



Quantitative ethnobotanical survey of medicinal plants used for gastrointestinal diseases in Bojnord, Iran

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Abstract:

This study was aimed to ethnobotanical survey on important medicinal plants that are used for treatment of gastrointestinal disorders which are available in medicinal markets of Bojnord, Iran. The indigenous knowledge was collected through interviews (30 men and 4 women) of medicinal plants sellers for a period of 5 years from 2017 to 2022. Data were analyzed using ethnobotanical quantitative indices for Frequency of Citations (FC), Relative Frequency Citation (RFC), Use Report (UR), Cultural Importance Index (CII), Number of Uses (NU), Relative Importance Index (RII), Fidelity Level (FL), and Family Importance Value (FIV). In total, 90 plant species belonging to 35 plant families were reported for treatment of gastrointestinal disorders. The most FIV index was identified for Asteraceae (12 species with FIV = 35) followed by Apiaceae (10 species with FIV = 29). The most utilized plant parts were fruit (29%) followed by shoot (20%) and seed (18%). Based on the results, FC index ranged from 1 to 26. Some species such as *Bunium persicum*, *Anethum graveolens*, *Descurainia sophia* had minimum and *Melissa officinalis* had maximum citation. The NU index varied between 1 to 10 in which the highest used number was calculated for *Trachyspermum copticum*. In addition, the RFC ranged between 0.03 to 0.77, indicating the high native knowledge of people about medicinal plants and their usages. Result of this study indicated that although people in Bojnord County have access to modern medicinal preparations, a considerable population still use medicinal plants for therapeutic purposes. Regarding the rich traditional knowledge of these people, the represented data can potentially be a precious reference containing useful information for subsequent phytochemical, biological, and pharmacological investigations. The results clearly indicate that high number of used medicinal plants in the herbal markets of Bojnord is related to the diverse topographic-climatic of this region.

Keywords: Essential oils; Therapeutic potential; Herbal medicine; Relative Frequency Citation (RFC)

Introduction

Humans had consumed plants to treat diseases and maintain health since time ago (Toghranegar et al., 2020). Iran has one of the richest floras in the world. Since a high percentage of Iran's plant species constitutes medicinal plants, they have great abilities in this aspect. Rangelands have major roles in the supply of medicinal plants. Proper rangeland management is important for the purpose of sustainable use (Akbarlou and Nodehi, 2016). Nowadays, herbal medicines allocate a large proportion of pharmaceutical

products, considered as diverse bioactive natural agents and suitable alternatives for chemical medicines (Ziaei et al., 2014). According to the World Health Organization (WHO), 25% of conventional medications are originated from plants while recognizing therapeutic effects of most herbal medicines (74%) utilized in modern pharmaceutical technology has been traditionally documented a long time ago (Heshmati et al., 2016). Consumption of herbal medicine has a long and ancient history in Iran and like other parts of the world, it is expanding every day globally (Mosaddegh and Naghibi, 2002). Traditional and ethnob-

otanical medicines are two categories of interest in Iran and many countries. The science of ethnobotany is the survey of regional indigenous herbs and their applications through the traditional prescription from local culture and people (the word ethno means people and botany means plant). In fact, in an ethnobotanical study, the researcher refers to local people, old residents and experienced informants after visiting the area and the initial studies on familiarity with the area (Herbal medicine shop) and documents their oral information, traditional, and native knowledge of various plant applications including medicinal, food, dyeing, handicrafts, etc. (Vafadar and Toghranegar, 2020). Nowadays, due to the time situation, it seems necessary to conduct this research in parallel with laboratory research. Since the knowledge of elders of each region or local perfumers is recorded and passed on to the next generation. The use of plants for the treatment of diseases is increasing due to the fewer side effects of plants as a medicine.

