±0.67	1.09±0.24

Data are expressed as mean ± standard deviation (n = 118).

Validation of the ethnomedicinal importance of *C. colocynthis* in study areas of AJK, Pakistan

Citrullus colocynthis is a native plant of AJK territory, and it is prevalently used in different rural areas. The common uses of *C. colocynthis* in traditional ethnomedicines (TEMs) of AJK have been reported in other parts of the world, u nderlining the validity of traditional knowledge (Table 2).

Table 2. Traditional ethnomedicinal uses of *C. colocynthis* in different villages of the Division Mirpur AJK, Pakistan, and their citation in literature

Disease	Part used	Recipe	Previously reported in the world
Arthritis	Fruit	Paste is applied on joints	(Aburjai *et al.,* 2007; Marzouk *et al.,* 2010)
Baldness	Unripe fruit	Paste is applied	(Qureshi *et al.,* 2010)
Cancer	Fruit or Seeds	Tea or decoction	(Chawech *et al.,* 2015; Saeed *et al.,* 2019)
Constipation	Pulp	Powder is orally taken with water	(Qureshi *et al.,* 2010; Upadhyay *et al.,* 2007)
Dermatitis	Fruit	Paste is applied	None
Diabetes	Fruit and Seeds	Raw seeds or powder of whole fruit is taken orally	(Abo *et al.,* 2008; Abdel-Hassan *et al.,* 2000; Drissi *et al.,* 2021; Eddouks *et al.,* 2002; Ghauri *et al.,* 2020; Huseini *et al.,* 2009; Jayaraman *et al.,* 2009; Lahfa *et al.,* 2017; Oryan *et al.,* 2014)
Hyperlipidemia	Fruit or Seeds	Powder or whole seeds are orally taken.	(Dallak *et al.,* 2011; Daradka *et al.,* 2007; Rahbar and Nabipour, 2010)
Hypertension	Whole fruit	Decoction	(Eddouks *et al.,* 2002)
Inflammation	Fruit and leaves	Poultice is applied	(Aly and Naddaf, 2006; Bourhia *et al.,* 2021; Marzouk *et al.,* 2010; Wasfi *et al.,* 1995)
Microbial infections	Seeds, pulp, or/and rind	Decoction	(Ali *et al.,* 2013; Bourhia *et al.,* 2021; Degola *et al.,* 2019; Hadizadeh *et al.,* 2009; Hameed *et al.,* 2020; Kim *et al.,* 2014; Marzouk *et al.,* 2009)
Obesity	Fruit or its parts	Tea or cooked	(Amamou *et al.,* 2011)
Pest attacks	Whole plant	Aqueous extract is sprayed	(Ahmad *et al.,* 2020; Chawech *et al.,* 2017; Khatri *et al.,* 2021)

Plant Part Value (PPV)

Plant part value (PPV) results indicated that fruit and its parts, i.e., rind, pulp, and seeds, are mostly used by local people for ethnomedicinal as well as ethnoveterinary purposes. The highest PPV was 90 for whole fruit and seeds. Rind and pulp showed the second- and third-highest PPVs of 83.33 and 80, respectively. The leaves, stem, and roots showed PPVs of 26.67, 20, and 6.67, respectively (Figure 2).

