

Traditional medicines of plant origin used for the treatment of inflammatory disorders in Pakistan: A review

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Abstract

OBJECTIVE: To pool data on ethnobotanical medicine for the treatment of inflammatory disorders in Pakistan.

METHODS: We reviewed 237 research publications based on data from the six provinces in Pakistan (Punjab = 85, Khyber Pakhtunkhwa = 65, Sindh = 15, Balochistan = 8, Gilgit Baltistan = 22, Azad Jammu and Kashmir = 42) published until June 2015 in various journals. This was achieved using seven online databases: ScienceDirect, Google, Google Scholar, PubMed, Wiley Online Library, Springer-Link, and MEDLINE. Data were analyzed from different perspectives.

RESULTS: People from Pakistan made use of 371 plant species belonging to 263 genera and 99 families for the treatment of inflammatory disorders. Plants from the Asteraceae family were used most often. Herbs were the dominant growth form. Leaves were the plant parts used most often. Decoctions were the main preparation method. Nine plant species were used most frequently in the

dwelling of most regions of Pakistan. A total of 111 plants were shown experimentally to have neither anti-arthritic nor anti-inflammatory activities, and 148 plant species were threatened. Eighty-four species had commercial importance. Twelve plant species were imported, and 25 plant species were exported, from Pakistan.

CONCLUSION: This review provides baseline data for plant species in Pakistan that have potential anti-inflammatory/anti-arthritic activities.

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Keywords: Inflammation; Anti-inflammatory agents; Anti-arthritic; Ethnobotanical; Market; Review

INTRODUCTION

Inflammation is a multifaceted biologic reaction of vascular tissues to detrimental stimuli. It is typified by redness, joint pain, stiffness, swollen joints, and diminished joint functioning. Acute inflammation is allied with augmented migration of leukocytes, capillary damage, and vascular permeability.¹ Chronic inflammation is a protracted, devastating immune-mediated condition² with genetic and environmental elements.³ Synthetic drugs such as non-steroidal anti-inflammatory drugs, disease-modifying anti-rheumatic drugs, and biologic agents can diminish acute and chronic inflammation.⁴ However, use of such agents can lead to adverse effects. Herbal therapies could have a better risk-benefit ratio.⁵ Also, herbal plants have several medicinally important chemical constituents that target multiple signaling pathways.⁶ Use of herbal medicine and plant-based drugs is growing on account of their low cost, easy availability, and negligible side effects.⁷

Nature has provided humans with a colossal treasure of herbal plants that have been used for treating illnesses.⁸ According to a World Health Organization report, more than three-quarters of the world population depends on traditional medicines of plant origin because they cannot afford synthetic medicines.⁹

Pakistan possesses \approx 6000 species of wild plants, of which nearly 400-600 have been said to be therapeutically important. Approximately 84% of Pakistan inhabitants use traditional medicines for their disorders.¹⁰ About 50 000-60 000 hakims (local healers) and a huge number of unregistered practitioners in the rural and distant hilly regions of Pakistan make use of > 200 plants as household remedies for curing numerous ailments.¹¹ Exploration of the anti-inflammatory potential of herbal medicines has yielded an enormous number of herbal extracts and polyherbal formulations that are employed to treat various inflammatory disorders.⁴ The prime aim of this review article was to pool data on ethnobotanical medicine (EBM) for the treatment of inflammatory disorders in Pakistan. We intended to answer the 10 major questions.

What is the distribution and geographic pattern of flora in Pakistan used for the treatment of inflammatory disorders?

Which plant species are used most often for the treatment of inflammatory disorders?

What are the growth forms of medicinal plants used for used for the treatment of inflammatory disorders?

Which plant parts are used most often in traditional medicine?

How are the remedies prepared and applied?

Which plant species are used most frequently for the treatment of inflammatory disorders in the different provinces of Pakistan?

What are the reported anti-inflammatory/anti-arthritic activities and herbal formulations/manufacturers of the plants used for the treatment of inflammatory disorders in Pakistan?

Which plant species have no pharmacologic activity against inflammatory/arthritis disorders?

Which plant species are marketed nationally and internationally?

What is the conservation status of the plant species used for used for the treatment of inflammatory disorders in Pakistan?

MATERIALS AND METHODS

We reviewed 237 research publications based on data from the six provinces in Pakistan (Punjab = 85, Khyber Pakhtunkhwa = 65, Sindh = 15, Balochistan = 8, Gilgit Baltistan = 22, Azad Jammu and Kashmir = 42) published until June 2015 in various journals. This was achieved using seven online databases: ScienceDirect, Google, Google Scholar, PubMed, Wiley Online Library, SpringerLink, and MEDLINE.

The search terms used were "medicinal plants", "ethno-

medicinal flora", "traditional plants", "districts", "Pakistan", "Punjab", "Balochistan", "Khyber Pakhtunkhwa", "Sindh", "Gilgit Baltistan" and "Azad Jammu and Kashmir". The term "Pakistan" and province names were used to limit the geographic scope of our search.

Selection of plants was focused on their use in the treatment of inflammation, rheumatism, joint pain, and joint swelling in folklore remedies. Data regarding inflammatory disorders in research articles on EBM investigations of each district of the provinces of Pakistan [i.e., Punjab (36 districts), Balochistan (32), Khyber Pakhtunkhwa (26), Sindh (29), Gilgit Baltistan (10), Azad Jammu and Kashmir (10)] was compiled. A "master list" was formulated that provided the botanical name, vernacular name(s), family, plant part used, growth form, and preparation method for the remedy.¹² The plant list was devised by counting each plant species only once if used in the different provinces of Pakistan for the treatment of inflammatory disorders.

The plants used by inhabitants of at least four provinces were considered to be those used most frequently. We searched the seven databases mentioned above for pharmacologic studies using plant species for the treatment of inflammatory disorders. Data regarding herbal formulations of commonly used plants was obtained from www.druginfosys.com/. Information concerning the conservation status and commercially valuable plant species used for the treatment of inflammatory/arthritis disorders was gathered from research articles.

The accuracy of the names of plant species provided in this review article are from the original sources. However, all scientific names were updated by consulting www.theplantlist.org and www.tropicos.org. In addition, some mistakes in family names were resolved according to information from www.theplantlist.org.

RESULTS

We reviewed the literature and collected data on the explored and unexplored regions of Pakistan. Ethnobotanical surveys have been reported from 30 districts of Punjab (Attock, Bahawalnagar, Bahawalpur, Bhakkar, Chakwal, Dera Ghazi Khan, Faisalabad, Gujranwala, Gujrat, Jhang, Jhelum, Kasur, Khushab, Lahore, Layyah, Lodhran, Mandi Bahauddin, Mianwali, Multan, Muzaffargarh, Narowal, Nankana Sahib, Pakpatan, Rajanpur, Rawalpindi, Sahiwal, Sargodha, Sialkot, Toba Tek Singh, Vehari); 12 districts of Balochistan (Awaran, Barkhan, Kachhi (Bolan), Chagai, Gwadar, Kalat, Khuzdar, Lasbela, Mastung, Musakhel, Quetta, Ziarat); 18 districts of Khyber Pakhtunkhwa (Abbottabad, Bannu, Battagram, Buner, Chitral, Dera Ismail Khan, Haripur, Karak, Kohat, Upper Kohistan, Lakki Marwat, Lower Dir, Malakand, Mansehra, Peshawar, Swat, Upper Dir, Lower Kohistan); 9 districts of Sindh (Ghotki, Jamshoro, Karachi, Khairpur, Sanghar, Sukkur, Tharparkar, Thatta, Karachi West); 7 districts of Gilgit Baltistan (Ghanche, Skardu, Astore, Diamer,

Ghizer, Gilgit, Hunza-nagar); 10 districts of Kashmir (Muzaffarabad, Hattian, Neelum, Mirpur, Bhimber, Kotli, Poonch, Bagh, Haveli, Sudhnati) and 11 agencies of Federally administered tribal areas (Khyber Agency, Kurram Agency, North Waziristan Agency, Orakzai Agency, South Waziristan Agency, FR Bannu, FR Dera Ismail Khan, FR Kohat, FR Lakki Marwat, FR Peshawar, FR Tank). On the other hand, 6 districts of Punjab (Chiniot, Hafizabad, Khanewal, Okara, Rahim Yar Khan, Sheikhpura), 20 districts of Balochistan (Dera Bugti, Harnai, Jafarabad, Jhal Magsi, Kech (Turbat), Kharan, Kohlu, Killa Abdullah, Killa Saifullah, Loralai, Nasirabad, Nushki, Panjgur, Pishin, Sherani, Sibi, Washuk, Zhob, Lehri, Sohbatpur); 8 districts of Khyber Pakhtunkhwa (Charsadda, Hangu, Mardan, Nowshera, Shangla, Swabi, Tank, Tor Ghar), 22 districts of Sindh (Badin, Dadu, Hyderabad, Jacobabad, Kashmore, Larkana, Matiari, Mirpurkhas, Naushahro Firoze, Shaheed Benazirabad, Kambar, Shahdadkot, Shikarpur, Tando Allahyar, Tando Muhammad Khan, Umerkot, Sujawal, Karachi Central, Karachi East, Karachi South, Korangi, Malir), 1 district of Gilgit Baltistan (Kharmang) and 2 agencies of Federally administered tribal areas (Bajaur Agency, Mohmand Agency) have not yet been investigated regarding traditional knowledge.