In this regard, several studies have been directed by researchers in diverse regions of Iran, such as ethnobotanical investigation of herbal medicine in Mashhad Market (Amiri and Joharchi, 2016), ethnopharmacology study of effective herbal medicine in the treatment of gastrointestinal diseases in Mahneshan, Zanjan province, Iran (Toghranegar et al., 2020), traditional use of some herbal drugs in the cure of gastrointestinal diseases in western part of Mazandaran province (Ahvazi and Akbarzadeh, 2017), ethnobotanical study of medicinal plants on gastrointestinal diseases in Lorestan province (Delfan et al., 2015). Besides, ethnobotanical study of some herbal medicine in Abadeh city has been situated in Fars province (Razmjoue et al., 2015). Among the studies that have been done in the northeastern part of Iran, the following researches can be mentioned: ethnobotanical study of common medicinal herbs in North Khorasan perfumeries for the treatment of neurological diseases (Nadaf et al., 2019), medicinal herbs in Farooj city (Farouji and Khodayari, 2016), and ethnobotany of medicinal plants of Razo and Jorglan county (North Khorasan) (Arvin and Firuzeh2022, 2022).

Gastrointestinal diseases are one of the challenges of cos-

metic health system and one of the common causes of mortality (Lenti et al., 2019). Indigestion and reflux are the most common gastrointestinal diseases that reduce the quality of life and cause a heavy economic burden. Although the gastric ulcer prevalence is 6 – 15% globally, this rate is estimated by 41% in Iran (Toghranegar et al., 2020). According to studies, diarrhoea is another common infectious disease that affects between 19 and 83 people per 100 throughout a geographical area. In addition, nausea, parasitic diseases, infectious diseases, bloating, constipation, irritable bowel syndrome, intestinal inflammation, fatty liver and liver failures are the most common gastrointestinal disorders. The development of gastrointestinal diseases is usually dependent on dietary pattern, food restriction, fasting or overeating, and irregular meals (Thakur et al., 2020). The purpose of this survey was to identify and introduce important medicinal herbs used in perfumeries (Herbal medicine shop) of Bojnord city located in Northern Khorasan province, Iran, to help treat gastrointestinal diseases and prepare a record of valuable traditional medicinal plants which should not be forgotten as an indigenous knowledge of this region. The introduced plant species are pasture plants. Due to their importance, proper management of pastures can be effective in maintaining the diversity of pasture vegetation, and by informing people, the unprincipled collection of these valuable species can be prevented.

Materials and methods

Study area

Bojnord is situated in the north-eastern part of Iran, the capital city of North-Khorasan province, in a geographic location between 57°17' to 57°28' eastern longitude and 37°13' to 37°50' northern latitude (figure 1). The whole area of Bojnord County is 36 km² with the population of about 230,000 people. Based on the de Martonne climatic classification, Bojnord has a semiarid and cold climate with 19.9 °C maximum temperature to 6.8 °C minimum temperature. The city is renowned for its multi-ethnic background. For this reason, different languages including Persian, Tur- kic, Kurdish, Tati, etc. are spoken. (Nadaf et al., 2019).

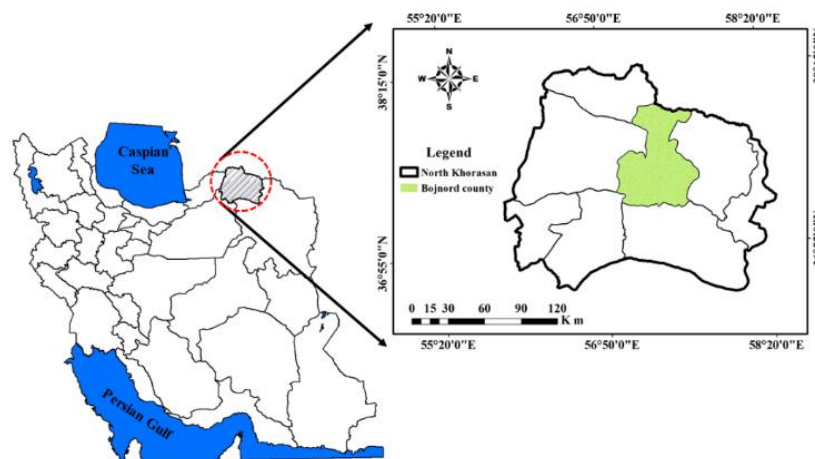


Figure 1. Map of the North Khorasan province.