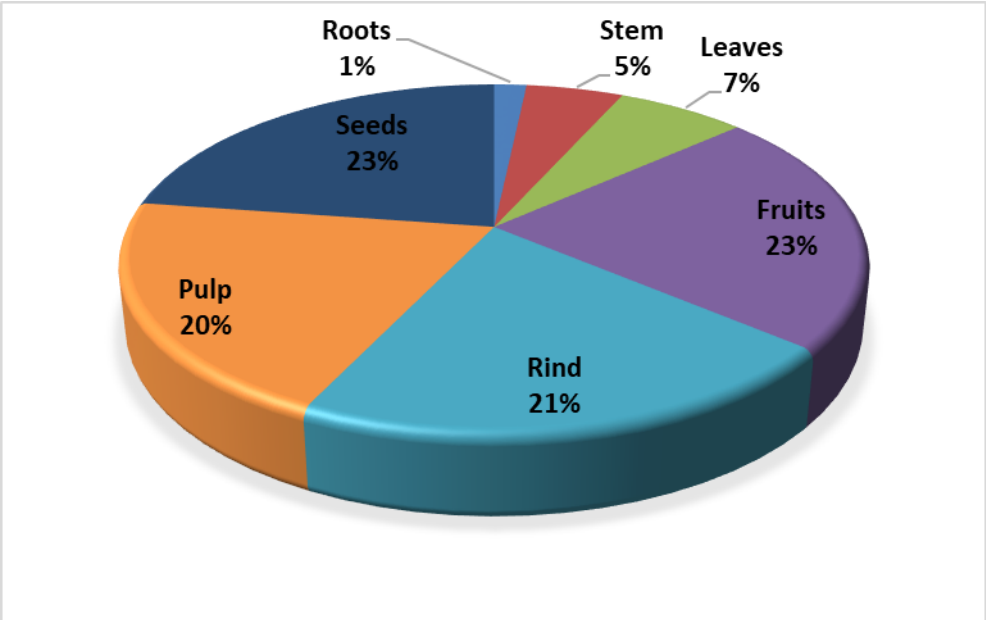

Figure 2. Plant parts value (PPV) estimation of *C. colocynthis*

Fidelity Level (FL)

Data analysis for fidelity level (FL) shows that most commonly, *C. colocynthis* is used for treatment of microbial infections (FL = 0.91), diabetes (FL = 0.86), and obesity (FL = 0.84). Results have shown that *C. colocynthis* is used for the treatment of constipation, hyperlipidemia, inflammation, pest attacks, baldness, cancer, dermatitis, and arthritis (Table 3).

Table 3. Fidelity Level (FL) of different parts of *C. colocynthis* in Division Mirpur AJK, Pakistan

Part of Plant	I_p	I_u	F.L.% = (I_p / I_u) × 100
Arthritis	7	118	0.06
Cancer	19	118	0.16
Constipation	96	118	0.81
Dermatitis	18	118	0.15
Diabetes	101	118	0.86
Hyperlipidemia	87	118	0.74
Hypertension	67	118	0.57
Inflammation	25	118	0.21
Microbial infections	108	118	0.91
Baldness	21	118	0.18
Obesity	99	118	0.84
Pest attacks	21	118	0.18

FL = Fidelity level; I_p = number of respondents who reported specific use; I_u = number of respondents who mentioned the plant for any use

Informant Agreement Ratio (IAR)

The informant agreement ratio (IAR) is an index for measuring the usability of certain plants in the treatment of any particular disease. IAR values of *C. colocynthis* for different diseases depict that the highest IAR value is 0.96

against diabetes (Table 4). The second-highest IAR value was calculated for hyperlipidemia and obesity, i.e., 0.91, which shows the importance of *C. colocynthis* as an antilipidemic agent. The third and fourth highest IAR values were calculated for constipation and antimicrobial activity, which were 0.89 and 0.88, respectively. IAR values indicate that *C. colocynthis* has significant antidiabetic, antilipidemic, antimicrobial, and antioxidant potential.

Table 4. Informant Agreement Ratio (IAR) of *C. colocynthis* for different diseases/ailments in Division Mirpur AJK, Pakistan

Disease	N_t	N_{ur}	N_{ur} - N_t	N_{ur} - 1	IAR = (N_{ur} - N_t) / (N_{ur} - 1)
Arthritis	5	7	2	6	0.33
Baldness	13	21	8	20	0.4
Cancer	17	19	2	18	0.11
Constipation	11	96	85	95	0.89
Dermatitis	8	18	10	17	0.59
Diabetes	5	101	96	100	0.96
Hyperlipidemia	9	87	78	86	0.91
Hypertension	12	67	55	66	0.83
Inflammation	8	25	17	24	0.71
Microbial infections	13	108	95	107	0.88
Obesity	10	99	89	98	0.91
Pest attacks	7	21	14	20	0.7

N_t = All species reported for a disease; N_{ur} = Citation of *C. colocynthis* for this disease

Mode of administration

The results of the ethnobotanical survey indicated that the preparations of *C. colocynthis* used in TEMs include cooked fruits, decoctions in water, ingested parts, applied as paste or poultice, oral intake as powder with water, and tea formation. It was discovered that it is most commonly used as ingested parts (36%), applied paste (22%), or decoction (16%). Details of modes of administration are given in Figure 3.