Diversity of medicinal plants

In total, 371 plant species belonging to 263 genera and 99 families reported as being used as traditional medicines in Pakistan to treat inflammatory disorders were noted. Of these, 192 plants were reported from Punjab, 116 from Khyber Pakhtunkhwa, 88 from Gilgit Baltistan, 85 from Azad Jammu and Kashmir, 22 from Sindh, and 17 from Balochistan. Many plant species were used in more than one province, so these plants were counted just once when listing plants from across Pakistan.

Distribution of medicinal plants

Considering the distribution of families, the EBM surveys have revealed that Asteraceae/Compositae occupied 39 species. Well represented families were Leguminosae/Fabaceae (20 species); Liliaceae/Apocynaceae/Asclepiadaceae/Asphodelaceae and Solanaceae (17 species each); Polygonaceae (16 species); Malvaceae (14 species) and Poaceae (11 species). Other families reported include Lamiaceae, Papilionaceae and Ranunculaceae (10 species each); Brassicaceae/Cruciferae and Moraceae (9 species each); Capparidaceae (7 species); Amaranthaceae, Apiaceae, Chenopodiaceae, Euphorbiaceae and Rosaceae (6 species each); Berberidaceae, Boraginaceae, Convolvulaceae and Verbenaceae (5 species each); Caesalpiniaceae, Primulaceae/Myrsinaceae/Ericaceae and Umbelliferae (4 species each); Anacardiaceae, Cactaceae, Cucurbitaceae, Cupressaceae, Ephedraceae, Geraniaceae, Labiatae, Papaveraceae/Fumariaceae, Pinaceae, Plantaginaceae, Scrophulariaceae, Urticaceae and

Zygophyllaceae (3 species each). The least signified families which consisted of 2 and 1 species each were a total of 61 families. These comprised Acanthaceae, Araceae, Balsaminaceae, Buxaceae, Cannabinaceae, Cuscutaceae, Cyperaceae, Fagaceae, Grossulariaceae, Helvelliaceae, Meliaceae, Mimosaceae, Moringaceae, Portulacaceae, Rutaceae, Rhamnaceae, Sapindaceae/Hippocastinaceae, Salvadoraceae, Saxifragaceae and Thymelaeaceae (2 species each) while, Acoraceae, Agavaceae, Araliaceae, Arecaceae, Aizoaceae, Betulaceae, Bombaceae, Caprifoliaceae, Caryophyllaceae, Colchicaceae, Combretaceae, Dryopteridaceae, Ebenaceae, Elaeagnaceae, Gentianaceae, Hypericaceae, Iridaceae, Juglandaceae, Lauraceae, Linaceae, Menispermaceae, Myrtaceae, Neuradaceae, Nyctaginaceae, Nymphaeaceae, Oleaceae, Onagraceae, Oxalidaceae, Paeoniaceae, Punicaceae, Rubiaceae, Salicaceae, Schizaeaceae, Tamaricaceae, Taxaceae, Tiliaceae, Valerianaceae, Vitaceae, Violaceae, Xanthorrhoeaceae and Zingiberaceae (1 specie each).

The distribution of medicinal plants in different families depicts the colossal "therapeutic flora" of Pakistan. Our results illustrate that many plant species used in Pakistan for inflammatory disorders belong to Asteraceae family.

Growth forms of medicinal plants

As regards the growth form of anti-inflammatory/anti-arthritic plant species mentioned in EBM reports, herb (116 species) was the highest prevailing growth habit. The next dominant life form was shrub (42 species), trailed by tree (25 species), sub-shrub (5 species), creeper and climber (2 species each). In the present study, the growth form was not mentioned for most of the plant species studied in the literature.

Plant parts used

Overall, we distinguished 28 plant parts to be used as herbal therapies for curing inflammatory disorders, with plant leaves being used most often (Figure 1). In the present study, however, the plant parts of six species were not mentioned in literature we evaluated. For many medicinal plants, two or more plant parts were used to treat inflammatory disorders.

Preparation methods and administration routes

Out of 371 medicinal plants used across Pakistan for treating inflammatory disorders, most of the preparations were used internally. Our evaluation of literature showed that indigenous people used 20 preparation methods to create medicinal formulations at home. Most medicinal formulations were consumed *via* oral route in the form of decoctions (Figure 2). We also found that many plant species were prepared by multiple procedures. Detailed preparation methods were mentioned rarely in most EBM reports; they consisted of lists of medicinal plants used and specified which plant parts were used for a particular disease.

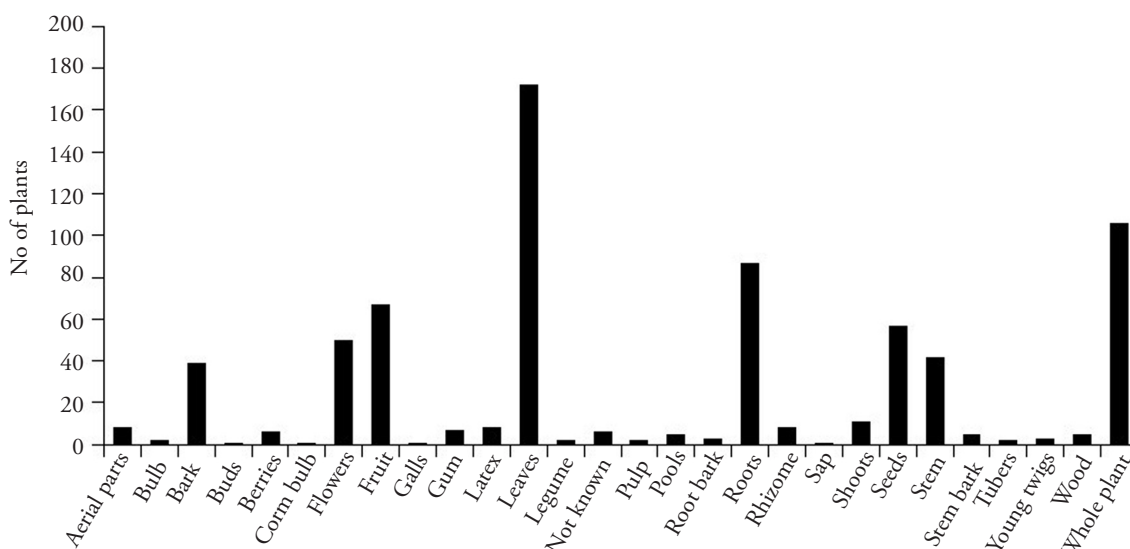


Figure 1 Use frequency of different plant parts. Numbers represent species

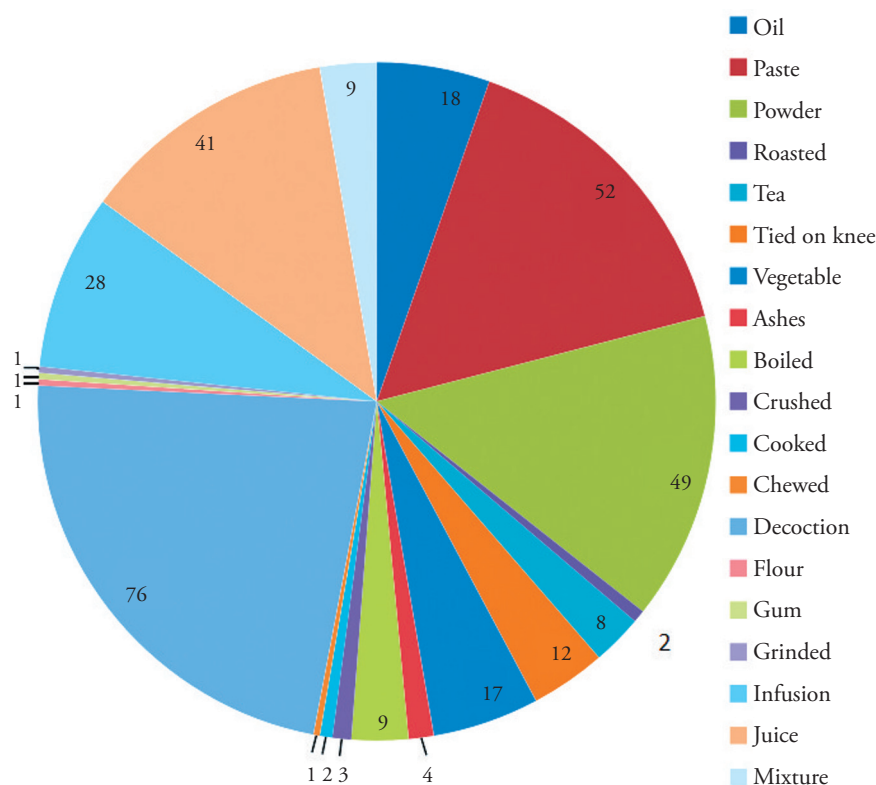


Figure 2 Use frequency of remedy preparation techniques. Numbers represent species

Plants used most frequently for the treatment of inflammatory disorders

Our literature survey revealed that some plant species were used principally for treatment of inflammatory disorders across Pakistan. Among 371 plant species being used, only those plants used by the inhabitants of at least four provinces of Pakistan (including Azad Jammu and Kashmir) were considered. The scientific evidence and herbal formulations of nine plants in Pakistan used most frequently by local people for inflammatory complaints is presented in Table 1. Furthermore, the preparation and sale of herbal formulations by various manufacturers in Pakistan showed

that most of them comprised more than one medicinal plant.

