



Ethnobotanical survey and therapeutic ranking of medicinal plants in Muzaffargarh, Pakistan: From traditional use to research priority

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Research

Abstract

Background: The use of medicinal plants in Muzaffargarh, Pakistan, remains poorly documented. This study systematically investigates and ranks the medicinal plants used by local communities, highlighting their therapeutic significance.

Methods: A structured ethnobotanical survey was conducted with 79 informants across 40 communities, using semi-structured interviews and direct field observations. The Garrett ranking technique was applied to priorities medicinal plants by perceived efficacy. Ethnobotanical indices were used to assess the significance of plants.

Results: Seventy-nine informants across Muzaffargarh District documented 75 medicinal plant species from 43 families. Quantitative ethnobotanical analysis using the Garrett-ranking technique identified *Nigella sativa* as the highest-ranked species, indicating strong community consensus for its use in metabolic and cardiovascular disorders. *Zingiber officinale* and *Trigonella foenum-graecum* were highly prioritized, reflecting their frequent use for digestive and metabolic health, while *Moringa oleifera* ranked among the top species for its perceived role in immune support and overall wellness. Decoction was the most commonly reported preparation method, followed by infusion, maceration, and powdered forms, with oral administration predominating. A statistically significant correlation ($p < 0.05$) was observed between the Relative Frequency of Citation and the Fidelity Level, indicating consistency between use frequency and perceived therapeutic specificity.

Conclusions: The findings highlight the ethnopharmacological potential of these species, emphasizing the need for phytochemical validation and pharmacological studies. This study presents the first Garrett-ranked ethnobotanical assessment of medicinal plants in Muzaffargarh. These findings contribute to the preservation of traditional knowledge in Muzaffargarh District while emphasizing the need for careful validation of their efficacy and safety.

Keywords: Ethnobotany, Ethnopharmacology, Medicinal plants, Muzaffargarh, Traditional knowledge.

Background

Ethnobotany plays a crucial role in preserving indigenous knowledge and identifying medicinal plants with therapeutic potential. Traditional medicine remains the primary healthcare option for over 80% of the global population, particularly in resource-limited regions (Shewamene *et al.* 2021; Sibanda *et al.* 2016). Notably, nearly 25% of modern pharmaceuticals originated from traditional plant-based extracts (Hussain *et al.* 2023), highlighting the relevance of ethnobotanical knowledge to contemporary drug discovery. These include acetylsalicylic acid, digoxin, morphine, and quinine, which are derived from bioactive compounds such as flavonoids, glycosides, polyphenols, tannins, anthocyanins, carotenoids, saponins, and catechins (Ullah *et al.* 2024; Okoduwa *et al.* 2024a). It is estimated that over 50,000 species of flowering plants (angiosperms) are used globally in traditional medicine, with Pakistan alone harboring more than 6,000 medicinal plant species, a proportion of which have confirmed therapeutic potential (Zareef *et al.* 2023).

Despite their significance, traditional medicinal knowledge is rapidly declining due to modernization, industrialization, and socio-environmental changes. The increasing reliance on synthetic pharmaceuticals, coupled with reduced transmission of indigenous knowledge, threatens the preservation of ethnobotanical heritage (Amin *et al.* 2024; Okoduwa *et al.* 2018). Rural communities, which historically relied on medicinal plants for primary healthcare, are shifting toward commercialized healthcare systems, gradually eroding plant-based healing practices. Given that a significantly high proportion of the global population continues to rely on medicinal plants for primary healthcare, preserving and documenting traditional knowledge (TK) is crucial (Mgalula, 2024).

Pakistan is home to over 6,000 medicinal plant species; however, most ethnobotanical studies conducted to date have focused primarily on qualitative documentation rather than quantitative prioritization of key species (Afzal *et al.* 2024; Iqbal *et al.* 2023; Naheed *et al.* 2023). While several regional ethnobotanical surveys in Punjab and other parts of the country have documented medicinal plant diversity and traditional uses, few have applied statistically grounded ethnobotanical indices within a community-based ranking approach to assess relative cultural therapeutic importance. To date, no comprehensive ethnobotanical investigation in Muzaffargarh District has combined multiple quantitative indices with community consensus to systematically prioritize medicinal plant species. The present study addresses this gap by applying a quantitative framework that integrates ethnobotanical indices with community-based ranking to identify species of high ethnomedicinal relevance.

Ethnobotanical research remains essential for understanding human-plant relationships and the role of traditional knowledge in shaping modern pharmacology (Nasution *et al.* 2020). Medicinal plants continue to play a critical role in preventive and therapeutic healthcare, particularly in economically disadvantaged communities where limited healthcare infrastructure and high medical costs drive reliance on locally available herbal remedies (Okoduwa *et al.*, 2024b; Bhat *et al.* 2021; Bahadur *et al.* 2020). Additionally, rising inflation, resource constraints, and inadequate transportation infrastructure further emphasise the urgency of conducting region-specific ethnobotanical surveys (Ullah *et al.* 2023).

To date, no ethnobotanical study in Muzaffargarh has applied a statistical prioritization method such as Garrett ranking to determine the most culturally and therapeutically significant species. The present study was designed to quantitatively prioritize medicinal plant species used in Muzaffargarh District, Punjab, Pakistan, to identify those of the highest perceived therapeutic importance and research relevance. Specifically, the objectives were to: (i) document and quantify the medicinal plants used by local communities in Muzaffargarh District using core ethnobotanical indices, including Relative Frequency of Citation (RFC), Fidelity Level (FL), Cultural Importance Index (CI), and Cultural Value Index (CVI); (ii) prioritize medicinal plant species based on perceived therapeutic effectiveness by applying the Garrett ranking technique, thereby identifying the species with the highest community consensus and research priority; (iii) evaluate patterns of traditional knowledge distribution and erosion across informant groups and discuss implications for ethnobotanical conservation and future pharmacological validation.

Materials and Methods

Study location

The study was conducted in Muzaffargarh District, located in southern Punjab province (Figure 1). It extends from latitude 29.016°N to 30.765°N and from longitude 70.537°E to 71.726°E. It is divided into four tehsil units (Muzaffargarh, Jatoi, Kot

Addu, and Alipur), and five Markaz comprising 35 Union Councils, 33 of which are rural and 2 are urban (Saifullah *et al.* 2007). Details of the study location are provided in Supplementary Methods S1

Study area and target population

The study was conducted in Muzaffargarh district, Punjab, Pakistan, an agriculturally rich region known for its diverse plant biodiversity and strong reliance on traditional medicinal practices. The target population included local herbal practitioners (hakims), elderly community members, traditional healers, and individuals with extensive knowledge of medicinal plants. These participants were selected due to their significant role in preserving and utilizing ethnobotanical knowledge.

Survey locations and participant characteristics

A total of 40 communities across the four tehsils of Muzaffargarh District were visited to collect ethnobotanical data (Table S1, Figure 2). For each location, we recorded GPS coordinates, altitude, ecological type, dominant ethnicity, languages spoken, religion, estimated population, and participant demographics (number, gender, age range, and occupation). GPS readings were obtained using a Garmin eTrex 32x handheld GPS unit, and altitudes were verified against topographic maps. Ecological categories (semi-arid plain, irrigated cropland, riverine floodplain, or desert fringe) followed the classification of Mahmood *et al.* (2021). Participant data were collected during interviews and cross-checked with community records where available. This approach ensures spatial transparency and enables cross-site comparisons across cultural and ecological contexts. Details of the surveyed locations, including their ecological and socio-demographic characteristics, are summarised in supplementary Table S1, while their spatial distribution within Muzaffargarh District is illustrated in Figure 2. The numbered points on the map correspond directly to the site IDs listed in the table.

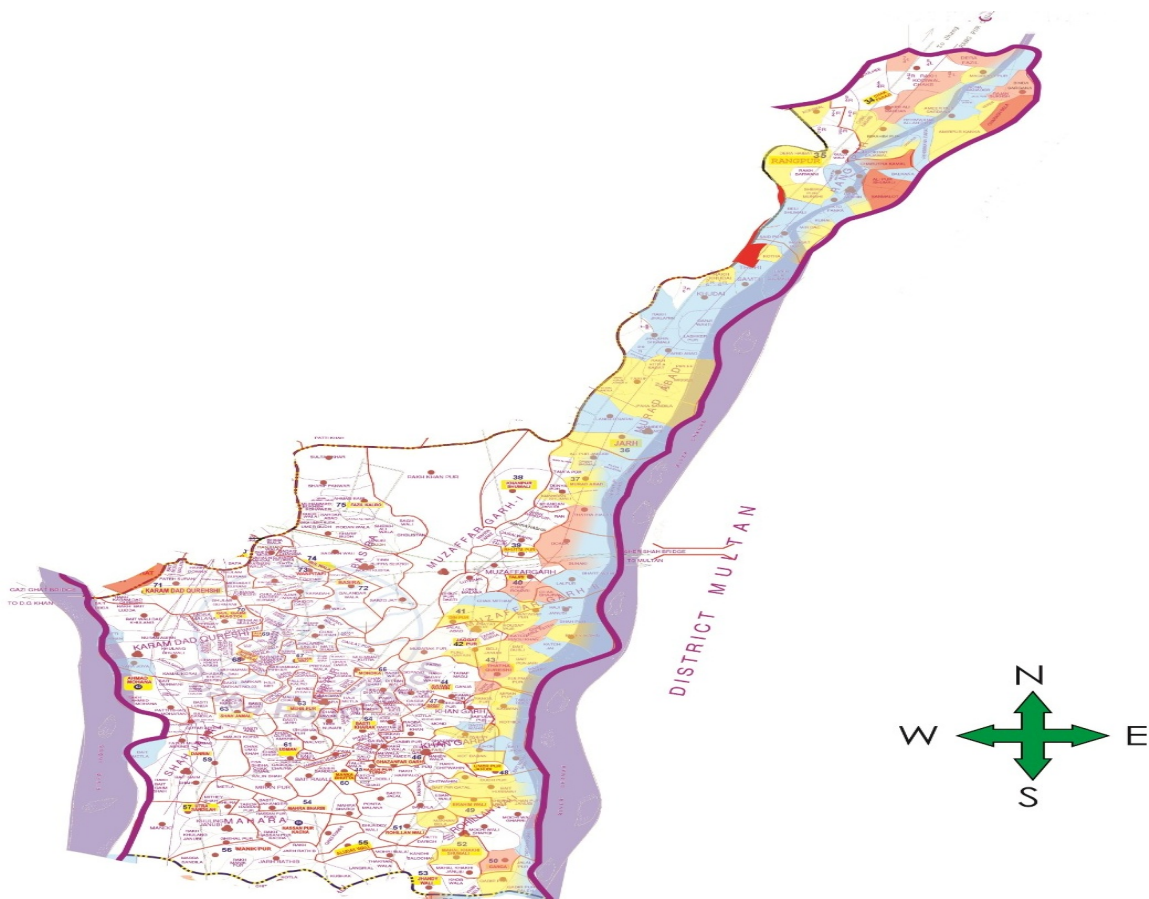


Figure 1. Geographical map of the district Muzaffargarh showing the study area

Sampling and data collection

A purposive sampling approach was used to select informants based on age (preferably over 40 years), role (traditional healers, herbalists, and elder community members), and recognised ethnobotanical knowledge within their community. Each of the 40 communities contributed at least one informant, and selection was carried out in collaboration with local community leaders to ensure representation from all four tehsils of Muzaffargarh District. To minimise sampling bias, data

triangulation was applied by cross-verifying responses among informants and conducting consensus analysis. A total of 79 informants were surveyed through semi-structured interviews and direct field observations conducted between April 2021 and March 2023. The informants were distributed across the four tehsils (subdivisions) of Muzaffargarh District, as shown in Figure 3. Ethical considerations, including prior informed consent (PIC), were obtained before conducting interviews. Comprehensive ethnobotanical inventories and quantitative indices are provided in Supplementary Tables S1-S3. Novel ethnomedicinal reports were identified through a systematic comparison of documented plant species, therapeutic uses, and preparation methods with existing ethnobotanical literature from the study region and neighbouring areas. Details of the data collection procedures are provided in Supplementary Methods S1.

Ethical consideration:

The study was approved by the Ethical Committee of Bahauddin Zakariya University, Multan (Approval No. 640/23) and conducted in accordance with the 1964 Helsinki Declaration. All participants provided informed consent before data collection. The purpose of the study was explained to all participants, and written consent to participate and to publish the study results was obtained from all participants.

Plant identification and taxonomy

Medicinal plant identification was conducted through direct field observations and consultations with local herbalists and traditional healers. Collected plant specimens were authenticated using standard botanical keys and taxonomic literature. Further verification was performed by comparing the specimens with herbarium collections at the Pakistan Museum of Natural History (PMNH) and the Botanical Garden of Bahauddin Zakariya University, Multan. The scientific, family, and local names were validated against the Plant List Database and the International Plant Names Index (IPNI) to ensure consistency in nomenclature.

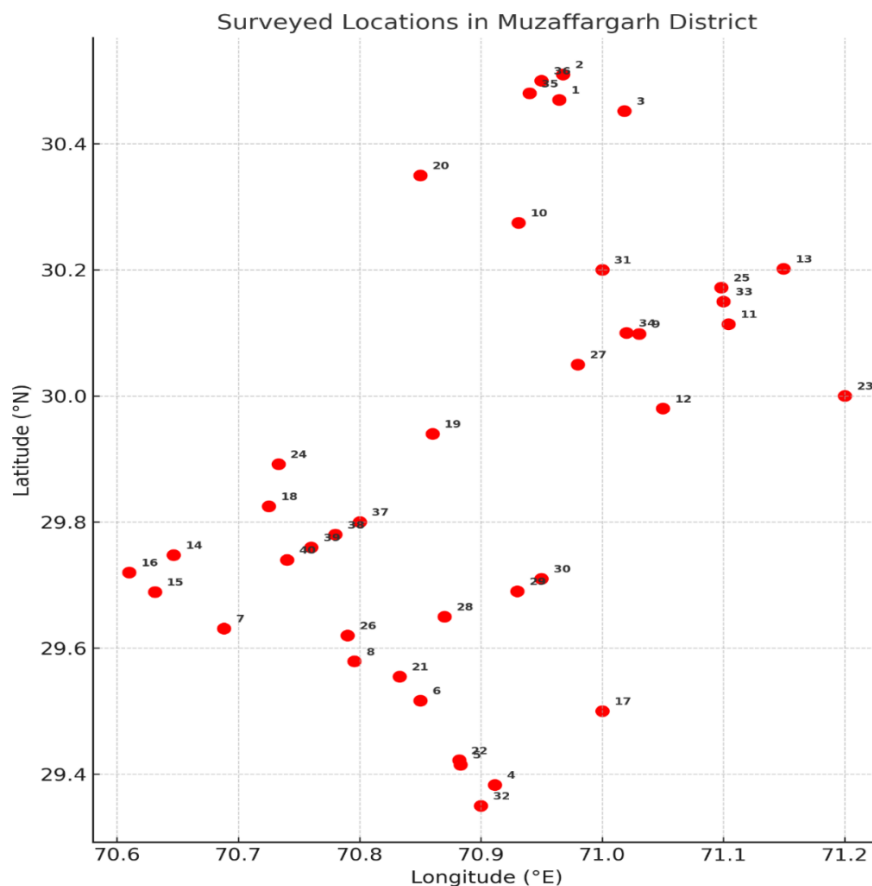


Figure 2. Map of Muzaffargarh district showing the surveyed villages included in this ethnobotanical study

Note: Each red point is labelled with an ID number, which corresponds directly to the serial numbers (site ID) and details provided in supplementary Table S1.

Statistical Analysis

Quantitative ethnobotanical data were analyzed using standard descriptive and inferential statistical approaches. Ethnobotanical indices, including Fidelity Level (FL), Relative Frequency of Citation (RFC), Relative Importance (RI), Cultural Importance Index (CI), and Cultural Value Index (CVI), were calculated using established formulas described in the literature. The Garrett ranking technique was applied to convert informant-based ordinal rankings into quantitative scores for prioritizing medicinal plants based on perceived therapeutic efficacy. Correlation analysis was conducted to examine the relationship between key indices, particularly RFC and FL, and statistical significance was assessed at $p < 0.05$. Different catalogues, such as fidelity level (FL), relative importance (RI), cultural importance index (CI), cultural value index (CVI), and relative frequency of citation (RFC), were used to evaluate the importance and value of ethnobotanical field knowledge.