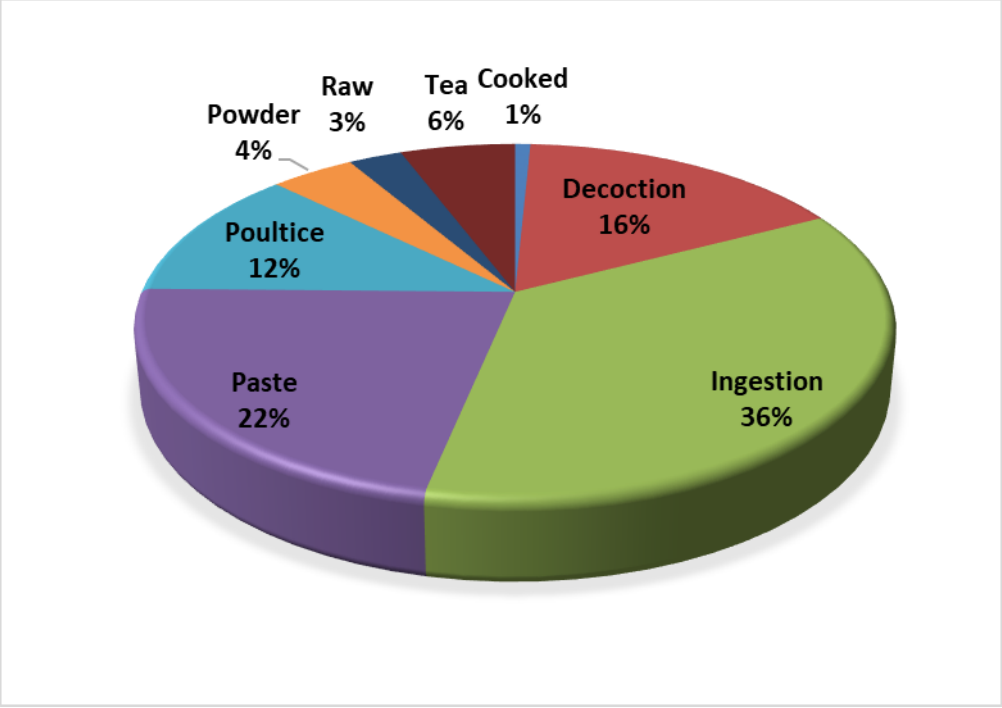

Figure 3. Mode of administration of *C. colocynthis* for the treatment of different diseases

Assessment of conservation status (CS)

Citrullus colocynthis is an important medicinal plant, and its unchecked utilization has threatened its survival in this study area. In this study, we surveyed 20 different villages in the study area and interviewed 118 local people. It was noticed that in 11 villages, *C. colocynthis* has completely vanished from the wild and is being cultivated by farmers for ethno-veterinary uses. *C. colocynthis* was found in the wild only in nine villages. On the basis of the collected data, the mean values for occurrence, availability, conservation efforts, threatening factors, and

reproductive potential were calculated as 1.28, 1.39, 2.05, 1.91, and 0.68, respectively. The conservation status calculated by the formula was found to be 1.82, and it was stated that *C. colocynthis* is considered vulnerable in the study area.

Discussion

In this study, 118 people of various gender, age, profession, and educational background were interviewed. It was found that males had a better understanding of the traditional medicinal uses of *C. colocynthis* as compared to female respondents. It might be due to the fact that males have a direct link with flora and fauna for domestic utilization. The older people reported more uses and mentioned more parts of *C. colocynthis* used for ethnomedicinal purposes. It clearly depicts that knowledge of ethnomedicinal uses of medicinal plants is being corroded in the study area. The results of our research are similar to previously reported ethnobotanical studies in the study area (Khanum *et al.* 2022). Thirty different uses of *C. colocynthis* were cited by respondents, out of which only 12 uses were cited by more than one respondent. All 12 ethnomedicinal uses of *C. colocynthis* in the study area were also found in previously published literature, except the treatment of dermatitis. The results of this research are in accordance with (Meena *et al.* 2014), who cited 39 uses of *C. colocynthis* in Rajasthan, India. Most of the uses cited in this study were also cited by respondents of previous research. On the basis of the findings of the ethnomedicinal survey and literature review, the ethnomedicinal uses of *C. colocynthis* in the study area are valid.

The quantitative analysis of ethnobotanical data by plant part value showed that the most important parts of *C. colocynthis* are its fruit and seeds. The published literature also cites fruit and seeds as having tremendous ethnomedicinal value, as documented by Hussain *et al.* (2014). The phytochemical analysis of fruit and seeds depicts that all the active ingredients in *C. colocynthis* are found in these parts (Khatri *et al.* 2021). The values of fidelity level and informant agreement ratio indicated that *C. colocynthis* is mostly used for the treatment of microbial infections, obesity, hyperlipidemia, diabetes, and cancer. Previously Rahimi *et al.* (2012) and Li *et al.* (2022) have documented that in traditional Iranian medicinal (TIM) culture, *C. colocynthis* was used for the treatment of diabetes, microbial infections, hyperlipidemia, and digestive system disorders.