Plants lacking anti-inflammatory activity

Of all the medicinal plant species used to treat inflammatory disorders, 111 plants have neither been explored experimentally for anti-arthritic nor anti-inflammatory activities (Table 2).

Marketing and trade

Economic analyses of yield data (Table 3) revealed that, among 371 plant species used for treatment of in-

Table 1 Reported antiinflammatory/antiarthritic activities and herbal brands/manufacturers of most frequently used medicinal plants of Pakistan for inflammatory disorders

Botanical name of plants	Family	Part used	Distribution region	Ethnobotanical claim	Pharmacological evidence	Herbal brands/Manufacturers
Berberis lycium Royle.	Berberidaceae	Roots, fruit, leaves, bark, wood	Punjab KPK Gilgit Kashmir	Rheumatism ⁶⁹	-	Bukharin (Hamdard laboratories Waqf Pakistan) Composition: Achillea millefolium Linn, Aconitum heterophyllum Wall. ex Royle, Adhatoda vasica Nees, Artemisia absinthium Linn, Bambusa arundinacea Retz, Berberis lycium Royle, Cichorium endivia Linn, Cuscuta reflexa Roxb, Foeniculum vulgare Miller, Fumaria officinalis, Glycyrrhiza glabra Linn, Melia azadarach Linn, Nymphaea lotus Linn, Sisymbrium irio Linn, Swertia chirata Buch. &Ham, Tinospora cordifolia (DC.) Miers ⁷⁰
Citrullus colocynthis (L.) Schrad	Cucurbitaceae	Whole plant, fruit, leaves, seeds, roots	Punjab Balochistan KPK Kashmir	Rheumatism ⁷¹	Antiinflammatory ^{72,75}	Habb-e-Banafsha Khas (Ashraf laboratories Pvt Ltd.) Composition: Acacia arabica (Lam.) Willd, Citrullus colocynthis (L.) Schrad, Convolvulus scammonia L, Glycyrrhiza glabra L. Ipomoea turpethum R.Br, Viola odorata L, Zingiber officinale Roscoe. ⁷⁰
Calotropis procera (Willd.); R.Br.	Asclepiadaceae	Root, leaves; bark, fruit, flower, young twigs	Punjab Balochistan Sindh KPK Kashmir	Rheumatism ^{69,76}	Antiinflammatory activity ^{77,80} Antiarthritic activity ^{80,82}	Pachnol (Hamdard laboratories Waqf Pakistan) Composition: Ammonium chloride, Calotropis procera, Ferula assafoetida Linn, Lake salt, Myrtus caryophyllus, Piper nigrum Linn, Potassium Carbonate, Sanchal Salt, Sodii boras, Zingiber officinale Roscoe. ⁷⁰
Datura innoxia Mill.	Solanaceae	Leaves, whole plant, seed	Punjab Balochistan KPK Kashmir	Inflammation, rheumatism ^{83,84}	-	-
Peganum harmala L.	Zygophyllaceae Nitriariaceae	Whole plant, seeds, leaves	Punjab Balochistan KPK Gilgit	Rheumatism ⁸⁵	Antiinflammatory activity ^{86,87}	Protone (Qarshi industries Pvt Ltd.) Composition: Acacia arabica (Lam.) Willd. (Gum), Anacyclus pyrethrum DC, Argyreia nervosa (Burm.f) Bojer, Caryophyllus aromaticus, Cinnabar, Coral calcium, Egg Shell Calcium, Hyoscyamus niger Linn, Mucuna pruriens (L.) DC, Myristica fragrans Houtt, Peganum harmala Linn, Withania somnifera (L.) Dunal. ⁷⁰ Roghhan Aujaa (Qarshi industries Pvt Ltd.) Composition: Alcanna tinctoria, Black salt, Caryophyllus aromaticus, Curcuma longa Linn, Myristica fragrans Houtt, Peganum harmala Linn, Potassium aluminium sulphate, Rubia cordifolia Linn, Saccharum Base. ⁷⁰

Table 1 Reported antiinflammatory/antiarthritic activities and herbal brands/manufacturers of most frequently used medicinal plants of Pakistan for inflammatory disorders (Continued)

Botanical name of plants	Family	Part used	Distribution region	Ethnobotanical claim	Pharmacological evidence	Herbal brands/Manufacturers
Ricinus communis L.	Euphorbiaceae	Whole plant Stem Leave Seeds	Punjab Sindh KPK Kashmir	Inflammation, Rheumatism ⁸⁴	Antiinflammatory activity ^{86,89} Antiarthritic activity ⁹⁰	Dawa-e-Malish (Hamdard laboratories Waqf Pakistan) Composition: Celastrus paniculatus Willd. (Oil), Cinnamomum cassia Blume (Oil), Ricinus communis Linn. (Oil), Sea Salt, Styra benzoin Dryander, Wax. ⁷⁰ Majoon Suranjan (Qarshi industries Pvt Ltd) Composition: Aloe barbadensis Mill, Apium graveolens Linn, Capparis decidua Linn, Colchicum autumnale Linn, Convolvulus scammonia Linn, Coriandrum sativum Linn, Cuttle Fish, Fish Beries, Foeniculum vulgare Miller, Ipomoea turpethum R. Br, Lawsonia inermis Lam, Piper nigrum Linn, Plumbago zeylanica Linn, Rosa damascena Miller, Table salt, Terminalia chebula Retz, Zataria multiflora Boiss, Zingiber officinale Roscoe, Ricinus communis Linn, Preservatives, Saccharum Base. ⁷⁰ Menorat (Hamdard laboratories Waqf Pakistan) Composition: Ban moonjh (Ash), Jute (Ash), Ricinus communis Linn, Flavouring agent, Sweetening agent. ⁷⁰ Arq Mako (Qarshi industries Pvt Ltd) Composition: Solanum nigrum Linn. ⁷⁰ Urosinal (Qarshi industries Pvt Ltd) Composition: Cichorium intybus Linn, Potassium nitrate, Solanum nigrum Linn. (Leaves), Solanum nigrum Linn. (Fruit), Hordeum vulgare Linn, Preservatives, Saccharum Base. ⁷⁰ , Bonjigar (Herbion Pakistan Pvt Ltd) Composition: Berberis aristata DC, Boerhavia diffusa Linn, Cichorium intybus Linn, Eclipta alba (L.) Hasskl, Picrorhiza kurrooa Royle ex Benth, Raphanus sativus Linn, Silybum marianum, Solanum nigrum Linn, Tamarix gallica Linn. ⁷⁰
Solanum nigrum L.	Solanaceae	Berries Leaves Whole plant Fruit	Punjab Balochistan KPK Kashmir	Rheumatism, Inflammation ⁹¹	Antiinflammatory activity ^{92,96}	
Solanum Surattense Burm. f.	Solanaceae	Fruit Leaves Whole plant	Punjab Sindh KPK Kashmir	Rheumatism ⁷¹	Antiinflammatory ^{97,99}	
Verbascum thapsus L.	Scrophulariaceae	Flower Leaves	Punjab KPK Gilgit Kashmir	Inflammation, Rheumatism ^{100,101}	Antiinflammatory ¹⁰²	

Notes: ①: Total effective rate; ②: Conditions of childhood CVA recurrence in two years; ③: The cough duration after the childhood CVA reappeared in the last 1 year; ④: The peripheral blood eosinophils (EOS) count level; ⑤: IgE content in peripheral blood.

Table 2 Plants having no scientific validation of their folkloric antiinflammatory/antiarthritic claim