Data collection and nomenclature

The present investigation was performed for a period of 5 years from 2017 to 2022 in the herbal markets of Bojnord. Thirty-four herbal medicine shop (ages 28 – 70 years, 30 men and 4 women) were interviewed. During the interview, the local name, uses, and used parts of each plant were recorded. These medicinal plants in herbal markets in Bojnord were identified using various Flora, especially Flora Iranica (Rechinger, 2015), Flora of Iran (Asadi, 2012) and Flora of Iraq (Townsend et al., 1985). The list of scientific names of species and authors was standardized based on the database (IPNI = The International Plant Name Index) and the genera were standardized based on Angiosperm Phylogeny Groups (Angiosperm Phylogeny Group (APG-IV), (Chase et al., 2016)).

Data analysis

Frequency of Citation

The Frequency of Citations (FC) is the number of informants who have mentioned the species. In addition, Relative Frequency of Citation (RFC), Use Report (UR), Number of Uses (NU), Relative Importance index (RII), and Cultural Importance index (CII) indices for the species that had the most useful citations were calculated using software R.4.1.

Relative Frequency of Citation

The Relative Frequency of Citation (RFC) displays the local importance of each species, while it is attained by dividing the informant number who mention the use of the species (FC) by the informant number participating in the survey (N) (equation 1).

$$RFC = \frac{FC}{N} \quad (1)$$

This index varies from zero, when nobody refers to the herbs as valuable, to one; in case, every informant mentions it as valuable (Tardío and Santayana, 2008).

Use Report

The function of Use Report (UR) calculates the number of use report for each species in the data set (equation 2).

$$UR_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui} \quad (2)$$

where:

UR_s is the entire usage of a species by wholly informant (from i to N) in each use-category for that species. It is the number of the informant numeral who indicates each use-category NC for the species and addition of all uses in each use-category (from u_1 to NC) (Prance et al., 1987).

Cultural Importance Index

In the current research, the Cultural Importance Index (CII) is another index that was calculated. UR index is used to calculate this index (Tardío and Santayana, 2008) for each species to allow the identity of the different herb species (equation 3).

$$CII = \frac{UR}{N} \quad (3)$$

where:

UR is the number of use report for each species and N is total number of use report for all species in the data set.

Number of Uses

The function of Number of Uses (NU) calculates the number of uses per species. NU is the sum of entire use classes for which a species is considered beneficial (Prance et al., 1987).

Relative Importance Index

The Relative Importance Index (RII) was calculated by the following equation (Tardío and Santayana, 2008) (equation 4).

$$RII = \frac{\{RFC(\max) + RNU(\max)\}}{2} \quad (4)$$

where:

RFC (max) = the relative frequency of citation over the maximum, i.e., it is achieved through dividing FC by the maximum value for whole species of the study,

RFC (max) = FC/max (FC), and RNU (max) is the used number of use-categories over the maximum, gained by dividing the number of species uses utilizing the highest value in whole species of the survey (equation 5).

$$RNU(\max) = \frac{N.\text{of Uses}}{\max UN} \quad (5)$$

The RII index differs theoretically from 0, when no one mentioned any use of the plant, to 1, when the plant was most often stated as beneficial in the highest number of used classes.

Fidelity Level

The Fidelity level (FL) index was assessed using the following formula (equation 6) to define the most favored species employed in the handling of a specific ailment as more than one herb species is employed in the same class. The FL function estimates the FL per species in the study. It is a way of estimating the ratio of informants who use a herb for a similar goal as compared to the whole uses of all herbs.

$$FL = \frac{N * 100}{FC} \quad (6)$$

where: N is the number of informants that exploits a specific herb for a particular goal, and FC is the total number of uses for the species.