Fidelity level (FL)

The fidelity level, basically a parameter, is used to determine the curative potential of specific plant species for specific diseases compared to other diseases. The FL is an ethnobotanical index used to determine the relative healing potential of a plant species for a specific ailment compared to its use for other ailments, reflecting informant consensus (Friedman *et al.* 1986; Alexiades & Sheldon 1996). The fidelity level was calculated by the formula and expressed in percentages (0% to 100%):

$$\text{Fidelity Level (FL)} = \left(\frac{Np}{N} \right) \times 100$$

Np = Number of informants mentioned the use of species for a particular disease

N = Number of informants mentioned the use of species for any disease.

The FL percentage ranges from 0 to 100.

Relative importance (RI)

The relative importance index is used in ethnobotany to investigate the importance of plant species within the community. The RI index evaluates the versatility of a plant species based on the number of pharmacological properties and body systems it affects and was originally proposed by Phillips and Gentry (1993), with later applications in quantitative ethnobotany (Bennett & Prance, 2000). The RI was measured by the formula and has a range from 0 to 1, with higher values representing higher RI:

$$\text{Relative Importance (RI)} = \left(\frac{Np + Ns}{2} \right)$$

Np = Number of pharmacological properties of the plant species

Ns = Number of body systems affected by the plant species.

Number of informants, score range from 0 to 1. RI is presented as a unitless ratio

Cultural importance index (CII)

The cultural importance index is utilized in ethnobotanical studies to assess the cultural importance of plant species within the community. The CII measures the cultural relevance of a plant species by considering both the diversity of its uses and the proportion of informants citing each use. This index was developed by Tardío and Pardo-de-Santayana (2008) and has since been widely applied in ethnobotanical research. The CII was calculated using the following formula:

$$\text{Cultural Importance Index (CII)} = \sum_{i=1}^n \left(\frac{U_i}{N} \right)$$

U_i = Number of particular plants' uses mentioned by informants

N = Total number of informants

N = Total number of informants who mentioned the plant

CII is presented as a unitless ratio

Cultural value index (CVI)

The Cultural Value Index (CVI) is an extension of cultural importance metrics that integrates frequency of citation, use diversity, and perceived importance into a single value. This index was proposed by Reyes-García *et al.* (2006) and further applied in later ethnobotanical studies (Tardío & Pardo-de-Santayana, 2008). The Cultural Value Index assesses the cultural significance of plant species using specific criteria. CVI was determined by the formula:

$$\text{Cultural Value Index (CVI)} = \sum_{i=1}^m \left(\frac{S_{ij}}{S_{max}} \right)$$

S_{ij} = Score assigned to plant (j) for criterion (i)

S_{max} = Maximum possible score for each criterion

m = Total number of criteria

CVI is presented as a unitless ratio

The Cultural Value Index (CVI) used in this study is a composite ethnobotanical metric that integrates the frequency of citation, diversity of uses, and perceived importance of plant species within the local community. While conceptually grounded in the Cultural Importance Index (CI) proposed by Tardío & Pardo-de-Santayana (2008), the CVI used here differs in scope by incorporating additional weighting criteria relevant to medicinal prioritization. This adapted formulation was selected to better reflect local ethnomedical valuation and to complement other quantitative indices (RFC, FL, RI) and the Garrett ranking technique used in this study. The approach allows for nuanced prioritization of species beyond simple citation frequency while remaining theoretically aligned with established cultural indices.

Relative frequency of citation (RFC)

The relative frequency of citation (RFC) is used to measure the importance of a plant species described by the frequency mentioned by informants. The Relative Frequency of Citation (RFC) is used to assess the local importance of a plant species based on the proportion of informants who mention its use. This index was originally described by Tardío and Pardo-de-Santayana (2008) and has been extensively employed in ethnobotanical surveys (Vitalini *et al.* 2013). The RFC was calculated by the formula, and presented in ranges from 0 to 1

$$\text{Relative Frequency of Citation (RFC)} = FC/N$$

FC = Number of informants who mentioned the use of a particular plant

N = Total number of informants

Number of informants, score range from 0 to 1. RFC is presented as a unitless ratio

Survey-based ranking techniques

The Garrett Ranking Technique, originally developed by Garrett (1947), was applied to enhance the reliability of data interpretation and priorities medicinal plants based on informants' perceived effectiveness, converting ordinal ranks into quantitative scores (Uprety *et al.* 2010). This method systematically ranks medicinal plants based on their perceived ethnobotanical significance. This method was chosen over other techniques because it converts ordinal rankings into quantitative scores, reducing subjectivity and capturing collective community judgment more robustly. Furthermore, it combines the structure of preference ranking with the statistical robustness of a scoring system, allowing each informant's opinion to be quantified and aggregated.

Other ranking techniques, such as Preference Ranking (PR) and Paired Comparison (PC), are qualitative tools useful for small datasets but less scalable. Use Value (UV) emphasizes the number of uses per species but may not reflect perceived effectiveness. Fidelity Level (FL) and Relative Frequency of Citation (RFC): Quantify consensus and frequency but not perceived priority or rank. The Garrett ranking is particularly useful in larger community-based studies where capturing nuanced priorities is essential, and it complements indices like FL and RFC by focusing on perceived efficacy rather than frequency alone.

Garrett Ranking Calculation

Ranking by respondents: Each informant ranked medicinal plants based on their effectiveness in treating specific ailments.

Conversion to per cent position: The rank values were converted into per cent positions using the formula:

$$p = \frac{R_{ij} - 0.5}{N_j} * 100$$

Where:

P = Percent position

R_{ij} = Rank given for the plant by the respondent

N_j = Total number of respondents

Garrett Score Calculation: The per cent positions were then converted into Garrett scores using a standard Garrett conversion table.

Final Ranking: The average Garrett score for each plant was computed to determine its relative importance in traditional medicine.

Results and Discussion

Demographic Characteristics of Informants

A total of 79 informants participated in this study, distributed across the four tehsils of Muzaffargarh District: Muzaffargarh (28%), Alipur (25%), Jatoi (24%), and Kot Addu (23%) (Figure 3). The majority were traditional herbal practitioners (36%), followed by elderly community members (32%) and local healers (32%) (Figure 4). Most informants had over 20 years of experience in using medicinal plants. The complete ethnobotanical inventory is presented in Supplementary Table S1.

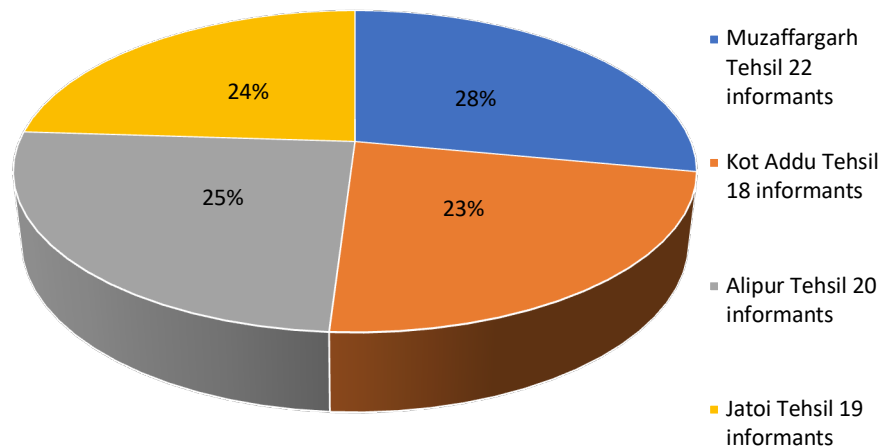


Figure 3. Demographic distribution of Informants in Muzaffargarh district

Medicinal Plant Diversity and Ethnobotanical Uses

A total of 75 medicinal plant species belonging to 43 families were documented (Supplementary Table S3). The most represented plant families were: Fabaceae (7 species), Lamiaceae (6 species) and Asteraceae (5 species). A total of 18 families contain only a single medicinal plant species, highlighting the diversity of plant usage in traditional medicine (Figure 5). The most commonly used plant parts were leaves (40%), followed by seeds (22%), roots (15%), bark (10%), and flowers (8%) (Figure 6). The Garrett ranking technique was used to determine the most significant medicinal plants based on informants' perceived efficacy in treating ailments. The top 10-ranked species and their Garrett scores (ranging from 69.8 to 95.3) indicate their relative importance (Table 1). Relative Importance (RI) values and other quantitative indices for all recorded species are provided in Supplementary Table S2.

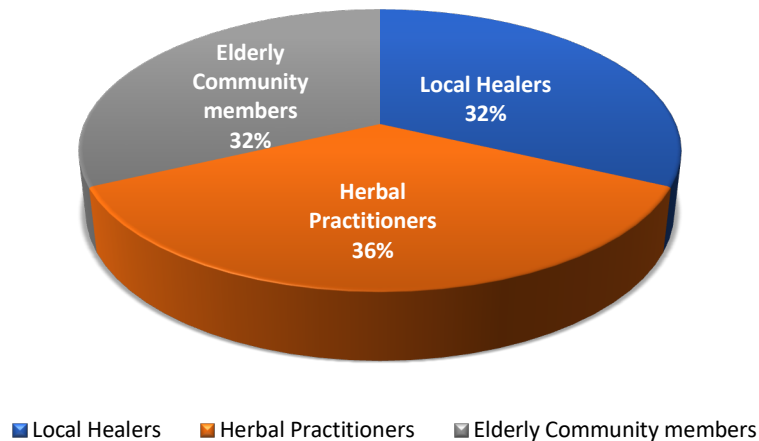


Figure 4. Demographic categories of Informants in Muzaffargarh district

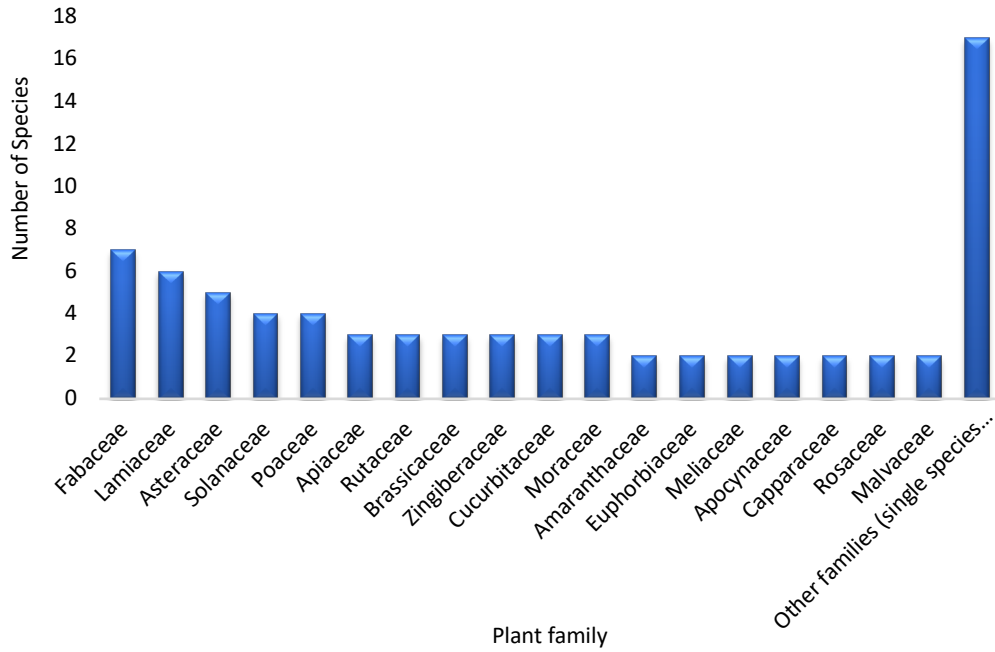


Figure 5. Statistics of plant families and the number of species by informants in Muzaffargarh District

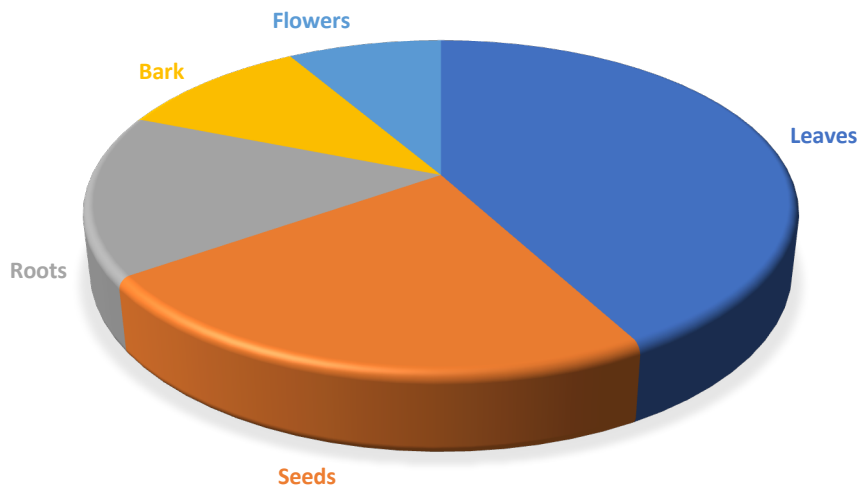


Figure 6. Percentage distribution of the most commonly used plant parts by informants in Muzaffargarh district

Table 1. Top 10 Medicinal plants based on the Garrett ranking

Rank	Medicinal Plant	Garrett Score	Primary Uses
1	<i>Nigella sativa</i> (Black cumin)	95.3	Metabolic disorders, immunity
2	<i>Zingiber officinale</i> (Ginger)	90.8	Digestive health, cardiovascular diseases
3	<i>Trigonella foenum-graecum</i> (Fenugreek)	88.6	Diabetes, inflammation
4	<i>Moringa oleifera</i> (Drumstick tree)	85.4	Immune booster, general wellness
5	<i>Foeniculum vulgare</i> (Fennel)	82.9	Gastrointestinal disorders, bloating
6	<i>Allium sativum</i> (Garlic)	79.7	Antimicrobial, cardiovascular health
7	<i>Cassia fistula</i> (Golden shower tree)	76.5	Detoxification, laxative
8	<i>Azadirachta indica</i> (Neem)	74.3	Skin infections, antimicrobial
9	<i>Mentha spicata</i> (Spearmint)	72.1	Digestive aid, nausea relief
10	<i>Trachyspermum ammi</i> (Ajwain)	69.8	Gastrointestinal relief, antiseptic

Mode of consumption of medicinal plants

The medicinal plants identified in this study were used in various preparations and consumed in different ways, depending on the ailment being treated. The primary modes of consumption reported by informants include:

Decoction (Boiling in water): Used for extracting medicinal properties from leaves, roots and barks commonly employed for digestive disorders, fever, and respiratory infections.

Infusion (Soaking in hot water): This method is mainly used for delicate plant parts such as flowers and leaves, but it is also effective for treating coughs, colds, and hypertension.

Powder (Dried and ground plant materials): Often mixed with honey, milk, or water; widely used for diabetes, arthritis, and gastrointestinal issues.

Paste (Crushed fresh leaves or seeds): Applied externally for skin infections, wounds and inflammatory conditions.

Juice (extracted from fresh plant parts): Consumed raw or mixed with other natural ingredients for liver disorders and immune system enhancement.

Oil extract (prepared from seeds or leaves): Used in massage therapy for joint pain, muscle stiffness, and skin diseases.

Chewing (Raw leaves or seeds): directly consumed for oral health, digestion, and minor throat infections.

Smoke/fumes (Burned plant parts): Used as an inhalant for treating respiratory congestion and headaches.

Therapeutic Applications

Metabolic disorders (30%) - *Nigella sativa*, *Allium sativum*, *Trigonella foenum-graecum*

Cardiovascular diseases (22%) - *Zingiber officinale*, *Moringa oleifera*

Digestive disorders (18%) - *Foeniculum vulgare*, *Trachyspermum ammi*

Skin infections & wounds (12%) - *Aloe vera*, *Azadirachta indica*

Quantitative Ethnobotanical Indices

To assess medicinal plant significance, five ethnobotanical indices were calculated (Table S2):

1. **Fidelity level (FL%)** - Highest agreement for:
 - *Eleusine coracana* (FL = 100%)
 - *Salvadora oleoides* (FL = 98.73%)
 - *Foeniculum vulgare* (FL = 92.41%)
2. **Relative frequency of citation (RFC)** - Most frequently cited plants:
 - *Eleusine coracana*, *Phalaris canariensis* (RFC = 1.00)
 - *Salvadora oleoides* (RFC = 0.98)
 - *Trigonella foenum-graecum* (RFC = 0.89)
3. **Cultural importance index (CI)** - Most culturally significant:
 - *Cassia fistula* (CI = 0.063)
 - *Foeniculum vulgare* (CI = 0.051)
 - *Trigonella foenum-graecum* (CI = 0.063)
4. **Garrett Ranking Results** (Table 1) Top-ranked plants based on perceived efficacy:
 - *Nigella sativa* (highest Garrett score)
 - *Zingiber officinale*,
 - *Trigonella foenum-graecum*
 - *Moringa oleifera*

Statistical Correlations

A significant correlation ($p < 0.05$) was observed between RFC and FL values, indicating that frequently cited plants also had high treatment agreement.