Botanical name of plants	Family	Ethnobotanical claim	Reference
<i>Acacia senegal</i> (L.) Willd	Fabaceae	Arthritis	103
<i>Aconitum chasmanthum</i> Stapf ex Holmes	Ranunculaceae	Rheumatism, inflammation	11,104
<i>Aconitum violaceum</i> Jacq. Ex Stapf	Ranunculaceae	Rheumatism	105
<i>Aconogonon tortuosum</i> (D.Don) Hara	Polygonaceae	Rheumatism	106
<i>Actaea spicata</i> L.	Ranunculaceae	Rheumatism	107
<i>Amaranthus graecizans</i> subsp. <i>Sylvestris</i>	Amaranthaceae	Inflammation	108
<i>Anaphalis nepalensis</i> (Spereng) Hand	Asteraceae	Joint pain	109
<i>Angelica glauca</i> Edgew	Apiaceae	Rheumatism	110
<i>Artemisia maritima</i> L.	Asteraceae	Joint pain, inflammation	104, 111
<i>Artemisia sieversiana</i> Ehrh.	Asteraceae	Joint pain	16
<i>Asphodelus tenuifolius</i> Cavan.	Liliaceae	Swelling, inflammation	71
<i>Atriplex crassifolia</i> C.A.Mey	Chenopodiaceae	Joint pain, inflammation	112
<i>Berberis brandisiana</i> Ahrendt	Berberidaceae	Joint pain	112
<i>Berberis baluchistanica</i> Ahrendt	Berberidaceae	Rheumatism	113
<i>Berberis lycium</i> Royle.	Berberidaceae	Rheumatism	69
<i>Berberis pseudumbellata</i> Parker	Berberidaceae	Rheumatism	106
<i>Bistorta affinis</i> (D. Don) Green	Polygonaceae	Inflammation, joint pain	112
<i>Bistorta amplexicaulis</i> (D.Don) Greene	Polygonaceae	Rheumatism	106
<i>Brassica campestris</i> L.	Brassicaceae	Rheumatism	101
<i>Brassica napus</i> L.	Brassicaceae	Rheumatism	114
<i>Buxus papillosa</i>	Euphorbiaceae	Rheumatism	115
<i>Cadaba farinosa</i> Forssk.	Capparidaceae	Rheumatism	116
<i>Calamin thanepata</i> (L.) Savi.	Lamiaceae	Inflammation	117
<i>Caltha palustris</i> L.	Ranunculaceae	Inflammation	117
<i>Caralluma edulis</i> (Edgew.) Bth. & Hk.	Asclepiadaceae/ Apocynaceae	Rheumatism	118
<i>Carthamus oxyacantha</i>	Asteraceae	Joint pain	119
<i>Clematis orientalis</i> L.	Ranunculaceae	Joint pain	112
<i>Cleome brachycarpa</i> L.	Capparidaceae	Joint pain, inflammation	115
<i>Convolvulus arvensis</i> L.	Convolvulaceae	Rheumatism, inflammation	114, 120
<i>Cortia depressa</i> (Don) Norman	Apiaceae	Swellings	121
<i>Corydalis govaniiana</i> Wall.	Fumariaceae	Swellings	122
<i>Cotula anthemoides</i> L.	Asteraceae	Rheumatism	115
<i>Cymbopogon jwarancusa</i> (Jones) SchultzMant	Poaceae	Rheumatism, inflammation	115,118
<i>Cyperus conlomeratus</i>	Cyperaceae	Rheumatism	123
<i>Cyperus glomeratus</i>	Cyperaceae	Inflammation	124
<i>Daphne mucronata</i> Royle	Thymelaeaceae	Rheumatism	125
<i>Datura innoxia</i> Mill.	Solanaceae	Inflammation, rheumatism	83, 84
<i>Debregeasia salicifolia</i> (D. Don.) Rendle	Urticaceae	Swelling	126
<i>Desmodium elegans</i> L.	Fabaceae	Rheumatism	127
<i>Dipterygium glaucum</i>	Capparidaceae	Rheumatism	114
<i>Ephedra gerardiana</i>	Ephedraceae	Rheumatism	128
<i>Ephedra intermedia</i> Schrenk & C.A. Mey	Ephedraceae	Rheumatism	129
<i>Euphorbia helioscopia</i> L.	Euphorbiaceae	Inflammation	130
<i>Farsetia jacquemontii</i> Hook. F. & Thoms.	Brassicaceae	Rheumatism	116
<i>Ficus benjamina</i> L.	Moraceae	Rheumatism	131
<i>Ficus palmata</i> L.	Moraceae	Inflammation	132
<i>Fritillaria roylei</i> Hook.f.	Liliaceae	Rheumatism	122
<i>Galium aparine</i> L.	Rubiaceae	Inflammation	117
<i>Geranium wallichianum</i> Fisch	Geraniaceae	Rheumatism	122

Table 2 Plants having no scientific validation of their folkloric antiinflammatory/antiarthritic claim (Continued)

Botanical name of plants	Family	Ethnobotanical claim	Reference
<i>Hedera nepalensis</i> K. Koch	Araliaceae	Rheumatism	133
<i>Helianthus tuberosus</i> L.	Asteraceae	Inflammation	134
<i>Heliotropium cabulicum</i> Bunge	Boraginaceae	Swelling	126
<i>Impatiens glandulifera</i> Royle	Balsaminaceae	Joint pain	135
<i>Indigofera articulata</i> Gouan	Fabaceae	Inflammation	136
<i>Inula grandiflora</i> Willd	Asteraceae	Rheumatism	137
<i>Ipomoea pentaphylla</i> (L.) Jacq.	Convolvulaceae	Swelling	138
<i>Isodon rugosus</i> (Wall.ex Benth.) Codd	Labiatae	Rheumatism	129
<i>Jurinea himalaica</i> R. R. Stewart	Asteraceae	Rheumatism	106
<i>Lamium amplexicaule</i> L.	Lamiaceae	Joint swelling	139
<i>Lasiurus scindicus</i>	Poaceae	Rheumatism	114
<i>Launaea procumbens</i> Roxb.	Asteraceae	Rheumatism	134
<i>Linum perenne</i> L.	Linaceae	Rheumatism	140
<i>Lygodium japonicum</i> (Thunb.) Sw.	Schizaeaceae	Swellings	141
<i>Malva neglecta</i> Wallr	Malvaceae	Inflammation	142
<i>Melilotus albus</i> Desr	Papilionaceae	Joint pain, inflammation	139
<i>Melilotus indicus</i> L.	Papilionaceae	Rheumatism	114
<i>Melilotus parviflora</i>	Papilionaceae	Swellings	143
<i>Merremia aegyptia</i> (Linn.) Urban	Convolvulaceae	Swelling	144
<i>Moringa rivae</i> Chiovenda	Moringaceae	Arthritis	103
<i>Nannorrhops ritchiana</i> (Griff.) Aitch	Arecaceae	Rheumatism	114
<i>Neolitsea chinensis</i> (Gamble) Chun	Lauraceae	Rheumatism	145
<i>Neurada procumbens</i> L.	Neuradaceae	Rheumatism	123
<i>Oxystelma esculentum</i>	Apocynaceae	Rheumatism, inflammation of joints	146
<i>Oxytropis lapponica</i> (Wahl.) Gay	Papilionaceae	Joint pain	121
<i>Periploca aphylla</i> L.	Asclepiadaceae	Swellings	147
<i>Perovskia abrotanoides</i> Kar.	Lamiaceae	Rheumatism	16
<i>Pinus wallichiana</i> . A.B. Jacks.	Pinaceae	Rheumatism	117
<i>Pluchea pinnatifida</i>	Compositae	Inflammation	18
<i>Poa supina</i> Schrad.	Poaceae	Inflammation	117
<i>Polygonum alpinum</i> L.	Polygonaceae	Joint pain	101
<i>Polygonum amplexicaule</i> D. Don	Polygonaceae	Rheumatism	137
<i>Polygonum plebeium</i> R.Br.	Polygonaceae	Inflammation	148
<i>Polypogon monspeliensis</i> (L.)	Poaceae	Rheumatism	149
<i>Polystichum braunii</i> (Spenner) Fée	Dryopteridaceae	Rheumatism	135
<i>Portulaca quadrifida</i>	Portulacaceae	Inflammation, joint swelling	139, 146
<i>Primula macrophylla</i> D.Don.	Primulaceae	Inflammation	122
<i>Prunus eburana</i>	Rosaceae	Bone weakness	150
<i>Quercus dilatata</i> Lindl.	Fagaceae	Joint swelling	151
<i>Quercus incana</i>	Fagaceae	Joint pain	152
<i>Quercus leucotrichophora</i>	Fagaceae	Rheumatism	69
<i>Ranunculus laetus</i> Wall. ex Hook.	Ranunculaceae	Joint pain	100
<i>Rhus coriaria</i> L.	Anacardiaceae	Inflammation	69
<i>Ribes alpestre</i> Decne	Grossulariaceae	Joint pain	112
<i>Ribes orientale</i> Desf.	Grossulariaceae	Rheumatism	129
<i>Rosa webbiana</i> Wall ex Royle	Rosaceae	Rheumatism, inflammation	101
<i>Rumex tianschanicus</i> Losinsk.	Polygonaceae	Joint pain	100
<i>Sarcococca saligna</i> D. Don. Muell	Buxaceae	Rheumatism	117
<i>Senna alexandrina</i> Miller.	Caesalpiniaceae	Rheumatism	153

Table 2 Plants having no scientific validation of their folkloric antiinflammatory/antiarthritic claim (Continued)

Botanical name of plants	Family	Ethnobotanical claim	Reference
<i>Senecio chrysanthemoides</i> DC.	Asteraceae	Rheumatism	16
<i>Senecio heteromella</i> D. Don	Asteraceae	Joint pain	109
<i>Sida cordata</i> Burm. F. Boiss	Malvaceae	Rheumatism	154
<i>Skimmia laureola</i> (DC.) Sieb. and Zucc. ex Walp. Nyra	Rutaceae	Rheumatism	106
<i>Solanum pseudocapsicum</i> L.	Solanaceae	Arthritis	155
<i>Tephrosia falciformis</i> Romaswami.	Fabaceae	Rheumatism	120
<i>Tephrosia lupinifolia</i> DC	Fabaceae	Rheumatism	143
<i>Trachomitum venetum</i> (L.) Woodson.	Apocynaceae	Rheumatism	156
<i>Trifolium alexandrinum</i> (L.)	Fabaceae	Rheumatism	149
<i>Trifolium repens</i> L.	Papilionaceae	Rheumatism	151
<i>Urtica utilis</i> hort. ex de Vriese	Urticaceae	Arthritis	110
<i>Valeriana himalayana</i> Grub.	Caprifoliaceae	Rheumatism	117
<i>Viola serpens</i> L.	Violaceae	Inflammation	101

flammatory disorders, 84 species were used widely and sold in markets. Only 25 out of 371 medicinal plant species (Table 4) are exported in international markets for revenue generation in Pakistan. Moreover, Pakistan imports 12 out of 371 plant species with anti-inflammatory/anti-arthritis activities from Sri Lanka, Tanzania, Indonesia, India, China, Iran and Afghanistan (Table 5).