High FL value indicates high frequency of the herbal species application for handling a specific ailment class using the informants of the study region (Bibi et al., 2014).

Family Importance Value

The Family Importance Value (FIV) (equation 7) provides the local importance of the families of species. It was assessed by taking the ratio of informant mentioning the family (Vitalini et al., 2013)

$$FIV = \frac{FC(\text{family})}{N \times 100} \quad (7)$$

where:

FC is the number of informants mentioning the family and N is the whole number of people participating in the survey.

Chord diagram of ethnobotany uses and species

Radial plots were made for URs, FCs, NUs, CIs indices; the chord plot is made for ethnobotany uses and species Gu (2014). Flow diagram frequency distributions across uses, experts and use classes were drawn using ggplot2 package in R ver. 4.2.1 software (Claus et al. 2020). In addition to the four medicinal species with the most citations, diagrams of the species with the highest number of usages were also drawn. Moreover, graphs of the part percentage used in the treatment of gastrointestinal diseases were plotted. These diagrams were drawn through excel ver. 2016 software.

Phytochemical data

For this work, phytochemical information about four species with the highest FC was obtained based on a comprehensive survey of scientific databases.

Results

In this survey, 90 traditionally consumed herbs were identified that have effective medicinal values for the treatment of gastrointestinal diseases (Table 1). The scientific names, herbal families, local names, usages, the used plant parts, FC, UN, relative frequency citation (RFC) are listed in Table 1.

Family important value

These medicinal species belong to 35 plant families and the most common family of therapeutic herb species, upon the number of species and FIV index was identified as Asteraceae (12 species with FIV = 35) followed by Apiaceae (10 species with FIV = 29) (figure 2).

Plant part used

The most applied herb parts were fruits (29%) followed by shoots (20%) and seeds (18%) (Figure 3). In addition, the lowest plant part used were latex (2%), gum (3%) and manna (6%).

Ethnobotanical quantitative indices

Based on the results, species such as *Bunium persicum*, *Anethum graveolens*, *Descurainia sophia* and *Melissa officinalis* had the maximum citation in the study (Table 2).

RFCs, URs, NUs, RIs, and CIs indices for species with maximum citations calculated by R software are presented

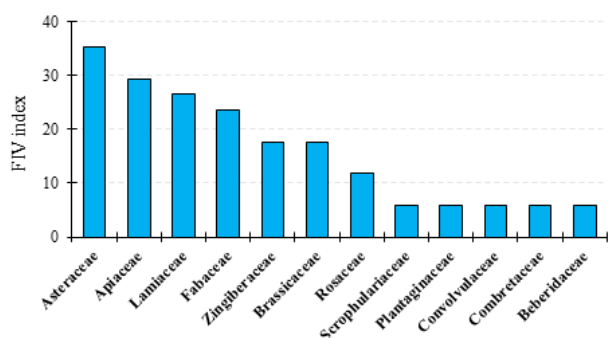


Figure 2. Family Important Value (FIV) of medicinal plants used for treatment of gastrointestinal diseases.

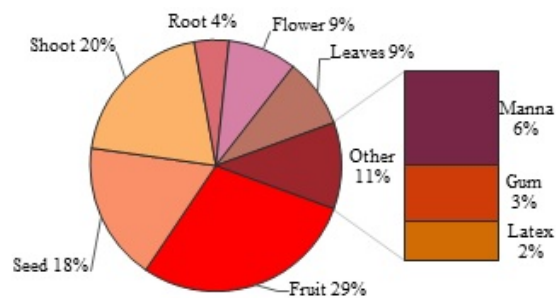


Figure 3. Plant part used in preparation of ethnomedicine.

in Table 2. As the results showed, *Bunium persicum* (FC = 26) demonstrated the maximum citation whereas *A. graveolens* (UR = 44) had the highest use report; *B. persicum* and *A. graveolens* (NU = 3 for both) followed by *Descurainia sophia* (NU = 2) and *M. officinalis* (NU = 1).