Citrullus colocynthis is an important medicinal plant in the study area. It is used for the treatment of several ailments in humans and cattle. Due to its great ethnomedicinal properties and extensive use by farmers, shepherds, and nomadic people, there is a great pressure on its survival in the study area. The conservation status of *C. colocynthis* was found to be vulnerable in the study area. Similar results have been reported by Ishtiaq *et al.* (2021) for several medicinal plants including *C. colocynthis* in the study area. Results of our study have found that *C. colocynthis* is an important medicinal plant in the study area. Recently, in the neighboring area, a study was carried out by Munir *et al.* (2022), who also found that *C. colocynthis* has a relative importance of 0.81 as an ethnomedicinal plant. Similar results for important medicinal plants in the region of Kashmir have been reported by Mir *et al.* (2021). They have reported 19% plants are endangered and 6% plants are vulnerable in Ladakh, Kashmir.

Conclusion

It can be concluded that *C. colocynthis* is a restorative plant. The fruits, rind, pulp, and seeds are its important parts. *C. colocynthis* is mostly used for the treatment of microbial infections, diabetes, obesity, and hyperlipidemia. *C. colocynthis* is vulnerable in the study area, and immediate conservative measures should be taken to save this medicinal plant.

Declarations

Abbreviations: CS: Conservation Status; FL: Fidelity Level; IAR: Informant Agreement Ratio; PPV: Plant Part Value; TEMs: Traditional Ethnomedicines.

Ethics approval and consent to participate: Prior informed consent (PIC) was obtained from all the respondents. The author belongs to the same locality and is well aware of the ethics and regulations of the community, so all the respondents answered the questions in the questionnaire with full confidence.

Consent for publication: The manuscript does not contain any individual person's data.

Availability of data and materials: Requests for data can be directed to the first author.

Funding: The study did not receive any funding.

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

Authors' contributions: Mubsher Mazher conceptualized the work, arranged surveys and wrote the initial manuscript. Muhammad Ishtiaq supervised the work, identified the plant and revised the manuscript. Mussaddaq Mazhar helped in data collection and recording answers of the respondents. Shiekh Marifatul Haq, Bilqeesa Hamid,

Faiza Bashir and Rainer W. Bussmann thoroughly revised the draft manuscript. All authors read and approved the final manuscript.

Literature Cited

Abdel-Hassan IA, Abdel-Barry JA, Mohammeda ST. 2000. The hypoglycaemic and antihyperglycaemic effect of *Citrullus colocynthis* fruit aqueous extract in normal and alloxan diabetic rabbits. Journal of Ethnopharmacology 71(1-2):325-30. doi: 10.1016/S0378-8741(99)00215-9

Abo KA, Fred-Jaiyesimi AA, Jaiyesimi AE. 2008. Ethnobotanical studies of medicinal plants used in the management of diabetes mellitus in Southwestern Nigeria. Journal of Ethnopharmacology 115(1):67-71. doi: 10.1016/j.jep.2007.09.005

Aburjai T, Hudaib M, Tayyem R, Yousef M, Qishawi M. 2007. Ethnopharmacological survey of medicinal herbs in Jordan, the Ajloun Heights region. Journal of Ethnopharmacology 110(2):294-304. doi: 10.1016/j.jep.2006.09.031

Ahmed M, Qin P, Ji M, An R, Guo H, Shafi J. 2020. Spinasterol, 22, 23-Dihydrospinasterol and fernenol from *Citrullus Colocynthis* L. with aphicidal activity against cabbage aphid *Brevicoryne brassicae* L. Molecules 25(9):2184. doi: 10.3390/molecules25092184

Akbar KF. 2017. Potential impacts of climate change on plant diversity of hilly areas of Azad Kashmir and their mitigation: a review. Journal of Mountain Area Research 2:37-44. doi: 10.53874/jmar.v2i0.24

Ali AA, Alian MA, Elmahi HA. 2013. Phytochemical analysis of some chemical metabolites of Colocynth plant (*Citrullus colocynthis* L.) and its activities as antimicrobial and antiplasmidial. Journal of Basic and Applied Scientific Research 3:228-236.

Al-Nablsi S, El-Keblawy A, Ali MA, Mosa KA, Hamoda AM, Shanableh A, Almehdi AM, Soliman SS. 2022. Phenolic Contents and Antioxidant Activity of *Citrullus colocynthis* Fruits, Growing in the Hot Arid Desert of the UAE, Influenced by the Fruit Parts, Accessions, and Seasons of Fruit Collection. Antioxidants 11(4):656. doi: 10.3390/antiox11040656

Aly AM, Naddaf A. 2006. Anti-inflammatory activities of Colocynth topical gel. Journal of Medical Sciences 6:216-221.

Alzarah MI, Alaqil AA, Abbas AO, Nassar FS, Mehaisen GM, Gouda GF, Abd El-Atty HK, Moustafa ES. 2021. Inclusion of *Citrullus colocynthis* seed extract into diets induced a hypolipidemic effect and improved layer performance. Agriculture 11(9):808. doi: 10.3390/agriculture11090808

Amamou F, Bouafia M, Chabane-Sari D, Meziane RK, Nani A. 2011. *Citrullus colocynthis*: a desert plant native in Algeria, effects of fixed oil on blood homeostasis in Wistar rat. Journal of Natural Product and Plant Resources 1:1-7.