Conservation status of plants

In the present study, 148 out of 371 plant species used for treatment of inflammatory disorders were endangered, vulnerable, growing rarely, or threatened (Table 6).

DISCUSSION

Natural sources such as plants have been used for prevention and cure of inflammatory disorders for centuries. They have been shown to be valuable and innocuous remedies for several disorders. This sustained dependence on plant medicines is ascribed to poor economic situations, which put the prevailing health amenities and pharmaceutical agents beyond the reach of people living in poverty.¹³ Pakistan is one of the few places on Earth endowed with distinctive biodiversity, and consists of various climates, topographic regions, ecologic zones and plant species.¹⁴ We found that most plant species being used for treating inflammatory disorders in Pakistan were from Punjab. The botanic diversity from Punjab might be because of its varied climate and soil types.¹⁵ Another reason might be that EBM surveys have been reported from most areas of Punjab, whereas some regions of Northern areas and many areas of Balochistan and Sindh have not been explored. However, the Northern regions (Khyber Pakhtunkhwa, Azad Jammu and Kashmir, and Gilgit Baltistan) of Pakistan are very biodiverse because of three mountain ranges located there: Himalaya, Karakorum, and Hindu Kush. This great biodiversity is due to the altitude, atmosphere, soil, moisture, topography, and location of plateau, which provides a favorable environment for

growth and local adaptation of plant species.^{16,17} Balochistan also has good habitats for medicinal plants because of numerous ecologic zones,¹⁸ but EBM research has been neglected in this province.¹⁹ Sindh has few medicinal flora because it is arid and delineated by harsh temperatures, severe drought, and little rainfall; EBM research from this province is scarce.²⁰ The knowledge of traditional plant-based remedies is vanishing because elderly rural people with such knowledge die without passing on information to the next generation.²¹ Preservation of this stock of knowledge is essential for socio-economic prosperity.

In this study, it was found that a large number of plant species being used therapeutically for inflammatory ailments belong to Asteraceae family, a finding substantiated by research conducted in other countries.²²⁻²⁷ Asteraceae has been designated as the largest plant family worldwide, comprising 23 000 species and 1535 genera.²⁸ Asteraceae holds a wide range of phytochemical constituents (volatile oils and terpenoids) and some bitter-tasting secondary metabolites such as sesquiterpene lactones.^{29,30} So, a wide use of Asteraceae family plants in Pakistan may be attributed to a large number of plant species this family holds, along with a diverse secondary metabolite profile of these plants. In addition, plants from Asteraceae family are among the first species to appear in fields after soil has been made primed for planting. This phenomenon may account for the greater number of species of this family documented among rural people, whose gardens are the main source of medicinal plants.²⁸

The dominance of herbs in this study as prominent growth form in Pakistan is supported by studies conducted in Bolivia, Canada, Brazil, India and Argentina, where most medicinal plants are grown as herbs.^{24, 26, 31-33} The dominance of herbaceous plants, as opposed to woody forms,³⁴⁻³⁶ in EBM has been stated by numerous authors to be due to their bioactive components as well as their greater availability, accessibility and affordability to people, particularly impoverished populations.^{25,37,38}

Table 3 Commercially important medicinal flora of Pakistan used for inflammatory complaints

Botanical name of plants	Reference
<i>Abies pindrow</i> Royle.	157
<i>Acacia modesta</i> Wall.	66
<i>Acacia nilotica</i> L.	56, 66
<i>Acacia senegal</i> (L.) Willd.	66
<i>Achillea millefolium</i> L.	158
<i>Achyranthes aspera</i> L.	68
<i>Aconitum heterophyllum</i> Wall. ex. Royle	159, 160
<i>Aconitum violaceum</i> Jacq. ex Stapf	68
<i>Acorus calamus</i> L.	56, 68, 159, 161
<i>Adhatoda vasica</i> Nees.	162
<i>Allium sativum</i>	53, 68
<i>Aloe vera</i> L. Burm. f.	53, 56
<i>Althaea officinalis</i> L.	53, 56
<i>Amaranthus viridis</i> L.	162
<i>Artemisia maritima</i> L.	53, 56
<i>Artemisia sieversiana</i> Ehrh.	53
<i>Asparagus racemosus</i>	53
<i>Berberis lycium</i> Royle.	56, 68, 157
<i>Bergenia ciliata</i> (Haw.) Sternb.	68, 157, 158, 159, 161
<i>Beta vulgaris</i> L.	159
<i>Bistorta amplexicaulis</i> (D.Don) Greene	68, 159, 161
<i>Carthamus tinctorius</i> L.	56
<i>Carum carvi</i> L.	61, 66
<i>Cassia fistula</i>	56
<i>Centella asiatica</i>	53, 56
<i>Cichorium intybus</i> L.	53, 56
<i>Citrullus colocynthis</i> (L.) Schrad	53
<i>Colchicum luteum</i> Baker	53, 56, 68, 159
<i>Coriandrum sativum</i> L.	56, 68
<i>Cuminum cyminum</i>	53, 56, 161
<i>Cuscuta reflexa</i> Roxb.	53, 56
<i>Daphne mucronata</i> Royle.	68
<i>Diospyros lotus</i> L.	68, 159, 161
<i>Ephedra gerardiana</i>	53, 56, 68
<i>Ephedra intermedia</i> Schrenk & C.A. Mey	53, 56
<i>Ferula assa-foetida</i> Regel.	53, 56
<i>Ficus carica</i> L.	53
<i>Foeniculum vulgare</i>	53, 56, 68
<i>Fragaria nubicola</i> Lindl ex Lacaita.	158
<i>Fumaria indica</i> L.	56, 68
<i>Galium aparine</i> L.	162
<i>Geranium wallichianum</i> Fisch	157, 159
<i>Hedera nepalensis</i> K. Koch	68, 158, 162
<i>Hippophae rhamnoides</i> L.	66
<i>Hyoscyamus niger</i> L.	53, 56, 68
<i>Hypericum perforatum</i> L.	163
<i>Juglans regia</i> L.	66, 68

Table 3 Commercially important medicinal flora of Pakistan used for inflammatory complaints (Continued)

Botanical name of plants	Reference
<i>Jurinea himalaica</i> R. R. Stewart	159
<i>Malva sylvestris</i>	56
<i>Melia azedarach</i> L.	53
<i>Mentha longifolia</i> L.	56, 68
<i>Morchella conica</i> Fries	68
<i>Morchella esculenta</i> (L.) Pers.	159, 160, 161
<i>Morus alba</i> L.	66
<i>Nannorrhops ritchiana</i> (Griff.) Aitch	66
<i>Ocimum basilicum</i> L.	53, 56
<i>Paeonia emodi</i> Royle.	68, 158, 159
<i>Peganum harmala</i> L.	53, 56
<i>Picrorhizza kurroa</i>	164
<i>Plantago major</i> L.	56
<i>Plantago ovata</i> Forsk.	53, 56
<i>Plantago lanceolata</i>	68
<i>Polygonatum verticillatum</i> All.	68
<i>Polygonum amplexicaule</i> D. Don	53, 56
<i>Pongamia glabra</i>	56
<i>Portulaca oleracea</i> L.	68
<i>Punica granatum</i>	53, 56, 66, 68, 157
<i>Rheum australe</i> D. Don	56, 68
<i>Ricinus communis</i> L.	53, 56
<i>Saussurea lappa</i> Decne	53, 159, 160
<i>Saussurea costus</i> (Falc.) Lipsch.	56, 159
<i>Sisymbrium irio</i> L.	53, 56
<i>Skimmia laureola</i> (DC.) Sieb. and Zucc. ex Walp. Nyra	53
<i>Solanum nigrum</i> L.	53
<i>Solanum surattense</i>	68
<i>Terminalia chebula</i>	53, 56
<i>Tribulus terrestris</i> L.	56
<i>Trichodesma indicum</i> (L.) R. Br.	157
<i>Urtica dioica</i> L.	162
<i>Valeriana jatamansi</i> Jones	56, 158, 159, 160, 161, 165
<i>Viola serpens</i> L.	53, 159, 161
<i>Vitex negundo</i> L.	68
<i>Vitis vinifera</i> L.	53
<i>Withania somnifera</i> (Linn.); Dunal.	56, 68

Most importantly, the growth form and type of vegetation is influenced by topographic changes, seasonal fluctuations in temperature, soil types, climate and rainfall.¹⁷

Similar to our investigation, leaves were found to be the plant part used most often in many other types of EBM in Bangladesh, India, Brazil and Ethiopia.^{39,40,32,31,41,27} Leaves are considered to be the prime choice in EBM because of their easy collection, preparation and accessibility.^{42,43} In addition, use of plant leaves does