The survey results are summarised in supplementary Tables S2 and S3, which provide information on ethnobotanically useful herbs in the Muzaffargarh district. Supplementary Table S3 provides extensive documentation of the medicinal plants used by the local population, highlighting their vernacular names, parts utilised, and therapeutic applications. The frequency of usage for different ailments, including diabetes, obesity, heart disease, digestive disorders, and general well-being, is also analyzed. The data illustrate the prominence of certain species, such as *Allium sativum* (garlic), *Zingiber officinale* (ginger), and *Nigella sativa* (black cumin), which are widely recognized for their therapeutic potential. Additionally, the table shows variations in community awareness of specific plant uses, as indicated by "Don't know" responses for certain species. The

prevalence of “Don’t know” responses, particularly for species like *Prosopis cineraria*, *Salvadora oleoides*, and *Melia azedarach*, may indicate a decline in ethnobotanical knowledge transmission, especially among younger generations. This phenomenon is observed in the context of modernization, urban migration, and the shift toward allopathic medicine, which have previously been linked to the erosion of traditional practices (Ullah & Badshah, 2024; Hussain et al., 2024). We emphasised the urgent need for community-based education, intergenerational knowledge sharing, and ethnobotanical documentation to preserve indigenous medicinal knowledge.

Figure 7 presents the top 10 most frequently cited medicinal plants in the Muzaffargarh district. This ranking is based on the informants' relative citation frequency. Supplementary Table S3 presents the ethnobotanical indices of medicinal plants in the Muzaffargarh district, ranking them by their relative cultural and medicinal importance.

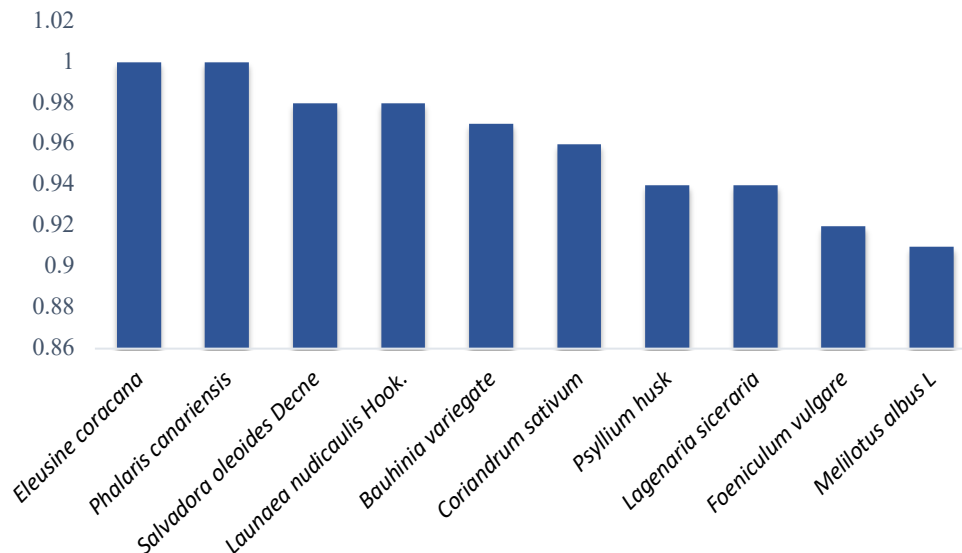


Figure 7. Top 10 most frequently cited medicinal plants in Muzaffargarh district based on the Relative Frequency of Citation

The ethnobotanical survey conducted in Muzaffargarh, Punjab, Pakistan, provides valuable insights into the community's medicinal plant utilization patterns. Although some plant species reported in this study overlap with those documented in previous surveys from the same region, this research introduces new ethnomedicinal uses, updated perception-based rankings, and a multi-index analytical framework that together offer an expanded and more nuanced understanding of plant-based knowledge in Muzaffargarh. Table S3 presents a comprehensive record of medicinal plants used to treat various health conditions, revealing both their cultural significance and therapeutic potential. The findings highlight a strong reliance on plant-based remedies, particularly for metabolic disorders, cardiovascular diseases, digestive issues, and general well-being.

The study documents 75 medicinal plant species used for various ailments, with a notable preference for herbs, followed by shrubs and trees. The most frequently used species include *Allium sativum* (garlic), *Zingiber officinale* (ginger), *Nigella sativa* (black cumin), and *Mentha spicata* (mint), all of which are well-documented for their medicinal properties in previous studies (Rahman et al. 2023; Maqsood et al. 2022; Alamgeer et al. 2018). These plants are particularly valued for their antioxidant, anti-inflammatory, and antimicrobial properties, supporting their widespread use in traditional medicine.

The study reveals that metabolic disorders such as diabetes and obesity are among the primary health concerns addressed through ethnobotanical remedies. Plants such as *Allium sativum*, *Nigella sativa*, and *Citrullus colocynthis* are frequently used for their hypoglycemic effects, aligning with existing pharmacological evidence that supports their role in blood sugar regulation (Gudalwar et al. 2021). Similarly, *Foeniculum vulgare* (fennel) and *Trachyspermum ammi* (ajwain) are predominantly used for digestive ailments, reflecting their long-standing use as carminatives and gastrointestinal stimulants (Noreen et al. 2023).

Comparative ethnobotanical analyses reveal notable overlaps and differences between the medicinal plant preferences in Muzaffargarh and those documented in other regions. For example, *Nigella sativa* and *Zingiber officinale*, the two highest Garrett-ranked species in our study, are also among the top-ranked medicinal plants in surveys from Swat (Pakistan) (Afzal et al. 2024) and the Al Baha region of Saudi Arabia (Aati et al. 2019), indicating shared cultural valuation across Muslim-

majority regions where prophetic medicine traditions are strong. Similarly, *Foeniculum vulgare* and *Trigonella foenum-graecum*, prioritized in Muzaffargarh for digestive and metabolic health, are also highly valued in Mediterranean ethnomedicine, particularly in Italy and Morocco (Benítez et al. 2010; Fakchich et al. 2022; Jaouad et al. 2025), suggesting convergent use in geographically distant but agrarian societies. In contrast, certain species with high local importance in Muzaffargarh, such as *Cassia fistula* and *Moringa oleifera*, are less frequently cited in temperate-zone surveys, reflecting climatic and ecological constraints on availability. These cross-regional patterns highlight both the universality of certain ethnomedicinal solutions, and the cultural specificity shaped by local ecology, agricultural practices, and the transmission of historical knowledge.

An interesting aspect of the data is the variation in community awareness regarding medicinal plant applications. For certain species, a significant proportion of respondents indicated "Don't know" as their response, particularly for plants like *Prosopis cineraria*, *Salvadora oleoides*, and *Melia azedarach*. This suggests a potential decline in traditional knowledge transmission, possibly due to modernization and a shift toward allopathic medicine. Previous studies have noted that younger generations in rural communities often lack detailed knowledge of medicinal plants, highlighting the need for conservation and educational initiatives (Ullah and Badshah 2024, Hussain et al. 2024). The observed decline in detailed plant knowledge among younger informants suggests a weakening of oral transmission practices, a trend echoed in other ethnobotanical studies. Moreover, community elders noted that certain plants are now harder to access due to land-use changes, overgrazing, and canal expansion. This emphasizes the need for local conservation planning alongside cultural preservation efforts.

Several plants were reported to provide "multiple benefits," indicating their broad therapeutic applications. For instance, *Ricinus communis* (castor plant) and *Calotropis gigantea* (giant milkweed) were recognized for their diverse medicinal uses, including anti-inflammatory, analgesic, and antimicrobial effects. The versatility of these plants aligns with prior ethnopharmacological studies that demonstrate their pharmacological potential (Ullah et al. 2025; Hussain et al. 2024).

The mode of consumption was strongly influenced by TK and cultural practices, with some preparations passed down through generations. These findings highlight the diverse applications of medicinal plants and their continued relevance in community healthcare. The inhabitants of local communities consume medicinal plants in the form of powders, juices, or extracts, or incorporate them into their diet for better therapeutic outcomes. Several ethnomedicinal plants and their components have been investigated for their therapeutic properties. The descriptions of each part in this research provide a comprehensive explanation of the potential health benefits of plants found in the local villages of Muzaffargarh. The stems of *Mentha spicata*, *Withania somnifera*, and *Zygophyllum arabicum*, the fruit parts of *Allium sativum* and *Zingiber officinale*, the leaves of *Ricinus communis* and *Trigonella foenum-graecum*, the seeds of *Nigella sativa* and *Cassia fistula*, and many more plants were selected based on ethnobotanical data.

From the data presented in the Supplementary Table S2, several key observations can be made. The highest Fidelity Level (FL = 100%) was recorded for *Eleusine coracana* and *Phalaris canariensis*. This indicates strong agreement among informants on their medicinal use. *Salvadora oleoides* had an FL of 98.73%, underscoring its widespread use in treating ailments. *Foeniculum vulgare* (FL = 92.41%) and *Trigonella foenum-graecum* (FL = 89.87%) also had high medicinal credibility. Plants with FL > 85% are highly reliable and should be prioritized for pharmacological validation.

Cassia fistula had the highest RI (1.75), suggesting its use in multiple therapeutic applications. *Trigonella foenum-graecum* (RI = 1.5) and *Foeniculum vulgare* (RI = 1.3) were also used for diverse ailments. Plants such as *Tamarix aphylla* (RI = 0.9) and *Zingiber officinale* (RI = 0.65) showed moderate versatility in treatment. Higher RI values indicate broad-spectrum medicinal applications, making these plants valuable for multifunctional herbal treatments.

The highest RFC (1.00) was observed for *Eleusine coracana* and *Phalaris canariensis*. This means all informants acknowledged using medicine. *Salvadora oleoides* (RFC = 0.98) and *Trigonella foenum-graecum* (RFC = 0.89) were also widely cited. *Nigella sativa* (RFC = 0.55) had moderate recognition despite its established medicinal reputation. Plants with RFC > 0.80 are deeply rooted in traditional knowledge and cultural preference, reinforcing their therapeutic reliability.

Cassia fistula (CI = 0.063) and *Foeniculum vulgare* (CI = 0.051) had the highest cultural importance, indicating their strong socio-cultural integration. *Trigonella foenum-graecum* (CI = 0.063) and *Salvadora oleoides* (CI = 0.037) were also highly valued. *Eleusine coracana* and *Phalaris canariensis* had low CI (0.012) despite their high FL and RFC values. High CI plants are deeply embedded in traditional healing and cultural beliefs, making them ideal for ethnomedical conservation efforts.

Eleusine coracana and *Phalaris canariensis* had the highest CVI (1.00), reflecting their balanced medicinal and cultural significance. *Cassia fistula* (CVI = 0.455) and *Nigella sativa* (CVI = 0.556) were highly valued in traditional medicine. *Salvadora oleoides* (CVI = 0.987) had one of the highest scores, emphasizing its strong ethnobotanical relevance. High CVI values (>0.90) confirm that these plants are key medicinal resources, deserving priority in conservation and pharmacological studies.

Unlike previous research, this study introduces a novel approach by incorporating the Garrett ranking to quantify the ethnobotanical significance of medicinal plants. By prioritizing plants based on their perceived effectiveness, this study offers a quantitative perspective on traditional herbal medicine, bridging the gap between ethnobotanical documentation and statistical validation.

The findings of this study reinforce the need for ethnobotanical conservation. Overreliance on specific plant species for medicinal use may lead to overharvesting and habitat loss, threatening biodiversity and local healthcare resources. Sustainable harvesting practices, together with community-based conservation programmes, are essential to maintain the availability of these medicinal plants for future generations (Ghorbani et al. 2011). Additionally, integrating ethnobotanical knowledge into modern healthcare systems can provide complementary treatment options. Many of the documented plants have been validated through pharmacological research, highlighting the potential for further clinical studies and commercial applications (Ali et al. 2018). To improve interpretability, the Garrett Ranking Method was used to assess the relative significance of medicinal plants according to their perceived effectiveness. The results highlight community preferences and the most valued ethnobotanical species.

Nigella sativa (Black cumin) received the highest Garrett score, indicating its widespread use for managing diabetes and cardiovascular health.

Zingiber officinale (Ginger) and *Trigonella foenum-graecum* (Fenugreek) were also highly ranked due to their strong association with digestive and metabolic health.

Moringa oleifera (Drumstick tree) was ranked among the top plants, reflecting its role in immune support and overall well-being. These rankings underscore the importance of medicinal plants in Muzaffargarh District and offer insights into traditional healthcare preferences.

Ethnobotanical studies have played a crucial role in documenting traditional medicinal knowledge, particularly in regions where plant-based healing remains integral to primary healthcare. Previous studies, such as Afzal et al. (2024), have provided extensive insights into the medicinal flora of Muzaffargarh, cataloguing numerous plant species used by indigenous communities. Similarly, Khan et al. (2023) and Nawaz et al. (2022) have explored ethnomedicinal practices in adjacent regions of Punjab, highlighting the therapeutic significance of various plant species. While these studies contribute valuable baseline knowledge, they primarily emphasise qualitative plant documentation, with limited efforts towards quantitative ranking or comparative analysis of plant usage patterns.

Unlike previous research, this study introduces a Garrett ranking-based approach to priorities medicinal plants according to community preferences and perceived effectiveness. This method enables hierarchical classification of medicinal plants, providing a structured, data-driven perspective on plant selection trends. Additionally, statistical indices such as Relative Frequency of Citation (RFC), Fidelity Level (FL), and Cultural Importance Index (CI) have been incorporated, ensuring that plant importance is assessed with greater statistical rigour (Ahmad et al. 2023; Hussain et al. 2022).

Furthermore, this study provides a comparative ethnobotanical analysis of regional variations in medicinal plant utilization. While Afzal et al. (2024) documented plant diversity, this research evaluates which plants are most preferred for specific ailments using Garrett scores. For example, *Nigella sativa*, *Zingiber officinale*, and *Trigonella foenum-graecum* were the most significant medicinal plants in this study, consistent with findings from other South Asian ethnobotanical surveys (Shaheen et al. 2023). However, differences in plant selection trends across communities indicate regional adaptations in traditional medicine, reinforcing the need for localised ethnobotanical assessments (Kumar et al. 2021).

Additionally, this study incorporates updated field data (April 2021 - March 2023) from 79 informants, ensuring that the findings reflect contemporary shifts in medicinal plant use. The expanding influence of modern pharmaceuticals, environmental changes, and socio-economic factors necessitates continuous documentation of indigenous knowledge before it declines further (Bibi et al. 2023). The integration of qualitative and quantitative methodologies in this research

provides a more holistic understanding of medicinal plant selection and utilization trends, bridging the gap between traditional healing practices and modern biopharmaceutical research.

While previous studies, including Afzal *et al.* (2024), Khan *et al.* (2023), and Nawaz *et al.* (2022), have significantly contributed to the ethnobotanical understanding of Muzaffargarh and its surrounding regions, this study advances the field by introducing a quantitative ranking framework, employing additional statistical indices, and presenting updated field data. These methodological enhancements strengthen the scientific validity of ethnobotanical research and provide a data-driven foundation for future pharmacological validation and biopharmaceutical exploration of medicinal plants (Hussain *et al.* 2023; Ahmad *et al.* 2023). Although data were collected across four tehsils in Muzaffargarh, this study did not statistically compare medicinal plant usage patterns between sub-regions. Future studies with larger sample sizes per tehsil could explore regional variations in greater detail.

Comparative Ethnobotanical Insights in Pakistan

Comparative analysis was primarily conducted using ethnobotanical studies from Pakistan to ensure cultural, ecological, and methodological comparability, as traditional medicinal knowledge is strongly influenced by local flora, healthcare access, and socio-cultural practices. However, selected international examples are included to contextualize key findings within a broader ethnomedicinal framework. Our findings were compared with previous ethnobotanical studies conducted in Pakistan to assess novelty, commonalities, and cultural interpretation of plant use for metabolic and associated disorders.