Amaral FM, Ribeiro MN, Barbosa-Filho JM, Reis AS, Nascimento FR, Macedo RO. 2006. Plants and chemical constituents with giardicidal activity. Revista Brasileira de Farmacognosia 16:696-720.

Azad Jammu and Kashmir at a glance-2015. 2015. Bureau of Statistics, Planning and Development Department, Government of the state of Azad Jammu and Kashmir.

Azad Jammu and Kashmir at a glance-2021. 2021. Bureau of Statistics, Planning and Development Department, Government of the state of Azad Jammu and Kashmir.

Banda LJ, Tanganyika J. 2021. Livestock provide more than food in smallholder production systems of developing countries. Animal Frontiers 11(2):7-14. doi: 10.1093/af/vfab001

Benariba N, Djaziri R, Bellakhdar W, Belkacem N, Kadiata M, Malaisse WJ, Sener A. 2013. Phytochemical screening and free radical scavenging activity of *Citrullus colocynthis* seeds extracts. Asian Pacific Journal of Tropical Biomedicine 3(1):35-40. doi: 10.1016/S2221-1691(13)60020-9

Bibi F, Abbas Z, Harun N, Perveen B, Bussmann RW. 2022. Indigenous knowledge and quantitative ethnobotany of the Tanawal area, Lesser Western Himalayas, Pakistan. PloS one. 17(2):e0263604. doi: 10.1371/journal.pone.0263604

Bourhia M, Bouothmany K, Bakrim H, Hadrach S, Salamatullah AM, Alzahrani A, Khalil Alyahya H, Albadr NA, Gmouh S, Laglaoui A, El Mzibri M. 2021. Chemical profiling, antioxidant, antiproliferative, and antibacterial potentials of chemically characterized extract of *Citrullus colocynthis* L. seeds. Separations 8(8):114. doi: 10.3390/separations8080114

Bussmann RW, Paniagua-Zambrana NY. 2022. Ethnobotany in the Andes and the Amazon in a world of Nagoya Protocol and post SARS-CoV-2 pandemic. Botany 100(2):97-108. doi: 10.1139/cjb-2021-0062

Caporale F, Mateo-Martín J, Usman MF, Smith-Hall C. 2020. Plant-based sustainable development—the expansion and anatomy of the medicinal plant secondary processing sector in Nepal. Sustainability 12(14):5575. doi: 10.3390/su12145575

Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, Zidane L. 2019. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. Heliyon 5(10):e02191. doi: 10.1016/j.heliyon.2019.e02191

Chaturvedi M, Mali PC, Ansari AS. 2003. Induction of reversible antifertility with a crude ethanol extract of *Citrullus colocynthis* Schrad fruit in male rats. Pharmacology 68(1):38-48. doi: 10.1159/000068727

Chawech R, Jarraya R, Girardi C, Vansteelandt M, Marti G, Nasri I, Racaud-Sultan C, Fabre N. 2015. Cucurbitacins from the leaves of *Citrullus colocynthis* (L.) Schrad. Molecules 20(10):18001-15. doi: 10.3390/molecules201018001

Dallak M. 2011. In vivo, hypolipidemic and antioxidant effects of *Citrullus colocynthis* pulp extract in alloxan-induced diabetic rats. African Journal of Biotechnology 10:9898-9903.

Daradka H, Almasad MM, WSh Q, El-Banna NM, Samara OH. 2007. Hypolipidaemic effects of *Citrullus colocynthis* L. in rabbits. Pakistan Journal of Biological Sciences 10(16):2768-71. doi: 10.3923/pjbs.2007.2768.2771

Degola F, Marzouk B, Gori A, Brunetti C, Dramis L, Gelati S, Buschini A, Restivo FM. 2019. *Aspergillus flavus* as a model system to test the biological activity of botanicals: An example on *Citrullus colocynthis* L. schrad. organic extracts. Toxins 11(5):286.