Table 4 Plants exported from Pakistan

Botanical name of plants	Reference
<i>Acacia nilotica</i> L.	56
<i>Acorus calamus</i>	166
<i>Allium sativum</i>	53
<i>Bergenia ciliata</i> (Haw.) Sternb.	161
<i>Bistorta amplexicaulis</i> (D. Don) Greene	161
<i>Carum carvi</i> L.	66
<i>Colchicum luteum</i> Baker	161
<i>Cuminum cyminum</i>	53, 56
<i>Diospyrus lotus</i>	166
<i>Ephedra Gerardiana</i>	53, 56
<i>Ephedra intermedia</i> Schrenk & C.A. Mey	53, 56
<i>Foeniculum vulgare</i>	53, 56
<i>Juglans regia</i> L.	66
<i>Morchella esculenta</i> (L.) Pers.	64, 161
<i>Morus alba</i> L.	66
<i>Nannorrhops ritchiana</i> (Griff.) Aitch	66
<i>Ocimum basilicum</i> L.	53
<i>Paeonia emodi</i> Royle	161
<i>Picrorhizza kurroa</i>	164
<i>Plantago ovata</i> Forsk.	53
<i>Punica granatum</i>	66
<i>Rheum australe</i> D. Don	56
<i>Ricinus communis</i> L.	53, 56
<i>Valeriana jatamansi</i> Jones	56, 161
<i>Viola serpens</i> L.	161

not have detrimental effects on plant lifecycles, and for most of the year, green leaves are found in ample amounts in Pakistan owing to good rainfall.⁴⁴ Leaves are the primary site of photosynthesis, produce a wide array of secondary metabolites, and are the metabolically active part of any plant.^{21,45} Akin to our study, the use of two or more plant parts in many other types of EBM have been detailed in other surveys.^{41,46}

Likewise, analogous to our data, oral administration accounts for a greater number of applications in many other countries.^{13,22,23,27,47} The most popular medicinal preparation used was a decoction in studies in Korea,²² India,⁴⁸⁻⁵⁰ Spain,²³ Ethiopia, Turkey,⁵¹ Canada²⁶ and Brazil.³¹ Decoctions may be the most popular method used by traditional healers because boiling eradicates microbes present in the plant part. Also, heat may expedite extraction of active ingredients in the plant part.¹³ Pakistan has ≈ 27 herbal-manufacturing companies, which utilize the plants being used by local people of Pakistan for inflammatory disorders to prepare herbal preparations and most of these herbal formulations comprise more than one medicinal plant.⁵² A prominent company is Hamdard, which has a pharmaceutical advisory committee and is associated with the Unani Institute of Health and Tibbi Research in Karachi.⁵³ Other smaller companies that manufacture remedies are Qarshi, Herbion, and Ashraf Laboratories Pakistan.

Table 5 Plants imported from other countries

Botanical name of plants	Country	Reference
<i>Aconitum heterophyllum</i> Wall. ex. Royle	India	53
<i>Acorus calamus</i> L.	India	53
<i>Aloe vera</i> L. Burm. f.	Tanzania and Aden	53
<i>Asparagus racemosus</i>	India	53
<i>Carum carvi</i> L.	Iran	53
<i>Cichorium intybus</i> L.	India and Indonesia	56
<i>Colchicum luteum</i> Baker.	Iran and Afghanistan	53
<i>Cuminum cyminum</i>	India	56
<i>Ferula assa-foetida</i> Regel.	Afghanistan	56
<i>Plantago major</i> L.	India and China	56
<i>Terminalia chebula</i>	India and Sri Lanka	53
<i>Withania somnifera</i> (Linn.); Dunal.	India and China	56

We have enlisted 111 plants whose pharmacologic studies are crucial to discover new, efficacious and inexpensive lead compounds having anti-arthritis/anti-inflammatory activities. Also, phytochemical and toxicity studies of these plant species must be carried out.

Pakistan has a multitude of medicinally important plant species, which are important for the livelihoods of impoverished communities.⁵⁴ Rural people gather and sell medicinal plants to generate income. The data obtained shows that 84 plant species were used widely for inflammatory disorders and sold in markets as leaves, bark, roots, powders, extracts, tonics, pills, teas and finished pharmaceutical products.⁵⁵ Herbal plants from Pakistan have a considerable market nationally and internationally. The main markets of crude herbal drugs are in Rawalpindi, Lahore, Faisalabad, Peshawar, Multan, Dir, Hyderabad, Sukkar, Karachi, Mingora and Bahawalpur. The Peshawar market supplies drugs to various markets in Pakistan and obtains herbal materials from other areas of Pakistan, Afghanistan and other Asian countries. Instead, the herbal market in Karachi is the chief center for export of medicinal plants.⁵⁶ Export of crude drugs is low compared with that of several other Asian countries.⁵⁶ International trade in herbal plants is from developing to industrial countries. China leads in the export of botanical drugs. Pakistan is among the top 12 exporters of crude drugs worldwide, but this export potential is likely to increase.⁵ Growing demand in herbal markets, a lack of certainty about delivery to markets, and substandard quality of local raw materials affect the import of some medicinal plants. Studies have shown that ≈ 60% of herbal drugs imported into Pakistan grow densely in Northern areas of Pakistan. These can be cultivated readily and import costs saved.⁵⁶ Overall, Pakistan can increase its share in national and international markets via tenable harvesting of medicinal-plant resources. It is imperative to formulate strategies to improve the medicinal-plant indus-

Table 6 Conservation status of medicinal flora of Pakistan used for inflammatory ailments

Botanical name of plants	Ethnobotanical claim	Conservation status
<i>Abies pindrow</i> Royle	Inflammation ¹¹⁷	Endangered, threatened ^{167,168,169}
<i>Abutilon indicum</i> (L.) Sweet	Inflammation ¹⁴³	Vulnerable ¹⁶⁸
<i>Acacia modesta</i> Wall.	Joint pain ¹⁷⁰	Vulnerable, endangered ^{67,168,171}
<i>Acacia nilotica</i> L.	Rheumatism ⁶⁹	Vulnerable, endangered ^{167,168,171,172}
<i>Acacia senegal</i> (L.) Willd	Arthritis ¹⁰³	Threatened ¹⁶⁹
<i>Achillea millefolium</i> L.	Inflammation ¹¹⁷	Rare ¹⁶⁷
<i>Aconitum chasmanthum</i> Stapf ex Holmes	Rheumatism, inflammation ^{11,104}	Critically endangered ¹⁷³
<i>Aconitum heterophyllum</i> Wall. ex. Royle	Inflammation, rheumatism ¹⁶⁷	Critically endangered, endangered, Rare ^{67,161,167,172,174}
<i>Aconitum violaceum</i> Jacq. ex Stapf	Rheumatism ¹⁰⁵	Vulnerable ^{68,161,175}
<i>Acorus calamus</i> L.	Rheumatism ¹⁷⁶	Endangered ^{168,161}
<i>Actaea spicata</i> L.	Rheumatism ¹⁰⁷	Rare ¹⁶⁷
<i>Adhatoda vasica</i> Nees	Rheumatism ⁸⁵	Rare ⁵³
<i>Aesculus indica</i> Wall. ex Camb	Rheumatism ¹⁷⁷	Vulnerable, endangered ^{65,67,167,168,172}
<i>Albizia lebbek</i> (L.) Bth	Inflammation ⁸⁴	Endangered ¹⁷¹
<i>Alhagi maurorum</i> Medic.	Rheumatism ¹⁷⁸	Rare ¹⁷¹
<i>Althaea officinalis</i> L.	Rheumatism ¹⁵³	Rare ⁵³
<i>Anagallis arvensis</i>	Inflammation, rheumatism ¹⁴⁴	Rare ¹⁷⁹
<i>Angelica glauca</i> Edgew.	Rheumatism ¹¹⁰	Critically endangered ^{172,180}
<i>Argemone mexicana</i> L.	Inflammation ¹⁴⁴	Critically endangered ¹⁷²
<i>Artemisia maritima</i> L.	Joint pain, inflammation ^{104,111}	Endangered, vulnerable ^{174,180}
<i>Artemisia sieversiana</i> Ehrh.	Joint pain ¹⁶	Vulnerable ⁵³
<i>Azadirachta indica</i> (L) A. Juss.	Inflammation, rheumatism ^{84,146}	Threatened ¹⁶⁹
<i>Berberis lycium</i> Royle.	Rheumatism ⁶⁹	Endangered, vulnerable ^{67,161,167}
<i>Berberis pseudumbellata</i> Parker	Rheumatism ¹⁰⁶	Endangered ¹⁷⁵
<i>Bergenia ciliata</i> (Haw.) Sternb.	Inflammation ¹¹	Endangered, Critically endangered ^{67,68,167,172,174}
<i>Betula utilis</i> D.Don	Rheumatism ¹²⁹	Endangered ^{167,180}
<i>Bistorta amplexicaulis</i> (D.Don) Greene	Rheumatism ¹⁰⁶	Endangered ^{68,161,167}
<i>Boerhavia procumbens</i>	Rheumatism, inflammation ¹⁴⁶	Rare ¹⁷⁹
<i>Bombax ceiba</i> L.	Arthritis ¹⁸¹	Endangered ¹⁷¹
<i>Buxus papillosa</i>	Rheumatism ¹¹⁵	Rare ⁵³
<i>Calotropis gigantea</i> R. Br.	Rheumatism, inflammation ⁸⁵	Rare ⁵³
<i>Calotropis procera</i> (Willd.); R.Br.	Rheumatism ^{69,76}	Critically endangered, rare ^{171,172}
<i>Capparis decidua</i>	Rheumatism ¹⁷⁰	Vulnerable ¹⁸²
<i>Capparis spinosa</i> L.	Rheumatism, inflammation ^{84,116}	Rare ¹⁸²
<i>Capsella bursa pastoris</i> (L.)	Rheumatism ¹⁴⁹	Vulnerable ⁶⁷
<i>Carthamus tinctorius</i> L.	Arthritis ¹¹⁰	rare ⁵³
<i>Cassia fistula</i>	Rheumatism, inflammation ^{84,115}	Vulnerable ¹⁷¹
<i>Cedrus deodara</i> (Roxb. ex Lamb) G. Don.	Rheumatism ¹¹⁷	Endangered, rare ^{65,67}
<i>Chenopodium album</i>	Rheumatism ¹¹⁹	Rare ⁶⁷
<i>Cichorium intybus</i> L.	Inflammation, swelling ^{125,139}	Endangered ¹⁷²
<i>Citrullus colocynthis</i> (L.) Schrad	Rheumatism ⁷¹	Vulnerable ⁵⁶
<i>Clematis orientalis</i> L.	Joint pain ¹¹²	Endangered ¹⁸³
<i>Colchicum luteum</i> Baker	Arthritis ¹⁸⁴	Endangered ^{161,172}
<i>Convolvulus arvensis</i> L.	Rheumatism, inflammation ^{114,120}	Rare ⁶⁷
<i>Conyza bonariensis</i> L.	Rheumatism ¹⁴⁹	Vulnerable ⁶⁷
<i>Coriandrum sativum</i> L.	Inflammation ¹⁰¹	Vulnerable ¹⁷²
<i>Cymbopogon jwarancusa</i>	Rheumatism, inflammation ^{115,118}	Threatened ¹⁸⁵
<i>Cynodon dactylon</i>	Inflammation ^{101,146}	Vulnerable ⁶⁷
<i>Daphne mucronata</i> Royle	Rheumatism ¹²⁵	Vulnerable ^{68,172}
<i>Daphne oleoides</i> Schreb.	Rheumatism ¹⁸⁶	Endangered ¹⁶⁸
<i>Datura alba</i>	Rheumatism, inflammation ¹⁴⁶	Infrequent ¹⁷¹