Novel Reports: Although similarity indices such as the Jaccard Index are useful for cross-regional comparisons, their application was beyond the scope of this single-community ethnobotanical survey. Peer-reviewed articles, theses, and ethnobotanical surveys were consulted to determine whether reported uses had been previously documented. Plant uses not found in the reviewed literature were classified as novel reports. Several species documented in Muzaffargarh appear to be novel records for the ethnomedicinal management of metabolic disorders in Pakistan. These include *Codariocalyx motorius* (locally known as “Ghoghro”), *Withania coagulans* (“Paneer”), and *Benincasa hispida*, “Tindy”). While these species have been occasionally reported elsewhere in South Asia for other ailments (Khan *et al.* 2025; Sinoriya *et al.* 2024), to our knowledge this is the first time they are specifically cited for metabolic conditions in the Pakistani context (Umair *et al.* 2017). Their appearance in the local pharmacopoeia underscores the adaptive and evolving nature of traditional knowledge.

Commonalities and Differences: Several species were consistently cited in our study and in earlier surveys across Punjab, Sindh, and Khyber Pakhtunkhwa, reflecting strong cross-cultural consensus. These include *Plantago ovata* (Ispaghul), *Nigella sativa* (Kalonji), *Foeniculum vulgare* (Saunf), *Trigonella foenum-graecum* (Methi), and *Coriandrum sativum* (Dhania) (Tufail *et al.* 2020). Their prominence may be attributed to both their established role in Unani-Tibb medicine and their integration into daily diets and household remedies (Usman *et al.* 2021b).

In contrast, some species that were frequently mentioned in Muzaffargarh are rarely reported elsewhere in Pakistan. These include desert-adapted taxa such as *Prosopis cineraria*, *Haloxylon salicornicum*, *Calligonum polygonoides*, and *Leptadenia pyrotechnica* (Sameen *et al.* 2025). Their ethnomedicinal use appears strongly linked to local ecology, as these shrubs are abundant in the arid landscapes of southern Punjab but absent in more mesic regions (Usman *et al.* 2021b). Likewise, culturally symbolic plants such as *Peganum harmala* (Esfand) and *Ficus religiosa* (Pipal) were cited in Muzaffargarh with ritual and symbolic dimensions, whereas their medicinal applications are more variably reported in other provinces (Chaudhary *et al.* 2018).

Cultural Interpretation: The overlap of highly cited plants across regions points to a shared ethnomedicinal foundation in Pakistan, particularly influenced by Unani-Tibb traditions and Islamic prophetic medicine (e.g., *Nigella sativa*) (Perveen *et al.* 2024). Conversely, divergences reflect the interplay of ecological availability, dietary integration, and cultural symbolism. For example, food-medicine species such as *Spinacia oleracea* (Palak) and *Agaricus bisporus* (Khumbi) are valued both nutritionally and medicinally, reflecting a food-health continuum in local cultural practice (Amjad *et al.* 2020). Meanwhile, desert taxa illustrate how ecological constraints shape the pharmacopoeia, while ritual plants (e.g., *Peganum harmala*) illustrate the symbolic and spiritual embedding of ethnomedicinal practices (Amjad *et al.* 2020).

Taken together, this comparative analysis highlights both the core ethnomedicinal repertoire that is widely recognized across Pakistan and the regional specificities that give Muzaffargarh’s traditional pharmacopoeia its distinctive character. Beyond the descriptive patterns of use and consensus values, it is equally important to interpret what these findings mean for the

wider community. In particular, the documented ethnobotanical practices are directly relevant to both the conservation of local ecosystems and the health of populations in Muzaffargarh. These broader implications are outlined below.

Environmental and Public-Health Implications for Muzaffargarh

1. Environmental implications

Conservation priorities and sustainable harvest: The prominence of arid-zone shrubs and small trees (e.g., *Prosopis cineraria*, *Haloxylon salicornicum*, *Calligonum polygonoides*, *Leptadenia pyrotechnica*) indicates reliance on ecologically fragile habitats. To prevent depletion, community-level protocols aligned with Good Agricultural and Collection Practices (GACP) should be adopted (seasonal bans during flowering/fruitletting, no-root harvesting for perennials, rotational collection sites) (WHO, 2003; EMA, 2025). Establishing small in-situ micro-reserves near villages and ex-situ nurseries/seed banks for high-use wild taxa (e.g., *Withania coagulans*, *Peganum harmala*) would reduce pressure on natural stands (EUROPAM, 2022).

Climate adaptation and landscape restoration: Several cited taxa are drought- and salt-tolerant (e.g., *Leptadenia*, *Haloxylon*, *Prosopis*). Integrating these into climate-smart hedgerows, shelterbelts, and farm woodlots could stabilize soils, buffer wind erosion, and diversify household resources under increasing heat and aridity ((Nchuchuwe *et al.* 2024)). Herbaceous “pollinator-friendly” species used as condiments/teas (e.g., *Foeniculum vulgare*, *Coriandrum sativum*, *Trachyspermum ammi*) can support on-farm biodiversity and crop pollination if left to flower in border strips (Ali *et al.* 2024; Mena & Gospodarek, 2024).

Native vs. high-risk exotics: Some frequently mentioned species (e.g., *Eucalyptus globulus*) entail trade-offs (e.g., water demand, allelopathy). Where shade/fuelwood is needed, preference should be given to native multipurpose species (*Salvadora persica*, *Vachellia nilotica*, *Ziziphus* spp.) to reduce ecological risk while maintaining local utility (WHO, 2003; EUROPAM, 2022).

Food-medicine cultivation to ease wild harvest: Where culturally important species are also foods (*Spinacia oleracea*, *Coriandrum sativum*, *Foeniculum*, *Trigonella*), domestic cultivation/kitchen gardens can meet demand with minimal ecological cost. Extension sheets detailing local varieties, seed saving, and low-input cultivation (aligned with GACP) can be delivered through agriculture departments and NGOs (WHO, 2023; FAO, 2022).

2. Public-health implications

Low-cost adjuncts for metabolic health (with safeguards): High-consensus species in our dataset—*Plantago ovata*, *Coriandrum sativum*, *Foeniculum vulgare*, *Trigonella foenum-graecum*, *Nigella sativa*—sit at the food-medicine interface and may serve as adjuncts to standard care for digestive/metabolic complaints when used in culturally typical preparations (infusions, condiments, fiber supplementation) (Thikekar *et al.*, 2021). To avoid overstatement, program materials should emphasize adjunctive use, not substitution for prescribed therapy (Thikekar *et al.*, 2021).

Safety, quality, and herb-drug interaction risk: Several taxa carry toxicity or interaction risks (e.g., *Datura innoxia*, *Nerium oleander*—toxic (Pillay & Sasidharan, 2019; Sacco *et al.* 2025)); *Peganum harmala*—MAO-inhibitory potential; glycemic/anticoagulant interactions reported for *Trigonella* and *Coriandrum*. (Berlowitz *et al.* 2022). We recommend a district “Do-Not-Use/Use-with-Caution” list, dosage guidance for household preparations, and a primary-care pharmacovigilance channel (simple adverse-event reporting form at clinics). Quality measures should address adulteration, pesticide residues, heavy metals, and mycotoxins in dried materials (storage/ drying SOPs; occasional market sampling) (WHO, 2004, Kongkaew *et al.* 2024).

Primary health-care integration: Community health workers can deliver brief counselling scripts on safe household use (e.g., psyllium dosing, fennel/coriander infusions), red-flag symptoms requiring referral (e.g., persistent hyperglycemia, chest pain), and interactions with antidiabetic and anticoagulant drugs (WHO, 2004). For oral health, the culturally embedded use of *Salvadora persica* twigs (miswak) can be supported with sustainable harvesting guidance and hygiene instructions (Ramli *et al.* 2021; Jassoma *et al.* 2019)

Equity, livelihoods, and gender: Because everyday preparation/collection is often handled by women, women-led grower groups and cooperatives can improve household income while standardizing quality. Linking these groups to local markets (fibre, spice, herbal teas) advances both SDG-3 (health) and SDG-5 (gender equality) (WHO, 2003; EUROPAM, 2022).

Antimicrobial resistance (AMR) and responsible messaging: Where plants are cited for “antimicrobial” uses, messaging should avoid implying antibiotic equivalence. Position such remedies as hygiene-supportive or symptomatic adjuncts while reinforcing prompt clinical care for infections to reduce inappropriate antibiotic use (WHO, 2004 Kongkaew *et al.* 2024).

3. Practical roadmap for local agencies

Prioritise species: Select ~8-10 high-consensus, low-risk taxa (e.g., *Plantago ovata*, *Foeniculum*, *Coriandrum*, *Trigonella*, *Nigella*, *Salvadora persica*) for district demonstration plots and kitchen-garden kits (WHO, 2003, EUROPAM, 2022).

Issue GACP briefs: One-page cultivation/collection SOPs (season, parts, drying, storage, yield) for priority species; include no-root harvest and rotational collection for wild shrubs (WHO, 2003, EUROPAM, 2022).

Safety package: A laminated dosing card for common preparations; “Do-Not-Use/Use-with-Caution” list; interaction chart for diabetes/anticoagulants; clinic poster with adverse-event QR/report form (WHO, 2004 Kongkaew *et al.* 2024).

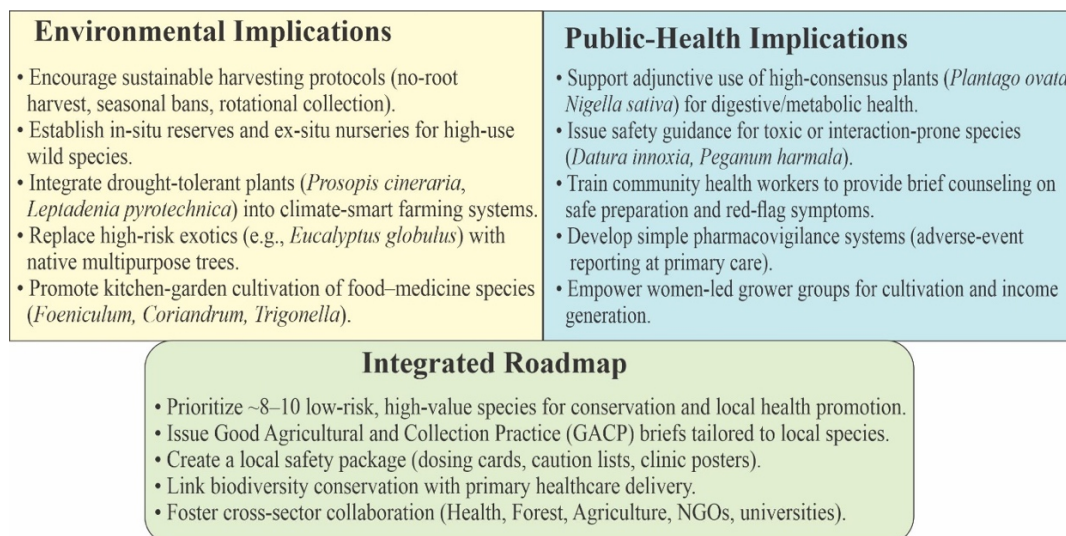
Sustainable supply: Voucher-backed community nurseries for *Withania coagulans*, *Peganum harmala*, native trees; replace high-risk exotics in public plantings with natives (WHO, 2003, EUROPAM, 2022).

Monitoring: Repeat household surveys every 2-3 years (use, source, adverse events), plus rapid habitat checks for wild populations (presence, regeneration, harvesting signs) (Ali *et al.* 2024; Mena & Gospodarek, 2024).

Research pipeline: Prioritize lab/pharmacological work on the top-consensus species (standardized preparations and doses actually used locally), and document cost-effectiveness vs. usual care as part of implementation research (Thikekar *et al.* 2021).

Overall, the dataset points to a dual opportunity: (i) conserve and restore arid-zone ecosystems by domesticating/cultivating culturally preferred taxa, and (ii) strengthen primary care for metabolic complaints with safe, standardized, and adjunctive use of high-consensus plants. Moving from documentation to implementation will require cross-sector coordination (Health, Forest, Agriculture, NGOs, and local universities) and adherence to best-practice frameworks (e.g., WHO-GACP) to ensure safety, equity, and ecological sustainability.

To provide a concise overview of the major insights, we synthesised the key environmental and public-health implications of the documented ethnobotanical knowledge into a structured summary (Box 1). This box highlights conservation priorities, sustainable use recommendations, and culturally relevant health applications, and outlines an integrated roadmap for linking biodiversity management with community healthcare and livelihoods. In addition to the tabulated summary (Box 1), we developed a visual roadmap (Figure 8) to illustrate the interconnected pathways through which ethnobotanical knowledge in Muzaffargarh can inform both environmental stewardship and public-health strategies. The figure highlights the links between sustainable plant use, community health benefits, and livelihood opportunities.



Box 1. Roadmap summarizing environmental and public-health implications of the documented ethnobotanical knowledge in Muzaffargarh District.

Box 1. Roadmap summarising environmental and public-health implications of the documented ethnobotanical knowledge in Muzaffargarh District. The diagram highlights three interconnected dimensions: (i) environmental priorities such as sustainable harvesting, conservation of arid-zone shrubs, and cultivation of food-medicine species; (ii) public health opportunities and risks, including the safe use of high-consensus plants, caution with toxic taxa, and integration into primary care education; and (iii) an integrated roadmap linking conservation with culturally appropriate healthcare and community livelihoods.

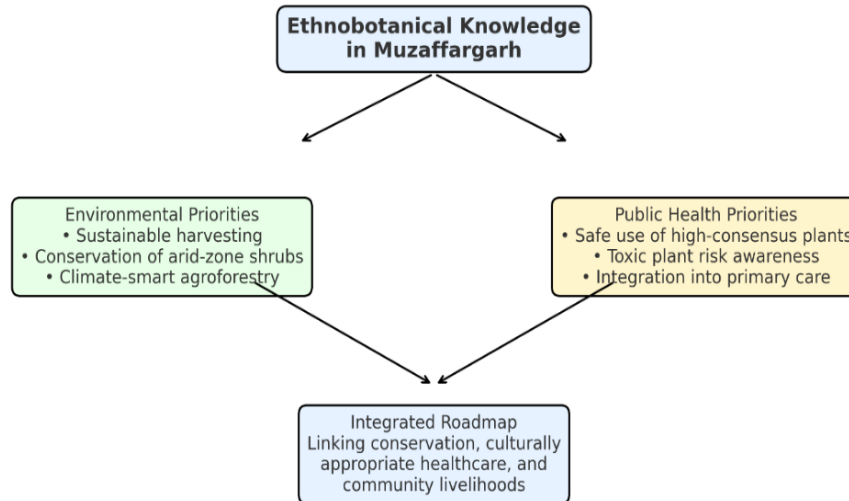


Figure 8. Visual roadmap of connections linking ethnobotanical knowledge in Muzaffargarh to environmental and public-health priorities.

The diagram highlights three interlinked dimensions: environmental priorities (sustainable harvesting, conservation of arid-zone shrubs, climate-smart agroforestry), public-health priorities (safe use of high-consensus plants, awareness of toxic species, and integration into primary care), and an integrated roadmap that connects conservation with culturally appropriate healthcare and community livelihoods. Taken together, these environmental and public-health considerations highlight the practical significance of our data and point to areas that warrant caution and further validation. The following section outlines the main limitations of the study, which should be kept in mind when interpreting these findings.

Limitations of the Study

While this study provides valuable insights into the ethnobotanical knowledge of Muzaffargarh, several limitations should be considered. First, the results are based on self-reported practices from a relatively small number of informants and may therefore be influenced by recall bias or selective memory. Second, although plant names were standardized using World Flora Online and MPNS, minor taxonomic ambiguity may persist due to overlapping vernacular nomenclature and recent taxonomic revisions. Third, a subset of species was cited with very low fidelity levels or “don’t know” responses; these have cultural significance but limited quantitative support and should not be over-interpreted. Finally, the findings represent community perceptions rather than pharmacological validation. While our analysis identifies plants with potential value for public health and conservation, further laboratory and clinical research is needed to confirm their efficacy and safety.

Conclusion

This study documents and analyses the ethnobotanical knowledge of 75 plant species (and one fungal species) used for metabolic and related disorders in Muzaffargarh District, Pakistan. The findings highlight species with high informant consensus, such as *Plantago ovata*, *Coriandrum sativum*, *Foeniculum vulgare*, and *Trigonella foenum-graecum*, which are consistently valued for supporting digestive and metabolic health. Other species, including *Withania coagulans*, *Moringa oleifera*, and *Nigella sativa*, were cited for their multipurpose medicinal roles. At the same time, a considerable number of species were reported with low fidelity levels or uncertainty, underscoring the variability of local knowledge and the need for careful interpretation.

Rather than definitive evidence of efficacy, these results provide a culturally grounded account of how communities conceptualize and utilize local biodiversity for health purposes. The study contributes to preserving intangible cultural knowledge and identifies candidate species for further pharmacological and phytochemical research. However, the findings should be interpreted in light of the study’s limitations, including reliance on self-reported practices and the absence of

experimental validation. Future interdisciplinary studies that combine ethnobotany with laboratory and clinical approaches will be critical for fully assessing the therapeutic potential of these species.