Drissi F, Lahfa F, Gonzalez T, Peiretti F, Tanti JF, Haddad M, Fabre N, Govers R. 2021. A *Citrullus colocynthis* fruit extract acutely enhances insulin-induced GLUT4 translocation and glucose uptake in adipocytes by increasing PKB phosphorylation. Journal of Ethnopharmacology 270:113772. doi: 10.1016/j.jep.2020.113772

Eddouks M, Maghrani M, Lemhadri A, Ouahidi ML, Jouad H. 2002. Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-east region of Morocco (Tafilalet). Journal of Ethnopharmacology 82(2-3):97-103. doi: 10.1016/S0378-8741(02)00164-2

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1986. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. Journal of Ethnopharmacology 16(2-3):275-287. doi: 10.1016/0378-8741(86)90094-2

Galván DC, Olvera ETM, Martínez GD, Gloria TA, Hernández GPA, Espinosa AE, Palacios MM, Lara BA, Mendoza MGD, Velázquez CLA. 2021. Influence of a polyherbal mixture in dairy calves: growth performance and gene expression. Frontiers in Veterinary Science 2021:1217. doi: 10.3389/fvets.2020.623710

Ghauri AO, Ahmad S, Rehman T. 2020. In vitro and in vivo anti-diabetic activity of *Citrullus colocynthis* pulpy flesh with seeds hydro-ethanolic extract. Journal of Complementary and Integrative Medicine 17(2). doi: 10.1515/jcim-2018-0228

Guo CA, Ding XY, Addi YW, Zhang Y, Zhang XQ, Zhuang HF, Wang YH. 2022. An ethnobotany survey of wild plants used by the Tibetan people of the Yadong River Valley, Tibet, China. Journal of Ethnobiology and Ethnomedicine 18(1):1-25. doi: 10.1186/s13002-022-00518-8

Hadizadeh I, Peivastegan B, Kolahi M. 2009. Antifungal activity of nettle (*Urtica dioica* L.), colocynth (*Citrullus colocynthis* L. Schrad), oleander (*Nerium oleander* L.) and konar (*Ziziphus spina-christi* L.) extracts on plants pathogenic fungi. Pakistan Journal of Biological Sciences 12(1):58-63. doi: 10.3923/pjbs.2009.58.63

Hameed B, Ali Q, Hafeez MM, Malik A. 2020. Antibacterial and antifungal activity of fruit, seed and root extracts of *Citrullus colocynthis* plant. Biological and Clinical Sciences Research Journal 2020(1). doi: 10.54112/bcsrj.v2020i1.33

Haq SM, Hassan M, Bussmann RW, Calixto ES, Rahman IU, Sakhi S, Ijaz F, Hashem A, Al-Arjani ABF, Almutairi KF, Abd_Allah EF. 2022. A cross-cultural analysis of plant resources among five ethnic groups in the Western Himalayan region of Jammu and Kashmir. Biology 11(4):491. doi: 10.3390/biology11040491

Haq SM, Singh B. 2020. Ethnobotany as a science of preserving traditional knowledge: Traditional uses of wild medicinal plants from District Reasi, J&K (Northwestern Himalaya), India. Botanical Leads for Drug Discovery 277-293.

Haq SM, Yaqoob U, Calixto ES, Rahman IU, Hashem A, Abdullah EF, Alakeel MA, Alqarawi AA, Abdalla M. Hassan M, Bussmann RW. 2021. Plant resources utilization among different ethnic groups of Ladakh in Trans-Himalayan Region. Biology 10(9):827. doi: 10.3390/biology10090827

Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 1998. Medicinal plants in Mexico: Healers' consensus and cultural importance. Social Science and Medicine 47(11):1859-1871. doi: 10.1016/S0277-9536(98)00181-6

Huseini HF, Darvishzadeh F, Heshmat R, Jafariazar Z, Raza M, Larijani B. 2009. The clinical investigation of *Citrullus colocynthis* (L.) schrad fruit in treatment of Type II diabetic patients: a randomized, double blind, placebo-controlled clinical trial. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives 23(8):1186-1189. doi: 10.1002/ptr.2754

Hussain AI, Rathore HA, Sattar MZ, Chatha SA, Sarker SD, Gilani AH. 2014. *Citrullus colocynthis* (L.) Schrad (bitter apple fruit): A review of its phytochemistry, pharmacology, traditional uses and nutritional potential. Journal of Ethnopharmacology 155(1):54-66.

Ishtiaq M, Bhatti KH, Hussain I, Maqbool M, Hussain T, Mushtaq W, Ghani A, Azeem M, Khan SM, Thind S. 2021. Inventorization of traditional ethnobotanical uses of wild plants of Dawarian and Ratti Gali areas of District Neelum, Azad Jammu and Kashmir Pakistan. PLoS one 16(7):e0255010.