Table 6 Conservation status of medicinal flora of Pakistan used for inflammatory ailments (Continued)

Botanical name of plants	Ethnobotanical claim	Conservation status
<i>Datura metel</i>	Rheumatism ¹⁸	Rare ¹⁷¹
<i>Datura stramonium</i> L.	Rheumatism ¹⁸⁷	Vulnerable ¹⁷²
<i>Diospyros lotus</i> L.	Joint pain ¹⁷⁷	Endangered, rare ^{167,172}
<i>Dodonaea viscosa</i> (L.) Jacq	Rheumatism ⁸⁴	Endangered ¹⁷¹
<i>Eclipta alba</i> (L.) Hassk.	Inflammation ¹⁴⁴	Vulnerable ⁶⁷
<i>Ephedra gerardiana</i>	Rheumatism ¹²⁸	Endangered, vulnerable ^{68,180}
<i>Ephedra intermedia</i> Schrenk & C.A. Mey	Rheumatism ¹²⁹	Critically endangered ^{161,172}
<i>Epilobium hirsutum</i> L.	Inflammation, joint pain ¹¹²	Rare ⁶⁷
<i>Erigeron multiradiatus</i> (Lindl. ex DC.) Benth	Rheumatism ¹²¹	Vulnerable ⁶⁷
<i>Euphorbia helioscopia</i> L.	Inflammation ¹³⁰	Vulnerable ¹⁷²
<i>Fagonia cretica</i> L.	Inflammation ⁸³	Rare ⁵³
<i>Ferula assa-foetida</i> Regel.	Rheumatism ¹⁸⁸	Rare ⁵³
<i>Ficus benghalensis</i> L.	Rheumatism ¹⁷⁷	Rare ⁶³
<i>Ficus carica</i> L.	Inflammation ¹⁰¹	Vulnerable ^{168,171}
<i>Ficus palmata</i> L.	Inflammation ¹³²	Endangered, vulnerable ^{171,189}
<i>Ficus religiosa</i> L.	Inflammation ⁷⁶	Endangered ¹⁷¹
<i>Foeniculum vulgare</i>	Arthritis ¹⁹⁰	Critically endangered ¹⁷²
<i>Fritillaria roylei</i> Hook. F	Rheumatism ¹²²	Endangered ¹⁷²
<i>Fumaria indica</i> L.	Rheumatism ¹¹⁴	Vulnerable ¹⁷²
<i>Galium aparine</i> L.	Inflammation ¹¹⁷	Vulnerable ¹⁷²
<i>Geranium wallichianum</i> Fisch	Rheumatism ¹²²	Endangered, rare ^{167,67}
<i>Grewia asiatica</i>	Inflammation ⁸⁴	Threatened ¹⁶⁹
<i>Hedera nepalensis</i> K. Koch	Rheumatism ¹³³	Critically endangered ¹⁷²
<i>Hippophae rhamnoides</i> L.	Arthritis ¹⁶	Endangered ¹⁸⁰
<i>Hyoscyamus niger</i> L.	Rheumatism ¹⁷⁸	Endangered ¹⁸³
<i>Hypericum perforatum</i> L.	Rheumatism ¹⁴⁰	Vulnerable, endangered ^{172,191}
<i>Impatiens balsamina</i> L.	Joint pain ¹³⁵	Infrequent ¹⁶⁸
<i>Impatiens glandulifera</i> Royle	Joint pain ¹³⁵	Vulnerable ¹⁶⁷
<i>Juglans regia</i> L.	Rheumatism ¹⁰¹	Threatened, endangered ^{169,172}
<i>Juniperus communis</i> L.	Rheumatism ¹¹	Endangered ¹⁸³
<i>Juniperus macropoda</i> Bliss.	Rheumatism ¹⁰¹	Threatened ¹⁶⁹
<i>Malva sylvestris</i>	Inflammation ⁸⁴	Rare ⁵³
<i>Melia azedarach</i> L.	Rheumatism ¹⁴⁶	Endangered, critically endangered, Rare ^{67,168,171,172,191}
<i>Mentha arvensis</i> L.	Joint pain ¹⁰¹	Rare ⁶⁷
<i>Mentha longifolia</i> L.	Rheumatism, swelling ^{146,192}	Endangered ¹⁷²
<i>Morchella conica</i> Fries	Joint pain ¹²⁵	Rare ⁶⁸
<i>Morchella esculenta</i> (L.) Pers.	Joint pain ¹⁹³	Endangered ¹⁶⁷
<i>Morus alba</i> L.	Rheumatism ¹⁵⁶	Endangered, rare, vulnerable, Threatened ^{167,168,169,189}
<i>Morus laevigata</i> Wall.ex Brandis	Inflammation ¹³⁹	Endangered, rare ^{63,168}
<i>Morus nigra</i>	Inflammation, rheumatism ^{119,132}	Vulnerable ^{168,171}
<i>Ocimum basilicum</i> L.	Inflammation ¹³²	Rare ⁵³
<i>Olea ferruginea</i> Royle	Rheumatism ⁸⁴	Endangered, rare ^{67,167,168}
<i>Opuntia dillenii</i> (Ker Gawler) Haworth	Inflammation ¹⁹⁴	Endangered ¹⁷⁴
<i>Opuntia monacantha</i> Haw.	Inflammation ⁸⁴	Vulnerable ¹⁷¹
<i>Paeonia emodi</i> Royle	Rheumatism ¹⁹⁵	Endangered ^{168,174}
<i>Peganum harmala</i> L.	Rheumatism ⁸⁵	Endangered ¹⁷⁴
<i>Periploca aphylla</i> L.	Swellings ¹⁴⁷	Critically endangered ¹⁷²
<i>Picrorhizza kurroa</i>	Inflammation ¹⁸⁰	Endangered ¹⁸⁰

Table 6 Conservation status of medicinal flora of Pakistan used for inflammatory ailments (Continued)