Declarations

List of abbreviations: FL - Fidelity Level; RI - Relative Importance; CI - Cultural Importance Index; CV - Cultural Value Index; RFC - Relative Frequency of Citation; EU - European Union; MPNS - Medicinal Plant Names Services; TK - Traditional knowledge; PIC - Prior Informed Consent; UV - Use Value; PR - Preference Ranking; PC - Paired Comparison

Ethics approval and consent to participate: The questionnaire and methodology for this study were approved by the Human Research Ethics Committee of Bahauddin Zakariya University, Multan (Approval No. 640/23), and were conducted in accordance with the 1964 Helsinki Declaration. The participation of healers was subject to the acceptance of the Free and Informed Consent Form.

Consent for publication: All authors have read and approved the manuscript and provided consent to publish.

Informed consent to participate: The purpose of the study was explained to all the subjects. Written informed consent to participate and to publish the study results was obtained from all participants.

Availability of data and materials: Not applicable

Competing interests: There were no competing interests as declared by the authors.

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Declaration of generative AI and AI-assisted technologies in scientific writing: The authors declare that no generative AI or AI-assisted technologies were used in the writing, editing, data analysis, or production of this manuscript, unless otherwise explicitly acknowledged. Where AI tools were used, such usage was limited to language refinement and formatting assistance under the direct oversight of the authors, who remain fully responsible for the content and integrity of the manuscript.

Supplementary Material: Supplementary materials associated with this article are available after the literature cited section, and include extended methodological descriptions, complete ethnobotanical inventories, quantitative index tables, demographic analyses, and detailed ethnomedicinal descriptions.

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Supplementary materials

This supplementary material provides expanded methodological details and comprehensive datasets supporting the ethnobotanical survey and therapeutic ranking of medicinal plants in Muzaffargarh District, southern Punjab, Pakistan. The study area is characterized by a semi-arid climate, agriculture-based livelihoods, and a predominantly Saraiki-speaking population. Data were validated by cross-referencing across informants, and plant nomenclature was standardized using authoritative taxonomic databases to ensure accuracy. Supplementary tables present a complete inventory of survey locations and participant demographics, together with quantitative ethnobotanical indices—including fidelity level (FL), relative importance (RI), relative frequency of citation (RFC), cultural importance (CI), and cultural value index (CVI)—for numerous medicinal species documented in the region. Detailed ethnomedicinal descriptions further highlight traditional knowledge of plant uses for metabolic, digestive, cardiovascular, immune, and dermatological conditions, as well as their nutritional and cultural significance. Collectively, these materials enhance the transparency, reproducibility, and interpretability of the main manuscript by offering granular insights into sampling procedures, informant consensus, and species-specific applications, thereby strengthening the scientific foundation for future pharmacological investigation and the conservation of indigenous medicinal knowledge.

Supplementary Methods S1: Extended study area description and data collection procedures

Study location

Muzaffargarh District, located in southern Punjab province, covers an area of 8,250 km² and has a population of 4.32 million, or 564.1 persons per km² (Pakistan Bureau of Statistics, 2017). The climate in this area is semi-arid to desert, with a maximum temperature of 50°C in June and a minimum of 2°C in January (Mahmood et al. 2021). It is situated between the Chenab and the Indus rivers. People in this district have a classic and uncomplicated culture. The majority language spoken by the populace is Saraiki, and agriculture is their primary source of income and livelihood (Table S1). Nawab Muzaffar Khan Sadozai, the ruler of Multan, built the town in 1794. It was governed by the British and Sikhs after Sadozai. Due to political unrest, this area was established as a district in 1849 (Fiaz *et al.* 2021). The region is rich in natural resources and lush terrain and is well known worldwide for its cotton and mangoes (Akhtar & Noor, 2022).

Sampling and data collection

The collected data were further validated by cross-referencing responses across informants to ensure accuracy and reliability. Furthermore, scientific names were validated against the World Flora Online (www.worldfloraonline.org) (WFO, 2023) and the Medicinal Plant Names Services (MPNS) (<http://mpns.kew.org>). Synonyms were cross-checked and updated to accepted names. Plant habit, part(s) used, and ethnomedicinal applications were standardised across all entries. The ranking of the perceived relative importance of the plants based on the Garrett ranking score is shown in Table 2. Informant responses coded as 'Don't know' were excluded from fidelity level (FL) and relative frequency of citation (RFC) calculations, though such species were retained in Table S2 for completeness. For details on taxonomic sources, coding of multipurpose uses, and interpretation of FL values, see the explanatory notes provided below Table S2.

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Supplementary Table S1. Complete ethnobotanical inventory of survey locations and participant characteristics in Muzaffargarh district

Site ID	Location Name	GPS Coordinates	Altitude (m a.s.l.)	Ecology Type	Dominant Ethnicity	Language(s)	Religion	Estimated Population	Participants (n)	Gender (M/F)	Age Range (yrs)	Occupations Represented
1	Kot Addu City	30.4700° N, 70.9644° E	130	Semi-arid agricultural plain	Saraiki	Saraiki, Punjabi	Islam	50,000	7	4/3	42-71	Herbalists, farmers
2	Dera Din Panah	30.5102° N, 70.9675° E	129	Irrigated cropland	Saraiki	Saraiki	Islam	9,500	3	2/1	45-62	Farmers
3	Chowk Sarwar Shaheed	30.4521° N, 71.0183° E	132	Semi-arid plain	Saraiki	Saraiki, Urdu	Islam	12,000	5	3/2	50-68	Elders, healers
4	Alipur City	29.3830° N, 70.9115° E	115	Riverine floodplain	Baloch	Saraiki	Islam	45,000	6	2/3	44-69	Hakims, farmers
5	Khairpur Sadat	29.4152° N, 70.8831° E	118	Floodplain agriculture	Baloch	Saraiki	Islam	6,200	2	1/1	48-65	Elders
6	Jatoi Town	29.5167° N, 70.8500° E	122	Irrigated cropland	Saraiki	Saraiki, Urdu	Islam	21,000	6	4/2	40-72	Farmers, healers
7	Qasba Gujrat	29.6311° N, 70.6883° E	127	Semi-arid cropland	Saraiki	Saraiki	Islam	4,800	2	1/1	55-69	Elders
8	Muradabad	29.5789° N, 70.7956° E	125	Irrigated farmland	Saraiki	Saraiki	Islam	3,900	1	1/0	63	Farmer
9	Baseera	30.0985° N, 71.0306° E	128	Semi-arid plain	Saraiki	Saraiki, Punjabi	Islam	8,500	2	1/1	49-67	Herbalists
10	Mahmood Kot	30.2747° N, 70.9311° E	131	Irrigated cropland	Saraiki	Saraiki	Islam	11,500	3	2/1	46-61	Farmers
11	Rohilanwali	30.1139° N, 71.1042° E	133	Semi-arid plain	Saraiki	Saraiki, Urdu	Islam	6,800	1	1/0	65	Elder
12	Rungpur	29.9800° N, 71.0500° E	130	Semi-arid agricultural plain	Saraiki	Saraiki	Islam	5,600	1	1/0	60	Farmer
13	Khangarh	30.2020° N, 71.1495° E	135	Irrigated cropland	Saraiki	Saraiki	Islam	13,200	4	2/2	45-70	Farmers
14	Shehr Sultan	29.7475° N, 70.6467° E	120	Floodplain agriculture	Saraiki	Saraiki	Islam	7,400	2	1/1	53-68	Hakims
15	Khan Pur Shumali	29.6889° N, 70.6311° E	118	Riverine floodplain	Baloch	Saraiki	Islam	3,500	3	2/2	67	Elder
16	Mangrotha	29.7200° N, 70.6100° E	116	Riverine	Baloch	Saraiki	Islam	2,800	1	1/0	70	Elder

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17	Jalalpur Pirwala (fringe area)	29.5000° N, 71.0000° E	127	Irrigated cropland	Saraiki	Saraiki	Islam	3,200	1	1/0	64	Farmer
18	Bait Qaimwala	29.8250° N, 70.7250° E	126	Semi-arid plain	Saraiki	Saraiki	Islam	2,100	1	1/0	69	Elder
19	Shaher Fareed	29.9400° N, 70.8600° E	129	Semi-arid cropland	Saraiki	Saraiki	Islam	4,400	3	2/1	52-66	Elders
20	Ghazi Ghat	30.3500° N, 70.8500° E	132	Irrigated cropland	Saraiki	Saraiki	Islam	3,900	1	0/1	62	Herbalist
21	Kotla Laghari	29.5550° N, 70.8330° E	121	Cropland	Saraiki	Saraiki	Islam	2,700	1	1/0	55	Farmer
22	Khan Bela	29.4220° N, 70.8820° E	119	Floodplain	Baloch	Saraiki	Islam	3,200	1	1/0	58	Elder
23	Basti Malook (rural fringe)	30.0000° N, 71.2000° E	134	Semi-arid plain	Saraiki	Saraiki	Islam	2,500	1	1/0	60	Farmer
24	Fazilpur	29.8920° N, 70.7330° E	126	Semi-arid plain	Saraiki	Saraiki	Islam	5,100	3	1/2	45-63	Elders
25	Khairpur Daha	30.1720° N, 71.0980° E	131	Irrigated cropland	Saraiki	Saraiki	Islam	2,600	1	0/1	68	Herbalist
26	Muradabad Wala	29.6200° N, 70.7900° E	124	Cropland	Saraiki	Saraiki	Islam	1,800	1	1/0	66	Elder
27	Chak Farid	30.0500° N, 70.9800° E	129	Semi-arid cropland	Saraiki	Saraiki	Islam	3,000	1	1/0	63	Farmer
28	Jhangarh	29.6500° N, 70.8700° E	125	Cropland	Saraiki	Saraiki	Islam	2,200	1	0/1	65	Elder
29	Qasba Marral	29.6900° N, 70.9300° E	126	Cropland	Saraiki	Saraiki	Islam	2,400	1	1/0	64	Farmer
30	Basti Qaisrani	29.7100° N, 70.9500° E	127	Cropland	Saraiki	Saraiki	Islam	2,300	1	1/0	61	Farmer
31	Sultan Colony	30.2000° N, 71.0000° E	130	Cropland	Saraiki	Saraiki	Islam	3,500	2	1/1	44-62	Farmers
32	Ali Pur Rural Area	29.3500° N, 70.9000° E	114	Floodplain	Baloch	Saraiki	Islam	2,900	1	1/0	66	Elder
33	Shah Jamal	30.1500° N, 71.1000° E	132	Cropland	Saraiki	Saraiki	Islam	4,200	2	1/1	62	Herbalist
34	Pull Baseera	30.1000° N, 71.0200° E	128	Semi-arid plain	Saraiki	Saraiki	Islam	3,100	1	1/0	64	Farmer

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35	Kot Addu Rural	30.4800° N, 70.9400° E	129	Cropland	Saraiki	Saraiki	Islam	2,800	1	1/0	65	Farmer
36	Dera Din Panah Rural	30.5000° N, 70.9500° E	128	Cropland	Saraiki	Saraiki	Islam	2,700	1	0/1	69	Elder
37	Ghazanfargarh	29.8000° N, 70.8000° E	123	Semi-arid cropland	Saraiki	Saraiki	Islam	2,600	1	1/0	70	Farmer
38	Kotla Haji Shah	29.7800° N, 70.7800° E	122	Cropland	Saraiki	Saraiki	Islam	2,400	1	1/0	58	Farmer
39	Mauza Sardarabad	29.7600° N, 70.7600° E	121	Cropland	Saraiki	Saraiki	Islam	2,300	1	0/1	64	Herbalist
40	Basti Ahmadani	29.7400° N, 70.7400° E	120	Cropland	Saraiki	Saraiki	Islam	2,200	1	1/0	60	Farmer

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Supplementary Table S2. Quantitative ethnobotanical indices (RFC, FL, CI, CVI) of medicinal plants in Muzaffargarh district

Scientific Name	Most Common Use Citations	FL	RI	RFC	CI	CVI
<i>Eleusine coracana</i>	79	100	0.45	1	0.012	1
<i>Phalaris canariensis</i>	79	100	0.45	1	0.012	1
<i>Salvadora oleoides</i>	78	98.73	1.35	0.98	0.037	0.987
<i>Launaea nudicaulis</i>	78	98.73	0.45	0.98	0.012	0.987
<i>Bauhinia variegata</i>	77	97.47	0.9	0.97	0.025	0.974
<i>Coriandrum sativum</i>	76	96.2	1.1	0.96	0.037	0.962
<i>Psyllium husk</i>	75	94.93	0.85	0.94	0.037	0.949
<i>Lagenaria siceraria</i>	75	94.94	0.9	0.94	0.025	0.949
<i>Foeniculum vulgare</i>	73	92.41	1.3	0.92	0.051	0.924
<i>Melilotus albus</i>	72	91.13	1.35	0.91	0.037	0.911
<i>Ricinus communis</i>	71	89.87	0.7	0.89	0.012	0.898
<i>Trigonella foenum-graecum</i>	71	89.87	1.5	0.89	0.063	0.898
<i>Azadirachta indica</i>	70	88.61	0.9	0.88	0.025	0.886
<i>Withania coagulans</i>	70	88.61	0.45	0.88	0.012	0.886
<i>Acacia jacquemontii Benth</i>	70	88.6	1.1	0.88	0.037	0.886
<i>Blepharis scindica</i>	70	88.6	0.45	0.88	0.012	0.886
<i>Euphorbia prostrata Ait.</i>	70	88.61	0.9	0.88	0.025	0.886
<i>Aerva javanica</i>	70	88.61	0.9	0.88	0.025	0.886
<i>Ocimum basilicum</i>	70	88.61	1.35	0.88	0.037	0.886
<i>Raphanus sativus</i>	70	88.61	0.9	0.88	0.025	0.886
<i>Datura innoxia</i>	69	87.34	0.9	0.87	0.025	0.873
<i>Heliotropium indicum</i>	69	87.34	0.9	0.87	0.025	0.873
<i>Prosopis cineraria</i>	69	87.34	1.35	0.87	0.037	0.873
<i>Echinops echinatus</i>	68	86.07	0.9	0.86	0.025	0.861
<i>Ziziphus nummularia</i>	68	86.07	0.9	0.86	0.025	0.86
<i>Cucumis melo var. agrestis</i>	66	83.54	1.1	0.83	0.037	0.835

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<i>Portulaca oleracea</i>	65	82.27	0.9	0.82	0.025	0.822
<i>Asphodelus tenuifolius</i>	65	82.27	0.9	0.82	0.025	0.822
<i>Nerium oleander</i>	65	82.27	0.9	0.82	0.025	0.822
<i>Solanum xanthocarpum</i>	63	79.74	0.9	0.79	0.025	0.797
<i>Convolvulus prostratus</i>	62	78.48	0.9	0.78	0.025	0.781
<i>Allium sativum</i>	61	77.22	0.65	0.77	0.025	0.772
<i>Ziziphus sinensis</i>	60	75.94	0.85	0.75	0.037	0.759
<i>Vachellia nilotica</i>	60	75.94	1.1	0.75	0.037	0.759
<i>Chenopodium album</i>	60	75.95	0.9	0.75	0.025	0.759
<i>Lycium depressum</i>	60	75.94	1.1	0.75	0.037	0.759
<i>Zingiber officinale</i>	59	74.68	0.65	0.75	0.025	0.746
<i>Calotropis gigantea</i>	58	73.42	1.2	0.73	0.012	0.734
<i>Withania somnifera</i>	58	73.42	1.15	0.73	0.025	0.734
<i>Citrullus colocynthis</i>	58	73.42	1.1	0.73	0.038	0.734
<i>Raphanus sativus</i>	58	73.42	0.9	0.73	0.025	0.734
<i>Mentha spicata</i>	55	69.62	1.75	0.69	0.063	0.696
<i>Leptadenia pyrotechnica</i>	55	69.62	0.45	0.69	0.012	0.696
<i>Cleome brachycarpa</i>	54	68.35	1.35	0.68	0.037	0.683
<i>Trianthema portulacastrum</i>	45	56.96	0.9	0.56	0.025	0.569
<i>Nigella sativa</i>	44	55.69	0.65	0.55	0.025	0.556
<i>Tamarix aphylla</i>	44	55.69	0.9	0.55	0.026	0.556
<i>Tribulus terrestris</i>	44	55.69	1.35	0.55	0.037	0.556
<i>Phoenix dactylifera</i>	43	54.43	1.35	0.54	0.037	0.544
<i>Capparis decidua</i>	42	53.16	1.1	0.53	0.037	0.531
<i>Haloxylon salicornicum</i>	39	49.36	0.9	0.49	0.025	0.493
<i>Cassia fistula</i>	36	45.56	1.75	0.45	0.063	0.455
<i>Calligonum polygonoides</i>	35	44.3	1.35	0.44	0.037	0.443

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<i>Codariocalyx motorius</i>	34	43.04	1.3	0.43	0.05	0.43
<i>Linum usitatissimum</i>	26	32.91	1.5	0.32	0.063	0.329
<i>Moringa oleifera</i>	26	32.91	1.55	0.32	0.05	0.329
<i>Trachyspermum ammi</i>	25	31.64	1.3	0.31	0.05	0.316
<i>Euphorbia hirta</i>	24	30.37	1.35	0.3	0.037	0.303
<i>Xanthium strumarium</i>	24	30.38	1.35	0.3	0.037	0.303
<i>Anethum graveolens</i>	22	27.84	1.5	0.27	0.063	0.278
<i>Cenchrus echinatus</i>	22	27.84	1.35	0.27	0.037	0.278
<i>Ficus religiosa</i>	22	27.85	1.35	0.27	0.037	0.278
<i>Fagonia arabica</i>	17	21.52	0.85	0.22	0.037	0.215
<i>Cassia occidentalis</i>	17	21.52	1.35	0.21	0.037	0.215

Fidelity level (FL), Relative importance (RI), Cultural Importance (CI), Cultural value index (CVI), and Relative frequency of citations (RFC).