Ishtiaq M, Hanif W, Khan MA, Ashraf M, Butt AM. 2007. An ethnomedicinal survey and documentation of important medicinal folklore food phytonims of flora of Samahni valley,(Azad Kashmir) Pakistan. Pakistan Journal of Biological Sciences 10(13):2241-2256. doi: 10.3923/pjbs.2007.2241.2256

Ishtiaq M, Maqbool M, Ajaib M, Ahmed M, Hussain I, Khanam H, Mushtaq W, Hussain T, Azam S, Hayat Bhatti K, Ghani A. 2021. Ethnomedicinal and folklore inventory of wild plants used by rural communities of valley Samahni, District Bhimber Azad Jammu and Kashmir, Pakistan. Plos one 16(1):e0243151. doi: 10.1371/journal.pone.0243151

Jayaraman R, Shivakumar A, Anitha T, Joshi VD, Palei NN. 2009. Anti-diabetic effect of petroleum ether extract of *Citrullus colocynthis* fruits against streptozotocin-induced hyperglycemic rats. Romanian Journal of Biology - Plant Biology 54:127-134.

Khanum H, Ishtiaq M, Bhatti KH, Hussain I, Azeem M, Maqbool M, Hussain T, Mushtaq W, Thind S, Bashir R, Muzamil M. 2022. Ethnobotanical and conservation studies of tree flora of Shiwalik mountainous range of District Bhimber Azad Jammu and Kashmir, Pakistan. PloS one 17(2):e0262338. doi: 10.1371/journal.pone.0262338

Khatri S, Faizi S, Fayyaz S, Iqbal E. 2021. *Citrullus colocynthis*: A Treasure of Phytochemical, Pharmacological, Pesticidal and Nematicidal Compounds. Pakistan Journal of Nematology 39(2).

Kim MG, Lee SE, Yang JY, Lee HS. 2014. Antimicrobial potentials of active component isolated from *Citrullus colocynthis* fruits and structure activity relationships of its analogues against foodborne bacteria. Journal of the Science of Food and Agriculture 94(12):2529-33. doi: 10.1002/jsfa.6590

Kumar S, Kumar D, Saroha K, Singh N, Vashishta B. 2008. Antioxidant and free radical scavenging potential of *Citrullus colocynthis* (L.) Schrad. methanolic fruit extract. Acta Pharmaceutica 58(2):215-220. doi: 10.2478/v10007-008-0008-1

Lahfa FB, Azzi R, Mezouar D, Djaziri R. 2017. Hypoglycemic effect of *Citrullus colocynthis* extracts. Phytothérapie 15(2):50-56. doi: 10.1007/s10298-015-0997-4

Li QY, Munawar M, Saeed M, Shen JQ, Khan MS, Noreen S, Alagawany M, Naveed M, Madni A, Li CX. 2022. *Citrullus colocynthis* (L.) Schrad (Bitter Apple Fruit): Promising traditional uses, pharmacological effects, aspects, and potential applications. Frontiers in Pharmacology 12:3848.

Li QY, Munawar M, Saeed M, Shen JQ, Khan MS, Noreen S, Alagawany M, Naveed M, Madni A, Li CX. 2022. *Citrullus colocynthis* (L.) Schrad (Bitter Apple Fruit): Promising traditional uses, pharmacological effects, aspects, and potential applications. Frontiers in Pharmacology 12:3848.

Marzouk B, Marzouk Z, Décor R, Edziri H, Haloui E, Fenina N, Aouni M. 2009. Antibacterial and anticandidal screening of Tunisian *Citrullus colocynthis* Schrad. from Medenine. Journal of Ethnopharmacology 125(2):344-349. doi: 10.1016/j.jep.2009.04.025

Marzouk B, Marzouk Z, Haloui E, Fenina N, Bouraoui A, Aouni M. 2010. Screening of analgesic and anti-inflammatory activities of *Citrullus colocynthis* from southern Tunisia. Journal of Ethnopharmacology 128(1):15-19. doi: 10.1016/j.jep.2009.11.027

Meena MC, Meena RK, Patni V. 2014. Ethnobotanical studies of *Citrullus colocynthis* (Linn.) Schrad. An important threatened medicinal herb. Journal of Medicinal Plants 2(2):15-22.

Mir AY, Yaqoob U, Hassan M, Bashir F, Zanit SB, Haq SM, Bussmann RW. 2021. Ethnopharmacology and phenology of high-altitude medicinal plants in Kashmir, Northern Himalaya. Ethnobotany Research and Applications 22:1-15.

Nmila R, Gross R, Rchid H, Roye M, Manteghetti M, Petit P, Tijane M, Ribes G, Sauvaire Y. 2000. Insulinotropic effect of *Citrullus colocynthis* fruit extracts. Planta Medica 66(05):418-423. doi: 10.1055/s-2000-8586

Oryan A, Hashemnia M, Hamidi AR, Mohammadalipour A. 2014. Effects of hydroethanol extract of *Citrullus colocynthis* on blood glucose levels and pathology of organs in alloxan-induced diabetic rats. Asian Pacific Journal of Tropical Disease 4(2):125-130. doi: 10.1016/S2222-1808(14)60328-5

Petrovska BB. 2012. Historical review of medicinal plants' usage. Pharmacognosy reviews 6(11):1.