Botanical name of plants	Ethnobotanical claim	Conservation status
<i>Pinus wallichiana</i> A.B. Jacks.	Rheumatism ¹¹⁷	Endangered, threatened ^{167,169}
<i>Pistacia khinjuk</i> Stocks	Inflammation ¹²⁹	Threatened ¹⁶⁹
<i>Plantago major</i> L.	Rheumatism ¹³³	Vulnerable ¹⁷²
<i>Plantago ovata</i> Forsk	Rheumatism ¹⁰¹	Rare ¹⁶⁷
<i>Plantago lanceolata</i>	Inflammation ¹¹⁷	Vulnerable ¹⁷²
<i>Polygonatum verticillatum</i> All.	Rheumatism ¹²⁵	Endangered ⁶⁸
<i>Polygonum plebeium</i> R.Br.	Inflammation ¹⁴⁸	Vulnerable ^{67,172}
<i>Polypogon monspeliensis</i> (L.)	Rheumatism ¹⁴⁹	Vulnerable ⁶⁷
<i>Pongamia glabra</i>	Swelling, arthritis ¹¹⁹	Rare ⁵³
<i>Portulaca quadrifida</i>	Inflammation, joint swelling ^{139,146}	Vulnerable ¹⁷²
<i>Prosopis cineraria</i>	Rheumatism ¹⁸⁷	Threatened ¹⁸⁵
<i>Prunella vulgaris</i> L.	Inflammation ¹³⁵	Critically endangered ¹⁷²
<i>Prunus persica</i> Stokes.	Rheumatism ¹⁹³	Rare ¹⁷¹
<i>Punica granatum</i>	Swelling, inflammation ¹²⁹	Vulnerable ^{171,172}
<i>Quercus dilatata</i> Lindl.	Joint swelling ¹⁵¹	Endangered, vulnerable, threatened ^{63,168, 169}
<i>Quercus incana</i>	Joint pain ¹⁵²	Vulnerable, endangered, threatened ^{167,168,169}
<i>Rhazya stricta</i> Decene	Rheumatism ¹⁹⁶	Endangered ¹⁸⁹
<i>Rheum australe</i> D. Don	Swellings ¹⁶	Rare ¹⁶¹
<i>Rhododendron anthopogon</i> D. Don.	Inflammation ¹⁶	Threatened ¹⁶⁹
<i>Ricinus communis</i> L.	Inflammation, rheumatism ⁸⁴	Rare ¹⁷¹
<i>Rosa webbiana</i> Wall ex Royle.	Rheumatism, inflammation ¹⁰¹	Rare ¹⁹⁷
<i>Rumex hastatus</i> Don.	Rheumatism ¹¹	Rare ⁶⁷
<i>Salix alba</i> L.	Inflammation, rheumatism ^{101, 112}	Vulnerable ⁶³
<i>Salvadora oleoides</i> L.	Rheumatism ¹⁴⁶	Overharvested ¹⁹¹
<i>Salvadora persica</i> L.	Rheumatism ¹¹⁵	Rare ⁵³
<i>Sarcococa saligna</i> D. Don. Muell	Rheumatism ¹¹⁷	Endangered ¹⁶⁸
<i>Saussurea lappa</i> Decne.	Joint pain, inflammation ¹⁰¹	Endangered, threatened ^{167,169,180}
<i>Saussurea costus</i> (Falc.) Lipsch.	Arthritis ¹³⁵	Endangered ⁵⁶
<i>Senecio chrysanthemoides</i> DC.	Rheumatism ¹⁶	Critically endangered ¹⁷²
<i>Skimmia laureola</i> (DC.) Sieb. and Zucc. ex Walp. Nyra	Rheumatism ¹⁰⁶	Endangered ^{161,172}
<i>Solanum nigrum</i> L.	Rheumatism, inflammation ⁹¹	Vulnerable ¹⁷²
<i>Solanum surattense</i>	Rheumatism ⁷¹	Critically endangered ¹⁷²
<i>Sonchus asper</i> (L.)	Rheumatism, inflammation ^{119, 123}	Vulnerable ¹⁷²
<i>Tamarindus indica</i> L.	Inflammation ¹¹⁵	Vulnerable ¹⁷¹
<i>Tamarix aphylla</i> (L.) Karst.	Rheumatism, inflammation ^{146,198}	Vulnerable ¹⁸²
<i>Taraxacum officinale</i> Wigg.	Inflammation, rheumatism ^{117,147}	Rare, vulnerable ^{167,172}
<i>Taxus baccata</i> L.	Rheumatism ¹¹⁷	Endangered, threatened ^{165,169}
<i>Tribulus terrestris</i> L.	Rheumatism ¹⁹⁹	Rare ⁵³
<i>Urtica dioica</i> L.	Rheumatism, inflammation ¹¹⁷	Critically endangered, rare ^{168,172}
<i>Valeriana jatamansi</i> Jones.	Rheumatism ¹⁰⁶	Endangered, rare, critically endangered ^{167,172, 74}
<i>Verbascum thapsus</i> L.	Inflammation, rheumatism ^{100,101}	Vulnerable ¹⁷²
<i>Verbena officinalis</i> L.	Rheumatism, inflammation ^{130,178}	Vulnerable ⁶⁷
<i>Viola serpens</i> L.	Inflammation ¹⁰¹	Rare, vulnerable ^{53,168}
<i>Vitex negundo</i> L.	Rheumatism ²⁰⁰	Over harvested ^{68,191}
<i>Vitis vinifera</i> L.	Joint pain ¹⁹	Endangered ¹⁸⁹
<i>Withania coagulans</i> Dunal.	Inflammation, rheumatism ^{84,146}	Endangered, rare ^{53,201}
<i>Withania somnifera</i> (Linn.); Dunal.	Inflammation, arthritis ¹⁴⁶	Endangered, vulnerable ^{65,171}
<i>Xanthium strumarium</i> L	Rheumatism ¹⁴⁶	Endangered ¹⁷²
<i>Ziziphus mauritiana</i> Lam.	Inflammation ⁷⁶	Rare ⁶⁷

try and to expand more effective trade in medicinal plants for the economic stability and prosperity of Pakistan.

The medicinal plants of Pakistan are present in 13 natural areas, from alpine pastures to mangrove forests. More than 10% of the flora of Pakistan is threatened.⁵⁷ Research on threatened plants in Pakistan is extremely scarce, and available data are controversial. For example, Chaudhri *et al.*⁵⁹ reported 709 plants, Nasir⁵⁹ described 580 plants, and Ali *et al.*⁶⁰ stated that only 21 plants are threatened in Pakistan. In existing study, conservation status of 148 plant species is at risk. In addition, folkloric data on medicinal plants is diminishing, and organized recording of such knowledge is absent. Little or no consideration is being given to the cultivation and collection of medicinal flora, and there is a lack of consistent data on plants that require conservation.⁵⁶ More so, there are numerous barriers to the viable cultivation, collection, and use of herbal plants.^{61,62} Besides, 70% of the medicinal plants grown in mountain ranges (e.g., Himalayas, Karakoram and Hindu Kush) are on the verge of disappearance because mountain plant species are very sensitive to ecologic changes such as global warming. Also, political and tribal pressures halt the documentation of biodiversity and enactment of conservation plans.⁶³

Study limitations

Appropriate documentation of data was lacking in several of the research articles evaluated. There were many spelling mistakes of plant names and families. The growth forms and preparation methods for herbal remedies were not stated in many research articles.

Study recommendations/areas of improvement

First, there is an urgent need to systematically document knowledge of the use of medicinal plants from unexplored areas of Pakistan. This is because, in general, elderly people are the only guardians of such evidences. The rapid disappearance of traditional culture and natural resources due to the urbanization and industrialization of such areas mean that unrecorded information may be lost forever. Second, the problems of biodiversity loss can be lessened by the recommendations shown in the previous studies.^{55,61,64-68}

(a) Refinement of skills of herbal therapists and collaboration among taxonomists and local healers as ethnobotanical information endows elementary knowledge to pharmacologists, chemists and pharmacists for novel drug discovery.

(b) Pharmacologic validation as well as isolation, purification and characterization of therapeutically active constituents from unexplored plant species with anti-inflammatory/anti-arthritic. These constituents may serve as lead molecules for synthesis of safer, novel and cheaper therapeutic alternatives.

(c) Installation of more herbal industries in country, in order to increase the manufacture of herbal formulations. Also, this will allow the standardization as well as

the evaluation of therapeutic potential, toxicity, and possible interactions of herbal medicines prior to integrating in primary healthcare system.

(d) Documentation and preservation of information from indigenous communities by training and educating inhabitants about safeguarding indigenous flora and, thus, improving the local and national economy.

(e) Establishment of nurseries by the Ministries of Agriculture and Health, where medicinal plants are cultivated. Development of botanic gardens that set up seed banks for medicinal plants cultivated in country.

(f) Development of active policies by the Ministries of Agriculture, Health and Trade to sustain better cultivation, provision of high-quality planting materials and introduction of new methods of hybridization and grafting in order to conserve and expand many species.

(g) Initiation of afforestation projects and authorization of only feasible harvesting of medicinal plants.

(h) Control of overgrazing to regulate irreparable loss of medicinal flora.

(i) Reduction of biotic pressure by supplying gas and electricity.

(j) Appropriate monitoring of trade and marketing for stability in product supply and development of appropriate methods for consistency of pricing of medicinal herbs in market.

(k) Enactment of conservation policies comprising in situ and ex situ propagation and cultivation of selected medicinal plants in susceptible areas to thwart disappearance of local ethnobotanical culture and to increase their availability.

(l) Monitoring and documentation of overseas trade through unconventional routes, including cross-border exchanges that affect the economy.

In conclusion, people from Pakistan made use of 371 plant species belonging to 263 genera and 99 families for the treatment of inflammatory disorders. Plants from the Asteraceae family were used most often in Pakistan. Herbs were the dominant growth form. Leaves were the plant parts used most often. Decoctions were the main preparation method. Nine plant species were used most frequently in the dwellers of most regions of Pakistan. A total of 111 plants were shown experimentally to have neither anti-arthritic nor anti-inflammatory activities, and 148 plant species were threatened. Eighty-four species had commercial importance. Twelve plant species were imported, and 25 plant species were exported, from Pakistan. This review provides baseline data for plant species in Pakistan that have potential anti-inflammatory/anti-arthritic activities.

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