Relative Importance (RI) reflects the diversity of medicinal uses reported per species and follows standard ethnobotanical calculation procedures.

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Supplementary Table S3. Ethnobotanical Data of Medicinal Plant Use and Informant Consensus in Muzaffargarh District

S/N	Scientific Name (accepted)	Local Names / Popular English/Trade name	Habit	Part(s) Used	Primary Cited Uses	Number of informants who mentioned or cited the plant	Fidelity Level (%)
1	<i>Allium sativum</i> L.	Lehsen, Thaom (Garlic)	Herb	Bulb	Diabetes, obesity, and heart disease	79	77.2 / 22.8
2	<i>Zingiber officinale</i> Roscoe	Adrak (Ginger)	Herb	Rhizome	Digestive disorders, cardiovascular health	79	74.7 / 25.3
3	<i>Ricinus communis</i> L.	Harnoli, Arand (Castor plant)	Shrub	Leaves, seeds	Laxative, antimicrobial, skin uses	79	89.9
4	<i>Calotropis gigantea</i> (L.) W.T.Aiton	Aak, Madar (Giant milkweed)	Shrub	Stems, leaves, roots, and latex	Wounds, constipation, skin disorders	79	73.4
5	<i>Ziziphus jujuba</i> Mill.	Unnab, Bair (Jujube)	Tree	Fruits	Stress, insomnia, and digestion	79	17.7 (low consensus)
6	<i>Nigella sativa</i> L.	Kalonji (Black cumin)	Herb	Seeds	Metabolic disorders, cardiovascular health	79	55.7 / 31.6
7	<i>Trigonella foenum-graecum</i> L.	Methi, Methraa (Fenugreek)	Herb	Seeds, leaves	Diabetes, digestive issues, and inflammation	79	89.9
8	<i>Cassia fistula</i> L.	Amaltas (Golden shower tree)	Tree	Seeds, pods, leaves	Laxative, digestive, and fever	79	44.3 / 45.6
9	<i>Plantago ovata</i> Forssk.	Ispaghul (Psyllium husk)	Herb	Seeds	Constipation, cholesterol, digestive aid	79	94.9
10	<i>Coriandrum sativum</i> L.	Desi Dhania (Coriander)	Herb	Seeds, leaves	Digestive disorders, flavouring, tonic	79	96.2
11	<i>Codariocalyx motorius</i> (Houtt.) H.Ohashi	Ghoghro (Dancing plant)	Herb	Whole plant	Diabetes, obesity, tonic	79	43.1
12	<i>Linum usitatissimum</i> L.	Alsi (Flaxseed)	Herb	Seeds	Diabetes, digestive health, cardiac tonic	79	32.9
13	<i>Mentha spicata</i> L.	Podina (Spearmint)	Herb	Leaves, stems	Digestive aid, cold, nausea	79	69.6
14	<i>Moringa oleifera</i> Lam.	Sohanjna (Drumstick tree)	Tree	Leaves, seeds, flowers	Immune booster, diabetes, cardiac health	79	29.1 / 27.8
15	<i>Anethum graveolens</i> L.	Soya, Dill weed	Herb	Seeds	Digestive aid, hypertension, fever	79	27.8 / 44.3
16	<i>Trachyspermum ammi</i> (L.) Sprague	Ajwain (Carom seeds)	Herb	Seeds	Digestive aid, cough, hypertension	79	55.6 (multiple benefits)
17	<i>Foeniculum vulgare</i> Mill.	Sonf, Saunf (Fennel)	Herb	Seeds	Digestive disorders, bloating, appetite control	79	92.4

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18	<i>Withania somnifera</i> (L.) Dunal	Ashwagandha (Axghandashwa)	Herb	Leaves, stems, seeds	Stress, tonic, immune health	79	73.4
19	<i>Zygophyllum arabicum</i> L.	Dhamasa	Herb	Stems	Tonic, diabetes, multipurpose	79	21.5
20	<i>Citrullus colocynthis</i> (L.) Schrad.	Kortuma, Bitter apple	Herb	Fruits, seeds	Diabetes, obesity, digestive disorders	79	73.4
21	<i>Senna occidentalis</i> (L.) Link	Chavver, Kasonji	Shrub	Leaves, seeds	Laxative, fever, detoxification	79	21.5
22	<i>Bauhinia variegata</i> L.	Kachnar	Tree	Leaves, flowers, seeds	Cough, digestive disorders, tonic	79	97.5
23	<i>Prosopis cineraria</i> (L.) Druce	Jhundi, Jandi, Kanda	Tree	Whole plant	Multipurpose; rare medicinal use	79	Very low (mostly "don't know")
24	<i>Haloxylon salicornicum</i> (Moq.) Bunge ex Boiss.	Laana	Shrub	Whole plant	Tonic, multipurpose	79	49.4
25	<i>Salvadora oleoides</i> Decne.	Khabbar, Peelu	Shrub	Whole plant	Diabetes, tonic	79	98.7
26	<i>Vachellia nilotica</i> (L.) P.J.H.Hurter & Mabb.	Kikar, Babul	Tree	Seeds, flowers	Digestive disorders, diabetes, tonic	79	63.3 / 30.4
27	<i>Azadirachta indica</i> A.Juss.	Neem	Tree	Leaves, fruits	Skin infections, antimicrobial	79	75.9
28	<i>Capparis decidua</i> (Forssk.) Edgew.	Kavir	Shrub	Fruits, leaves	Digestive, tonic	79	11.4 (low consensus)
29	<i>Phoenix dactylifera</i> L.	Khajoor, Date palm	Tree	Fruits, pits	Heart health, nutrition	79	46.8
30	<i>Chenopodium album</i> L.	Bathu	Herb	Whole plant	Diabetes, digestive, tonic	79	54.4
31	<i>Withania coagulans</i> (Stocks) Dunal	Paneer	Herb	Fruits	Diabetes, heart tonic, immune booster	79	31.6 / 55.7
32	<i>Datura innoxia</i> Mill.	Datura	Herb	Seeds, leaves	Analgesic, sedative, ritual use	79	11.4 (low consensus)
33	<i>Solanum virginianum</i> L. (= <i>S. xanthocarpum</i>)	Dhelon, Choto-baigan	Herb	Fruits	Respiratory issues, diabetes, tonic	79	7.6
34	<i>Convolvulus prostratus</i> Forssk.	Hiran booti	Herb	Whole plant	Memory aid, tonic	79	20.3
35	<i>Cleome brachycarpa</i> Vahl ex DC.	Kastoori	Herb	Seeds	Digestive aid, tonic	79	21.5
36	<i>Cucumis melo</i> L. (var. <i>agrestis</i>)	Chibbar, Melon	Herb	Fruits, leaves	Heart disease, diabetes, digestion	79	29.1
37	<i>Heliotropium indicum</i> L.	Hathi sundi	Herb	Whole plant	Wounds, infections, tonic	79	5.1 (low consensus)
38	<i>Melilotus indicus</i> (L.) All.	Senji	Herb	Whole plant	Tonic, digestive	79	12.7

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39	<i>Vachellia jacquemontii</i> (Benth.) Ali (= <i>Acacia jacquemontii</i>)	Banwali	Shrub	Whole plant	Diabetes, tonic	79	5.1
40	<i>Portulaca oleracea</i> L.	Kulfa, Lonak (Purslane)	Herb	Whole plant	Cooling, scurvy prevention, heart health	79	11.4
41	<i>Leptadenia pyrotechnica</i> (Forssk.) Decne.	Khimp, Khipp	Shrub	Whole plant, fruits	Tonic, multipurpose	79	17.7
42	<i>Eleusine coracana</i> (L.) Gaertn.	Raggi (Finger millet)	Herb	Seeds	Digestive health, multipurpose	79	29.1
43	<i>Asphodelus tenuifolius</i> Cav.	Piazi	Herb	Seeds	Fodder, rarely cited medicinal	79	“Don’t know” (100%)
44	<i>Blepharis scindica</i> Stocks ex T.Anderson	Gandi booti	Shrub	Seeds	Tonic, multipurpose	79	“Don’t know” (100%)
45	<i>Calligonum polygonoides</i> L.	Phog	Shrub	Whole plant	Tonic, fuel, multipurpose	79	17.7
46	<i>Lycium depressum</i> Stocks	Chirchitta, Ganger	Shrub	Fruits	Tonic, multipurpose	79	11.4
47	<i>Echinops echinatus</i> Roxb.	Unt Katara	Herb	Whole plant	Digestive disorders, tonic	79	25.3
48	<i>Euphorbia prostrata</i> Aiton	Hazar Dani	Herb	Fruits	Digestive aid, multipurpose	79	12.7
49	<i>Launaea nudicaulis</i> (L.) Hook.f.	Bhattal	Herb	Whole plant	Tonic, multipurpose	79	13.9
50	<i>Euphorbia hirta</i> L.	Dudhani	Herb	Whole plant	Respiratory aid, tonic	79	11.4
51	<i>Aerva javanica</i> (Burm.f.) Juss. ex Schult.	Bhoe	Shrub	Whole plant	Multipurpose, rarely medicinal	79	1.3
52	<i>Ziziphus nummularia</i> (Burm.f.) Wight & Arn.	Beri	Shrub	Fruits, leaves	Diabetes, tonic, heart	79	30.4
53	<i>Tribulus terrestris</i> L.	Gokhru, Bhakra	Herb	Whole plant	Urogenital health, tonic	79	12.7
54	<i>Nerium oleander</i> L.	Kaner booti	Shrub	Whole plant	Toxic, ritual, limited medicinal	79	11.4
55	<i>Phalaris canariensis</i> L.	Cangni (Canary grass)	Herb	Seeds	Multipurpose; few medicinal reports	79	“Don’t know” dominant
56	<i>Trianthema portulacastrum</i> L.	Itsit (Pigweed)	Herb	Whole plant	Diabetes, digestive aid	79	31.6
57	<i>Xanthium strumarium</i> L.	Cocklebur	Shrub	Whole plant	Skin disorders, tonic	79	17.7
58	<i>Cenchrus echinatus</i> L.	Loot (Sandbur)	Herb	Whole plant	Fodder, rare medicinal	79	“Don’t know” (100%)
59	<i>Benincasa hispida</i>	Tindy (Ash gourd)	Herb	Fruits	Digestive disorders, diabetes	79	41.8
60	<i>Salvadora persica</i> L.	Pilu (Toothbrush tree)	Shrub	Fruits, twigs, roots	Oral health, tonic	79	38

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61	<i>Agaricus bisporus</i> (J.E. Lange) Imbach	Khumbi (Button mushroom)	Fungus	Fruiting body	Nutritional food; limited medicinal	79	Low (nutritional focus)
62	<i>Cordia myxa</i> L.	Lasoor	Tree	Leaves, fruits	Respiratory relief, digestive, tonic	79	31.6
63	<i>Albizia lebbek</i> (L.) Benth.	Shareen, Frywood, Koko	Tree	Seeds, leaves, bark	Respiratory aid, skin, tonic	79	6.3
64	<i>Morus alba</i> L.	Shehtoot (White mulberry)	Tree	Leaves, fruits, stems	Diabetes, cardiac health, tonic	79	29.1
65	<i>Eucalyptus globulus</i> Labill.	Safeda	Tree	Leaves, seeds	Cough, cold, fever, antimicrobial	79	1.3
66	<i>Melia azedarach</i> L.	Draiek (Chinaberry)	Tree	Leaves, fruits	Antimicrobial, tonic (low consensus)	79	21.5
67	<i>Lagenaria siceraria</i> (Molina) Standl.	Kaddu (Bottle gourd)	Herb	Fruits	Diabetes, heart, tonic	79	30.4
68	<i>Brassica rapa</i> L.	Shalgam (Turnip)	Herb	Root	Diabetes, digestive disorders	79	32.9
69	<i>Ocimum basilicum</i> L.	Tukhm-e-Malanga, Tulsi (Basil)	Herb	Seeds, leaves	Heart tonic, digestive	79	94.9
70	<i>Raphanus sativus</i> (L.) Domin	Mooli (Radish)	Herb	Root	Digestive aid, tonic	79	26.6
71	<i>Ficus religiosa</i> L.	Pipal	Tree	Leaves, fruits	Spiritual/ritual, tonic	79	11.4
72	<i>Spinacia oleracea</i> L.	Palak (Spinach)	Herb	Leaves	Nutrition, anemia, tonic	79	General use (not medicinal)
73	<i>Amaranthus viridis</i> L.	Tandula (Amaranth)	Herb	Leaves, stems	Diabetes, hypertension, tonic	79	Variable (low consensus)
74	<i>Solanum nigrum</i> L.	Mako (Black nightshade)	Herb	Leaves, fruits	Anti-inflammatory, digestive, tonic	79	Moderate
75	<i>Peganum harmala</i> L.	Esfand (Harmal, Syrian rue)	Herb	Seeds	Antimicrobial, ritual, digestive aid	79	Moderate

Notes:

Scientific names were verified and standardized using World Flora Online (WFO, 2023) and the Medicinal Plant Names Services (MPNS). Synonyms are indicated where applicable. Plant habit categories: Herb, Shrub, Tree, and Fungus (for *Agaricus bisporus*). "Part(s) used" reflects the most frequently reported plant organs cited by informants. "Primary cited uses" summarize the most common ethnomedicinal applications as reported by respondents; multipurpose or unspecified uses are indicated as "tonic" or "multiple benefits." Fidelity Level (FL%) values are based on the number of informants citing a species for a specific ailment category relative to total citations. Where multiple values are given, they reflect distinct major ailment categories. Species where informants responded predominantly "Don't know" are listed with minimal or no FL% values; these were excluded from quantitative ethnobotanical indices but retained for completeness. Non-medicinal but culturally or nutritionally significant species (e.g., *Spinacia oleracea*, *Agaricus bisporus*) are included to reflect local ethnobotanical knowledge.