Qureshi R, Bhatti GR, Memon RA. 2010. Ethnomedicinal uses of herbs from northern part of Nara desert, Pakistan. Pakistan Journal of Botany 42(2):839-851.

Rahbar AR, Nabipour I. 2010. The hypolipidemic effect of *Citrullus colocynthis* on patients with hyperlipidemia. Pakistan Journal of Biological Sciences 13(24):1202-7. doi: 10.3923/pjbs.2010.1202.1207

Rahimi R, Amin G, Ardekani MR. 2012. A review on *Citrullus colocynthis* Schrad.: from traditional Iranian medicine to modern phytotherapy. The Journal of Alternative and Complementary Medicine 18(6):551-554. doi: 10.1089/acm.2011.0297

Rizvi TS, Khan AL, Ali L, Al-Mawali N, Mabood F, Hussain J, Adnan M, Al-Harrasi A. 2018. In vitro oxidative stress regulatory potential of *Citrullus colocynthis* and *Tephrosia apollinea*. Acta Pharmaceutica 68(2):235-242. doi: 10.2478/acph-2018-0012

Saeed ME, Boulos JC, Elhaboub G, Rigano D, Saab A, Loizzo MR, Hassan LE, Sugimoto Y, Piacente S, Tundis R, Yagi S. 2019. Cytotoxicity of cucurbitacin E from *Citrullus colocynthis* against multidrug-resistant cancer cells. Phytomedicine 62:152945.

Shah AH, Mehmood A, Farooq M, Khan KR, Nawab B, Hussain M, Zohra L, Khan SM, Ahmad H. 2019. A new quantitative Ethnoecological approach to assessing the conservation status of plants: a case study of district Tor Ghar, Pakistan. Applied Ecology and Environmental Research 17(5):10399-10419. http://dx.doi.org/10.15666/aeer/1705_1039910419

Shaheen H, Qaseem MF, Amjad MS, Bruschi P. 2017. Exploration of ethno-medicinal knowledge among rural communities of Pearl Valley; Rawalakot, District Poonch Azad Jammu and Kashmir. PLoS one 12(9):e0183956. doi: 10.1371/journal.pone.0183956

Sultan A, Khan FU, Iqbal H, Khan MA, Khan IU. 2010. Evaluation of chemical analysis profile of *Citrullus colocynthis* growing in southern areas of Khyber Pukhtunkhwa Pakistan. World Applied Sciences Journal 10(4):402-405.

Sultana A, Hossain MJ, Kuddus MR, Rashid MA, Zahan MS, Mitra S, Roy A, Alam S, Sarker MM, Naina Mohamed I. 2022. Ethnobotanical Uses, Phytochemistry, toxicology, and pharmacological properties of *Euphorbia neriifolia* Linn. against infectious diseases: A comprehensive review. Molecules 27(14):4374. doi: 10.3390/molecules27144374

Tabuti JR, Dhillion SS, Lye KA. 2003. Ethnoveterinary medicines for cattle (*Bos indicus*) in Bulamogi county, Uganda: plant species and mode of use. Journal of Ethnopharmacology 88(2-3):279-286. doi: 10.1016/S03788741(03)00265-4

Tannin-Spitz T, Bergman M, Grossman S. 2007. Cucurbitacin glucosides: Antioxidant and free-radical scavenging activities. Biochemical and Biophysical Research Communications 364(1):181-186. doi: 10.1016/j.bbrc.2007.09.075

Upadhyay B, Roy S, Kumar A. 2007. Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India. Journal of Ethnopharmacology 113(3):387-399. doi: 10.1016/j.jep.2007.06.010

Varijakshapanicker P, Mckune S, Miller L, Hendrickx S, Balehegn M, Dahl GE, Adesogan AT. 2019. Sustainable livestock systems to improve human health, nutrition, and economic status. Animal Frontiers 9(4):39-50. doi: 10.1093/af/vfz041

Wasfi IA, Bashir AK, Abdalla AA, Banna NR, Tanira MO. 1995. Antiinflammatory activity of some medicinal plants of the United Arab Emirates. International Journal of Pharmacognosy 33(2):124-128. doi: 10.3109/13880209509055211

Yousuf S, Haq SM, Rasool A, Zulfajri M, Hanafiah MM, Nafees H, Tasneem S, Mahboob M. 2020. Evaluation of antidepressant activity of methanolic and hydroalcoholic extracts of *Acorus calamus* L. rhizome through tail suspension test and forced swimming test of mice. Journal of Traditional Chinese Medical Sciences 7(3):301-307. doi: 10.1016/j.jtcms.2020.07.002