Supplementary Text S1: Extended ethnomedicinal descriptions of selected medicinal plants

- 1. Garlic (Lehson):** Garlic, or *Allium sativum*, is widely used for various purposes among the rural communities. It is mainly used as the focal point of chutneys and as a taste enhancer in recipes. A traditional Indian cuisine, chit, made by cooking cumin seeds, ginger, garlic, and green chillies in clarified butter (ghee), is one example of this type of food. This method is also used to blend spices for cooking and to preserve pickles. It helps reduce cholesterol and blood pressure and relieve cold symptoms, while also improving digestive and immune health (Tsfaye & Mengesha, 2015).
 - 2. Ginger (Adrak):** Ginger, or *Zingiber officinale*, is locally known as "adrak" in Pakistan. It is employed as a potent taste enhancer and fragrant element in many culinary preparations. It is also used by local people as an ingredient in tea to help reduce body weight, lower blood pressure, and relieve pregnancy-induced nausea and vomiting. Ginger is good for digestive health and also for the menstruating women as it alleviates menstruation pain (Shahrajabian *et al.* 2019). Its use in digestive and cardiovascular health was related to its anti-inflammatory and antiemetic properties (Shahrajabian *et al.* 2019).
 - 3. Giant calotrope (Aak):** The giant calotrope, or *Calotropis gigantea*, is commonly known as Aak or Madar in Pakistani culture. Different parts of this plant, such as stems, leaves, roots, and latex, have traditionally been used to treat wounds, constipation, indigestion, pain, fever, nausea, vomiting, gout, snakebite, cancer, and skin complications. Its stem is a rich source of fiber which is used to make various products, including crafts, ropes, and certain coarse fabrics (Sarkar *et al.* 2014).
 - 4. Jujube (Unab):** *Ziziphus jujuba*, often called Unab or jujube in South Punjab, Pakistan, is a fruit commonly eaten as a snack and as an ingredient of fruit salads. These fruits are frequently consumed with baked items like bread and used in the manufacturing of spreads and preservatives. They are also commonly used in a wide range of pies and puddings. Unab is used to treat depression, insomnia (sleeplessness), stress, and indigestion, as well as to strengthen the immune, nervous, and intestinal systems (Liu *et al.* 2021).
 - 5. Black cumin:** *Nigella sativa*, the scientific name of black cumin or Kalonji, is usually mixed with the dough before baking in flatbread preparation. It is also used as a taste enhancer in the cooking of vegetable and lentil-based soups. Many rural individuals rely on black cumin for its therapeutic properties and use it to manage obesity, digestive problems, hepatic disorders, gastric ulcers, cancer, hypercholesterolemia, inflammation, hyperglycemia, and harmful microbial populations (Srinivasan, 2018). Traditional use for metabolic and cardiovascular health was linked to its antihyperglycemic, antihypertensive, and antioxidant effects supported by multiple studies (Srinivasan, 2018).
 - 6. Fenugreek:** Fenugreek, or *Trigonella foenum-graecum*, is commonly referred to as methraa, methi, or methray in Pakistani local communities. The unique flavour and aroma of dried fenugreek leaves make it an effective ingredient for rural inhabitants to use in preparing diverse recipes, particularly vegetable-based curries and stews. Traditionally, it is also used in several at-home skincare routines to reduce acne, wrinkles, scars, and inflammation. Fenugreek treats gastritis and constipation and helps regulate appetite, blood sugar, and blood pressure to maintain normal human physiology (Yadav & Baquer, 2014). Its application in diabetes and inflammation was connected to its role in regulating blood glucose and lipid profiles (Yadav & Baquer, 2014).
 - 7. Amaltas:** The most frequent tree in South Punjab is the amaltas, also known as the Golden Shower (scientific name: *Cassia fistula*), which grows out of control in government and educational structures. Its fruit, pod, and pulp are used to taste tobacco, while its blossoms are used to adorn hairstyles. Additionally, its leaves are used to make an herbal tea that aids digestion, and its roasted seeds are eaten as a snack. Its aesthetic value is evident as an ornamental tree along roadways and roadways. Moreover, it is conventionally used to treat infections, fever, and constipation, as well as to balance an acidic pH and promote digestive health by removing waste from the stomach (Tanveer *et al.* 2019).
 - 8. Ispaghol:** Isabgol, also known as ispaghol, *Plantago ovata*, or psyllium husk, is widely used traditionally as well as radically among the rural and urban communities of Pakistan. It is used as a thickener for foods such as ice cream and other frozen desserts. It is a well-known practice in many homes to cook isabgol in milk to prepare "Kheer." Additionally, it exfoliates the skin when combined with green tea and banana peel in various skincare products. Isabgol supports heart and digestive health by lowering cholesterol and treating constipation and acidity. Interestingly, making you feel fuller for longer helps you lose weight. Additionally, it helps prevent several cancers, including colon cancer (Verma & Mogra, 2013).
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9. **Coriander (Dhania):** Parsley, Coriander, or Cilantro (*Coriandrum sativum*), commonly known as Dhania, is a renowned herb in the traditional cuisines of Pakistan. Coriander leaves garnish and flavour multiple dishes, such as biryanis, curries, salads, chaats, and chutneys. It is also used to make a refreshing drink called dhania pani and herbal tea with mint, lemon, and honey, which is believed to have cooling and detoxifying effects in the body. Moreover, it is used to make a paste with green chillies, garlic, and salt to treat hair loss and dandruff. Parsley is widely used to make a poultice with turmeric and mustard oil, which is applied to wounds and skin infections to promote healing and prevent disease. Coriander helps relieve indigestion, bloating, chest pain, and coughs, and also lowers blood sugar levels and helps prevent diabetes. This herb supports heart, brain, and gut health by improving memory and promoting digestion (Nadeem et al. 2013).
10. **Flaxseeds (Aalsi):** Flaxseeds or linseeds, mostly called Aalsi, are scientifically referred to as *Linum usitatissimum*. They are roasted and ground into a powder, which is then mixed with salt, red chilli powder, and other spices to make a dry chutney or podi. Linseeds are soaked in water overnight to make porridge or kheer, a popular breakfast or dessert, especially given to new mothers to increase milk production and support recovery. Its oil, extracted from the seeds by cold pressing, is used for cooking or as a salad dressing. Moreover, the oil is applied to the skin and hair as a moisturiser and conditioner for various skin problems, such as eczema, psoriasis, acne, and burns. It helps manage weight, reduce cholesterol levels, and support heart, reproductive, and digestive health. Furthermore, it reduces cancer severity and prevents diabetes by stabilising blood sugar levels (Fadzir et al. 2018; Ansari et al. 2019).
11. **Spearmint (Podina):** Spearmint, locally known as Podina in South Punjab, is scientifically referred to as *Mentha spicata*. It adds traditional minty flavour to meals, including chutneys and salads. They are also used in "pudina chai," a popular beverage consumed after a meal. Pudina's fragrance is also a natural insect repellent, used outdoors and in fields. It helps treat indigestion, nausea, and heartburn, while also strengthening the immune system, reducing cold symptoms, and managing stress and anxiety (Mahendran et al. 2021; Yousuf et al. 2013).
12. **Miracle tree (Sohanjna):** Drumstick trees are also known as Sohanjna (*Moringa oleifera*). Moringa tea is a popular beverage for weight loss, which is made by boiling one teaspoon of Moringa powder, one pinch of cinnamon, and one pinch of garlic in water. Moringa powder is commonly used in skincare products like scrubs and face masks. "Qeema Sohanjna," is prepared by adding moringa flowers, spices, meat, and oil in Pakistani cuisine. Taking one teaspoon of Moringa powder in lukewarm water daily may help reduce joint pain in older adults. It is beneficial for controlling diabetes, addressing long-lasting inflammation, and treating bacterial, viral, and fungal infections. Moringa is also suitable for preventing joint pain and rheumatoid arthritis, and it helps protect the liver against nonalcoholic fatty liver disease (Islam et al. 2021; Meireles et al. 2020).
13. **Soy:** Soy, or soybean, known as *Glycine max* and *Anethum graveolens*, is used as a snack by boiling and mixing it with different spices. They are also added to curries and stews for flavour and aroma. Soybean oil is a significant product of soy used in frying. It is used in many traditionally manufactured textile-based products. Many dairy products, such as soy milk, are also used by lactose-intolerant individuals. It improves bone health, lowers blood pressure, and reduces the risk of certain cancers. Moreover, it helps manage hormones and supports reproductive health (Dukariya et al. 2020).
14. **Carom seeds (Ajwain):** The scientific term for carom seeds, sometimes referred to as ajwain locally, is *Trachyspermum ammi* L. They may be roasted in oil and ghee and used as flavouring agents in pickles and lentils. Its detox teas or waters are frequently used in weight-loss therapies to prevent bloating and indigestion. It is possible to extract carom oil from carom seeds and use it to treat stomach issues. Ajwain also lowers blood pressure, treats infections, and eases coughing. It is also an effective treatment for toothaches and asthma (Asif et al. 2014).
15. **Fennel (Sonf):** Fennel seeds, locally known as Sonf in South Punjab, are scientifically called *Foeniculum vulgare*. These are used as natural mouth fresheners, flavouring, and aromatic agents in the cooking of traditional sweets, deserts, herbal tea, curries, and pickles. It is conventionally used to reduce weight, appetite, heart disorders, inflammation. Moreover, it exhibits antibacterial properties, regulates blood pressure, improves eyesight, and relieves constipation (Rather et al. 2016). Its digestive benefits were tied to antispasmodic and carminative effects (Rather et al. 2016).
16. **Sesame (Til):** Sesame, or *Sesamum indicum*, is commonly known as Til in the local communities of Pakistan. As an energy-dense ingredient, sesame is widely used as a garnish in various recipes, including energy balls, chapatti (Nan), gajak, and laddos. Its oil can be a nourishing agent that hydrates the skin and helps repair damage. Moreover, its raw form can be

used in curries or gravies. Besides, it helps control blood sugar and reduces blood pressure and cholesterol levels. It can fight against infections and prevent cancer (Wei *et al.* 2022).

17. **Harmal (Esfand):** In Pakistan, the plant recognised by the name Esfand is Harmal, sometimes referred to as Syrian rue or *Peganum harmala* in science. It is a common ingredient in recipes meant to soothe upset stomachs. Harmal seeds may be burned to generate smoke, which keeps insects away. It can also be taken as an antidepressant to ease pain and tension. Harmal fights against infections by acting as an antibacterial agent (Shahrajabian *et al.* 2021).
18. **Bahuphali :** Bahuphali, or *Corchorus depressus* Linn., is referred to as Khurand, Boh phali or Bah phali. It lowers blood sugar and cholesterol levels, strengthens the immune system, and promotes heart health. It also treats various digestive health conditions, including bloating, diarrhoea, and constipation; cough; chronic cystitis; gonorrhoea; piles; and sexual abnormalities (Kumari *et al.* 2019).
19. **Spinach (Palak):** Spinach, or *Spinacia oleracea*, is commonly named Palak or Lahori Palak. It is commonly used in Pakistani dishes such as Pakorey, Palak parathay, Alu Palak, and Palak ghosht. It is traditionally used to increase appetite, for coughs, and for fevers. Additionally, it is considered a blood builder that nourishes the red blood cells (RBCs). Besides these uses, Palak is good for eye and heart health. It boosts immunity and is a natural laxative (Nayik & Gull, 2020; Roberts & Moreau, 2016).
20. **Amaranthus (Tandula):** *Amaranthus viridis*, also known as Tandula, lowers cholesterol and blood pressure, helping to reduce the prevalence of diabetes mellitus and cardiovascular disorders. Moreover, it is helpful for treating fever, asthma, dysentery, and various urinary tract infections. Amaranth helps to prevent cancer, improves digestion, and is a useful gluten-free option for celiac disease patients, as it can be used in various snacks and cereals (Ganjare & Raut, 2019; Abdulwaliyu *et al.* 2023).
21. **Purslane (Kulfa):** Common purslane is scientifically named *Portulaca oleracea*. It is commonly known as Kulfa or Lonak. It is traditionally used in making sauces because of its slightly sour or salty taste. Kulfa is cooked with potatoes or sometimes individually. Moreover, it is given to households as a diuretic and antibacterial plant. It boosts immunity and is considered the best remedy for scurvy, a disease that prevails daily. It is used in salads and soups and can be eaten raw or cooked. It shows benefits, including increased immunity and improved eye health. It is also suitable for bone health. It lowers the risk of cancer, diabetes, and hypertension. It also treats digestive problems, *e.g.*, constipation and diarrhoea. Common purslane contains a high number of oxalates. People with a history of kidney stones avoid taking this herb (Sultana & Rahman, 2013).
22. **Black Nightshade (Mako):** Black nightshade is scientifically known as *Solanum nigrum*. It is commonly known as Mako. Mako cannot be eaten raw because it contains toxins in its unripe form, and its fruits and leaves are used to make curry and soups. It has many health benefits, such as boosting the immune system and reducing inflammation; it also helps prevent arthritis pain and has pain-relieving properties. It is also used to treat stomach issues like indigestion and diarrhoea. It is also used to treat asthma. It contains a chemical called solanine, which is primarily present in green leaves and unripe fruit, so it is necessary to take precautions when using this herb (Chen *et al.* 2022).
23. **Castor plant (Arand):** The castor plant is scientifically called *Ricinus communis*. It is commonly named Arand. Castor oil extracted from castor beans is used to treat various ailments. It is used as a massage oil to relieve pain and improve circulation. It is a powerful laxative and has been used to treat constipation; it is also used for various skin conditions, such as eczema. It is also used to treat malaria and snake bites. It is generally safe, but care should be taken because of its strong laxative effect. The health benefits of the castor plant include relieving constipation, benefiting the skin and treating various skin problems, supporting hair care and promoting hair growth, and increasing immunity (Chouhan *et al.* 2021).
24. **Arugula (Taramira):** Arugula is scientifically called *Eruca sativa* and is commonly called Taramira. It is used in salads, stews, and stir-fries. It has a peppery and salty flavour and can be added to salads and soups. It is also used in making sauces. Moreover, it is used as a tonic to improve overall health. It is used to treat fever, cough, and inflammation and prevent anemia. Finally, it aids digestion, reduces inflammation and improves bone, skin, and heart health (Yaniv & Dudai, 2014).

25. **Bhakra:** Bakhra, scientifically called *Tribulus terrestris*, is commonly named Gokhru or Bhakra. It is not commonly used in its raw form because of its bitter taste, but it can be used cooked. Its fruit is used in making curry and soups. It helps control blood sugar levels, supports kidney health (including reducing the risk of urinary tract infections and kidney stones), boosts the immune system, and improves athletic performance. It has also been used to reduce inflammation and is generally safe to consume (Gunarathne *et al.* 2023).
26. **Kharasan thorn (Dhamasa) :** Kharasan thorn or Dhamasa, scientifically known as *Zygophyllum arabicum* (formerly known as *Fagonia arabica*), is not recommended to be consumed in its raw form because of its bitter taste. However, its cooked leaves can be used in making dishes. It also acts as a blood purifier and effectively treats hepatitis, polycystic ovarian syndrome, and cancers (Rajani *et al.* 2022).
27. **Bitter apple (Kor Tuma) :** In popular culture, the scientific term for bitter apple, *Citrullus colocynthis*, is often known as Kor Tuma. It is not edible because of its bitter flavour; boiling and drying make it palatable. Its fruit is used to make chutneys, jams, and jellies; its powder is used as a spice. It has several health benefits, including relieving tense muscles and helping with digestive issues such as gas, bloating, constipation, and indigestion. Additionally, it is a helpful herb for liver conditions such as jaundice. Diabetes, hypertension, and leukaemia are all treated using kor tuna. It is a component of several treatments for malignant tumors. Nevertheless, caution should be exercised when utilising this herb's potent laxative properties (Li *et al.* 2022).
28. **Indian Rennet (Paneer):** *Withania coagulans*, the scientific name for Indian rennet, is often known as paneer or dodi in popular culture. It is used to make paneer cheese because it may coagulate milk. It helps treat diabetes and reduce episodes of elevated blood sugar. It is also used to treat asthma, reduce tension, and promote wound healing when applied topically. It is helpful for women who experience irregular periods. Additionally, paneer is beneficial in treating headaches, fevers, coughs, colds, and bronchitis (Khan *et al.* 2021).
29. **Gum Arabic (Keekar Phali):** The gum Arabic tree is scientifically known as *Vachellia nilotica* and is commonly named Keekar Phali (Ahmed 2018). It has traditionally been used as a food additive, such as an emulsifier and stabiliser, in beverages, candies, and confectionery products. It is also a pharmaceutical ingredient used as a coating and binding agent in tablets and syrups. It is also used in printing, painting, and adhesives. It is also used in making drinks, sauces, mouthwash, and medicines. Keekar Phali is used to manage irritable bowel syndrome and support gut health. It promotes heart health and lowers cholesterol. It suppresses appetite and makes you fuller for longer (Ali, 2018).
30. **Indian lilac (Neem Phali):** Neem Phali is the popular name for Indian lilac, which is formally known as *Azadirachta indica*. There are several uses for neem oil, water, twigs, leaves, and bark. Skin disorders, including eczema and acne, are treated using its oil. For dental health, twigs are beneficial. Its bark is also ground into powder and applied topically to treat wounds. It possesses antibacterial, antifungal, anti-inflammatory, and antioxidant qualities. It strengthens the immune system and protects against infection. It could help to avoid cancer. In addition to treating malaria and nourishing hair, neem phalie also supports the health of the mouth, skin, digestive system, and respiratory system (Islas *et al.* 2020). Islas *et al.* (2020) linked its antimicrobial and anti-inflammatory uses to its rich profile of bioactive compounds.
31. **Australian cowplant (Gurmar Booti) :** Scientifically known as *Gymnema sylvestre*, the australian cowplant is also called Gurmar Booti. It has long been part of traditional medicine. Its constituents, known as gymnemic acids, have been demonstrated to improve insulin sensitivity and control diabetes. Controlling sweet cravings, reducing the taste of sweetness, and controlling appetite are also used to aid in weight loss. Because of its antioxidant and anti-inflammatory properties, it could also help reduce inflammation. Lastly, it reduces cholesterol and helps treat viral infections, allergies, and eye and heart health (Laha & Paul, 2019; Di Fabio *et al.* 2015).
32. **Kheep (Khipp):** *Leptadenia pyrotechnica*, the scientific name for Kheep, is more widely known as Khipp or Khimp. It can be eaten fresh, dried, or cooked, and is a common ingredient in salads, stews, and soups. Its roots are used to treat wounds and skin problems, and its seeds may be ground into flour. Moreover, oil is also made from seeds. Their roots and leaves, which are rich in nutrients, can cause cuts and skin problems. It is rich in nutrients because of the animals. In addition to manufacturing soap, mending fences, and providing cattle with fodder, it is also known as contents. Its qualities include antibacterial, anticancer, and antioxidant activities, as well as modest hepatoprotective activity (Idrees *et al.* 2016; Verma *et al.* 2014).

33. **Firebush (phog)** : Firebush, scientifically called *Calligonum polygonoides*, is commonly named Phog. Its flowers and buds are used to make pickles because they are edible and can be eaten raw or cooked. It is a fuel source because its dense stem wood burns well and is used to make furniture and baskets. This plant can be used as forage for livestock and has many medicinal properties, like anti-inflammatory and analgesic properties. It has some digestive and tonic properties and may help with asthma, coughs, and colds. It also manages arthritis, inflammatory bowel disease, and blood sugar levels. Phog promotes wound healing and boosts the immune system (Samejo *et al.* 2013).
34. **Buckbush**: Buckbush is scientifically called *Kali tragus*. Its berries are used to make jam and jellies and as dyes, because they produce a variety of colours. This plant is also used to prevent erosion. Its medicinal applications include treating skin conditions such as eczema, psoriasis, and acne and respiratory conditions such as asthma, bronchitis, and coughs. Buckbush is also used to treat digestive problems such as diarrhoea, constipation, and indigestion (Akrami-Dizaj & Sarabi, 2020).
35. **Slender dwarf morning-glory (Kari Booti)**: Slender dwarf morning glory is scientifically called *Evolvulus alsinoides* and is commonly named Kari Booti. Its stem is used as a ground cover to prevent soil erosion. It also suppresses weed growth. It is used to treat fever, enhance memory and learning, improve concentration, and treat patients with Alzheimer's disease. It has a calming effect, reducing stress and anxiety. It also improves mood and reduces the symptoms of depression. Due to its anti-inflammatory properties, it is beneficial for arthritis, asthma, and inflammatory bowel disease (Kathirvel *et al.* 2021).
36. **Monarch redstem (Krand)**: Monarch redstem, scientifically called *Ammannia baccifera*, is commonly named Krand. Its leaves are added to the curries, saag (cooked greens), and lentils to impart flavour. Moreover, its bark or red stems are used as a natural dye in the textile industry. It helps treat indigestion, stomach pain, constipation, and excessive flatulence, and is also beneficial for removing phlegm from the lungs and trachea. It is used to treat tuberculosis and typhoid fever, and to treat rheumatic pain (Loganayaki *et al.*, 2012).
37. **Purslane (Itsit)**: The Portulaca, Itsit, or Wisa plant is technically called *Trianthema portulacastrum*. Dressings, stews, and soups are made with it. As a dye, it is employed. There are occasions when it is fed to chickens. The anti-ageing effects of purslane are used in cosmetics. It also supports heart health and decreases blood pressure, cholesterol, and blood sugar. Finally, research has demonstrated that it reduces the risk of cancer, improves bone health, and benefits eye and immune health (Kumar *et al.* 2022).
38. **Donkeybur (Cocklebur)**: Donkeybur, sometimes called heartleaf or cocklebur, is a plant whose scientific name is *Xanthium strumarium*. It is believed to relieve constipation and promote digestion. Additionally, it helps relieve discomfort associated with migraines, muscle aches, and cramps during menstruation. Other possible advantages of this well-known plant include enhanced immunity and improved cardiovascular health. It can also cause yellow colouring inside the seed pods. The plant's traditional uses include its fruit, prickly burrs, and hitching rides on fur, hair, and clothes (Fazli Khuda *et al.* 2012).
39. **Moonflower (Dhatoora)**: Moonflower, or Thornapples, is scientifically called *Datura wrightii*. This plant has analgesic properties and is used to treat pain from various conditions, including headaches, toothaches, and muscle aches. It also treats respiratory problems such as asthma, bronchitis, and coughs. Moonflowers are beneficial for treating mental health conditions such as anxiety, depression, and insomnia. Thornapple poisoning can cause a variety of serious side effects, including seizures, coma, and death. Care should be taken with this herb due to its toxicity (Maheshwari *et al.* 2013).
40. **Graham's groundsel (Sonki)**: Sonki is a popular common name for this herbal plant in South Punjab. Scientifically, it is known as *Senecio bombayensis*. It is used to treat worm infections and relieve pain. Some commoners also use it for irregular or painful menstrual periods (dysmenorrhea) and epilepsy treatment. When applied directly to the affected area, this medicinal plant stops dental bleeding. Sonki is also a tapping tool used for gum, Arabic, and resin production (Katta *et al.* 2017).
41. **Foxtail millet (Kangni)**: Kangni is the common name, and *Setaria italica* is the scientific name of this plant. Traditionally, it is used as a staple food in Pakistan. Bajray ki roti, porridge (daliya), Bajray k laddu, and Khichdi are famous millet dishes. Its leaves and straw are used as fodder for livestock. This is also used in making malt. Medically, this is beneficial for

maintaining a healthy heart. It may improve glycemic control and fasting glucose levels in patients with type 2 diabetes. It can also help to reduce muscular spasms (Muthamilarasan & Prasad, 2021).

42. **Indian Plum (Bair):** The scientific name for the Indian plum, also known as Indian jujube or Bair, is *Ziziphus mauritiana*. When fruit is eaten as a snack, blood glucose levels are lowered, and extra weight gain around the abdomen is decreased, either in its fresh or dried state. It is used to reduce diarrhoea and boost appetite. Both blood glucose levels and healing agents are decreased by it. Weight increases around the midsection. It promotes wound healing and skin renewal. In Pakistan, leaves were cooked in water and used to bathe the deceased, a religious practice of significance. Its leaves are applied topically to strengthen bones, improve healing, and cure dermatitis. Indian plum also supports weight reduction, builds bones, and improves digestion (Jha *et al.* 2023).
43. **Barley (Bajra):** Jao, or barley, has the scientific name *Hordeum vulgare*. It is a staple food comprising roti (Bajrey ki roti), stews, soups, and porridge (Daliya) (Märginean *et al.* 2021). Straws and leaves are used as fodder for livestock. Its flour is used in the most famous drink, "Sattu," made with jaggery, barley, and lemon (Boanta *et al.* 2019). Moreover, it is also used in brewing malt. It also makes sweets like Laddu, Halwa, and Barfi. It also benefits various skincare remedies, such as milk and honey. Due to its high fibre content, it reduces cholesterol and blood sugar levels and protects against heart disease and diabetes. It may also reduce hunger, aid weight loss, and improve digestion.
44. **Wheat (Gandum):** Gandum is the most common household item in Pakistan. *Triticum aestivum* is the scientific name of this plant. It is an essential part of the meal in Pakistan. It is consumed as roti, paratha, naan, or chapati. Moreover, it is used in various skincare remedies. Mixing wheat flour into yoghurt and applying it to your face, hands, and feet can help brighten your skin. It is used to make the famous Punjabi dish "Daliya," or wheat porridge. Wheat straw is used as fodder for livestock, mixed with mud in floor furnishing, and for the construction of mud houses. Wheat improves digestion and gut health and also helps prevent colon cancer. Wheat is a good source of all vitamins and minerals (Dhanavath *et al.* 2017).
45. **Ashwa Gandha (Askand):** *Withania somnifera* is its scientific name; Askand or Ashwagandha are the more popular ones. Askand is a common ingredient in herbal teas and beverages to relieve tension or anxiety. Most often, askand-based herbal tea is used to promote restful sleep. For both men and women, it is used to improve sexual performance. To treat arthritic pain and swelling topically, the paste is administered. To increase height during the early stages of growth, one tablespoon of Askand powder is ingested with lukewarm milk. A diuretic, it improves urine flow in disorders affecting the kidneys and bladder, and it is used to treat gout and arthritis. Along with lowering anxiety and sadness, it is also used as a stress reliever (Joshi & Joshi, 2021; Kaul & Wadhwa, 2017).
46. **Persian lilac (Draiek):** Darek is a common name, and its scientific name is *Melia azedarach*. Its leaves are ground, and the juice is applied to hair roots for dandruff, eczema, ringworms, and allergies. Its aqueous extract is applied to joints with gout or arthritis. Moreover, bark paste can also be used for this purpose. Five millilitres of fresh juice from its leaves are recommended for alleviating menstrual problems. In addition, leaves are burned as a natural insect repellent. Its wood is used for fuel and construction. Medically, it is used to reduce fever and to kill and expel parasites. Persian lilac acts as a pain reliever. There should be caution when using this herb, especially for pregnant women and patients with liver and kidney disease (Sharma & Paul, 2013; Kilmer, 2010).
47. **Nilgiri tree (Safeda):** It is commonly known as Safeda, and its scientific name is *Eucalyptus × Hybrida* Maiden. The wood of this tree is utilised as fuel. Because it is termite-resistant, people use its wood to make furniture, doors, and windows. Its leaves and branches are also used to craft baskets, artefacts, and paintings. Safeda trees are planted as windbreaks to shield crops from intense storms, enhance soil fertility, and prevent erosion. The flowers serve as a nectar source for honeybees, so beekeepers often place beehives near *Eucalyptus × Hybrida* trees to harvest honey. Medicine uses it for nasal congestion, colds, respiratory problems, pain relief, and stress reduction. At times, it functions as an immunity booster. This plant also promotes oral health, alleviates dry skin and scalp conditions, and exhibits antimicrobial properties (Salehi *et al.* 2019; Vecchio *et al.* 2016).
48. **Sabestan plum (Lasoor):** The scientific name for the plum is *Cordia myxa*, which is commonly known as Lasorsa. The fruit is a popular ingredient in Punjabi pickles. It addresses cough and chest complaints and contains gum or mucilage that helps treat cough, ulcers, and issues related to the chest and uterus. Locals often use it as a laxative to manage constipation. Boil Lasorsa in water and drink it to relieve a sore throat. The kernels of Lasorsa are used to treat symptoms

of ringworms, wounds, and ulcers. Additionally, Lasorsa exhibits some anti-inflammatory and analgesic properties (Al-Snafi, 2015).

49. **Woman's tongue tree (Shareen):** The plant, known by various names like Shirin, Shareen, Frywood, and Koko, has a scientific name of *Albizia lebbek*. Its leaves serve as feed for cattle. A paste made from its bark is used for wound healing and to treat colds, coughs, and allergies, including respiratory issues like asthma. This plant's wood is valuable and used to make furniture and handicrafts, as well as for tanning in the leather industry. Additionally, Shirin is commonly used for shade (Balkrishna et al. 2022; Verma et al. 2013).
50. **Mulberry (Shehtoot):** Shehtoot is commonly known as mulberry, and its scientific name is *Morus alba*. It is often used as a snack. The leaves of the mulberry tree are the feed for silkworms, so planting mulberry trees is encouraged. "Toot Sayah" is the extract of mulberry, a popular remedy for coughs, colds, and sore throats. Mulberry helps regulate blood sugar levels, promotes heart and gut health, increases metabolism, and boosts the immune system. Its use also helps prevent anaemia (Kadam et al. 2019; Yuan & Zhao, 2017).
51. **Bottle gourd (Kaddu) :** "Ghia kaddu" is commonly known as bottle gourd, and its scientific name is *Lagenaria siceraria*. It is often cooked with lentils or meat and served as "Kaddu Dal" or "Kaddu Qeema." A popular dish in Punjabi culture is "Kaddu ka Raita," where grated bottle gourd is boiled and mixed with yoghurt, salt, and black pepper. Additionally, "Kaddu ka Halwa" is a well-liked sweet dish. Dried bottle gourd serves as a sponge for cleaning utensils and other washing purposes. It is beneficial for managing fever, cough, and flu, helping boost the immune system, and preventing infections. Eating raw bottle gourd (long) in the morning promotes long and strong hair. Bottle gourd also promotes heart health, aids hydration due to its high water content, supports digestion and weight loss, and lowers acidity for patients. It is suitable for hypertensive patients as it has a low sodium content (Tyagi et al. 2017).
52. **Turnip (Shalgam):** The scientific name for turnips is *Brassica rapa*, commonly known as Shalgam. "Shalgam Ghosht" is a famous Pakistani dish made from turnips with added spices, onions, and tomatoes. Additionally, applying water extracted from boiling turnips to the skin can help alleviate symptoms of skin allergies. In Punjabi culture, fermented turnip (Kanji) is a popular drink made by fermenting turnips, mustard seeds, red chilli, and black salt. Medically, turnips strengthen the immune system and protect against infections. It aids digestion, prevents constipation, and supports strong bones due to its calcium content. Moreover, it improves heart health and overall well-being. Being low in calories also supports weight loss (Paul et al. 2019).
53. **Butterfly ash (Kachnar):** Camel's foot or mountain ebony are some Western names, while in South Punjab, it is known as Kachnar, with the scientific name *Bauhinia variegata*. Kachnar flowers are used in Pakistani cuisines, with the most famous dish being "Qeema kachnar." Kachnar wood is used to craft souvenirs and handicrafts, and its leaves are used as fodder for livestock and as green manure to enhance soil fertility. Medically, kachnar helps lower blood sugar levels and regulate diabetes. It also supports skin and hair health, boosts immunity, and aids in weight loss. Additionally, this plant has anti-cancer properties (Mali et al. 2007).
54. **Radish (Mooli):** Mooli is the common name, and the scientific name for this plant is *Raphanus sativus*. It is widely used in salads, sliced or tiny pieces known as "kachumbar" in Pakistan. Additionally, it is commonly used in pickles, known as "Mooli ka achar chutney." Stuffed parathas with radish, called "Mooli k parathay," are a favourite dish in Pakistan, especially in Punjab. Radish has several health benefits, including lowering the risk of diabetes and regulating blood sugar levels. It also helps to regulate liver function, reduce the risk of heart disease, support digestion, enhance body metabolism, and aid in weight loss. Radish may have anti-fungal properties; it is good for the skin and strengthens immunity (Gamba et al. 2021).
55. **Basil seeds (Tukhm e Malanga):** Basil seeds are commonly known as "Tukhm e Malanga." Their scientific name is *Ocimum basilicum*. Drink a teaspoon of basil seeds in warm water and half a teaspoon of honey to relieve a sore throat. Add a teaspoon of basil seeds to their daily water bottle for weight loss. It can also be used after soaking in water to help with indigestion, flatulence, and constipation. In Pakistan, they are often used in refreshing drinks with Jam-e-Shirin or Rooh Afza, and sometimes milk is added for extra energy. Tukhm Malanga is a popular addition to the favourite drink, "Faloodah." It helps regulate blood pressure, control blood sugar levels, boost immunity, and fight infections. It also helps prevent cancer, relieve stress, and address digestive issues such as acidity and heartburn. Additionally, it is good for the skin and hair and can support weight loss (Singletary, 2018).

56. **Morel mushroom (Khumbi):** *Agaricus bisporus* is the scientific name for the plant, generally called "Khumbi." It is used in various recipes, including rice, tomato-based curries, and filled parathas. It is also palatable as a condiment. This plant lowers cholesterol, strengthens heart health, and reduces the risk of cancer, among other health benefits. When pickled in oil and vinegar, it aids digestion, strengthens the immune system, and reduces inflammation. Those with arthritis benefit most from it (Usman *et al.* 2021a).
57. **Sacred fig (Pipal):** Pipal and *Ficus religiosa* are the different names for the sacred fig tree. People use its bark extract to lighten dark skin, reduce scars, and treat pigmentation. Additionally, the bark is ground into a fine powder and taken with water (about one gram) for heavy menstrual bleeding. Boiling two grammes of the same powder in a glass of water can help with diarrhoea by preventing dehydration. Medically, it is effective in treating loss of appetite and may help with coughs and asthma. The tree's properties include its ability to kill microbes, aid in wound healing, and reduce inflammation and joint pain. It is also useful in dealing with itching or eczema (Kumar *et al.* 2018).

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