Fidelity Level (FL) index

Based on the results, *A. graveolens* and *B. persicum* had the highest FL for Carminative (60 and 57.69 %, respectively). In addition, the highest FL for stomach analgesia (Use_3), fatty liver purifier (Use_5) and eliminates gastric infection (Use_6) was observed for *B. persicum*, *D. Sophia* and *M. officinalis*, respectively (Table 3 and figure 4).

Phytochemical profile of species with most frequency of citation

Since four species had the most citations, their bioactive chemicals were presented by examining different sources. The predominant essential oils' composition of *D. sophia*, *B. persicum*, *A. graveolens* and *M. officinalis* are listed in Table 4.

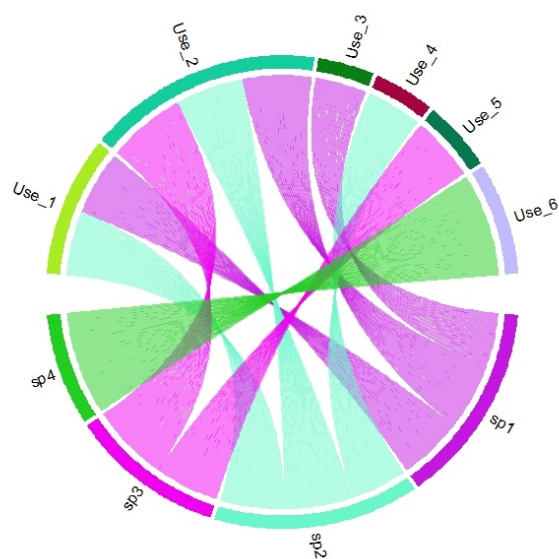


Figure 4. Chord diagram of ethnobotany uses and species with maximum citations. SP1: *Bunium persicum*, SP2: *Anethum graveolens*, SP3: *Descurainia sophia*, SP4: *Melissa officinalis*. Use 1 (carminative), Use 2 (Laxatives), Used 3 (Stomach pain reliever), Use 4 (Stomach tonic), Use 5 (Fatty liver purifier) and Use 6 (Eliminates gastric infection).

Table 1. Medicinal plants and their uses in the treatment of gastrointestinal disorders. FC: frequency of citations; NU: number of uses; RFC: relative frequency of citation. Be sure to consult a doctor before using these herbs.

No	Family	Scientific name	Local name	Part used	Uses	FC	NU	RFC
1	Amaranthaceae	<i>Dysphania botrys</i> (L.) Mosyakın & Clemants	Dermaneh Torki	Shoot	Relieve stomach pain, Excretion of intestinal and gastric worms, Gastric lavage	8	4	0.24
2	Anacardiaceae	<i>Rhus coriaria</i> L.	Somagh	Fruit	Antidiarrhea	22	1	0.65
3	Apiaceae	<i>Bunium persicum</i> (Boiss.) B.Fedtsch	Zireh Siah	Fruit	Carminative, Laxatives, Stomach pain reliever	26	3	0.77
4	Apiaceae	<i>Anethum graveolens</i> L.	Shevid	Fruit	Stomach tonic, Stomach pain reliever, Carminative	25	3	0.74
5	Apiaceae	<i>Foeniculum vulgare</i> Mill.	Razianeh	Fruit	Stomach pain reliever, carminative, Anti-stomach acid	22	3	0.65
6	Apiaceae	<i>Trachyspermum ammi</i> (L.) Sprague	Zenian	Fruit	Stomach tonic, Carminative, Anti-parasite, Stomach ache, Stomach disinfectant, Anti-stomach acid, Stomach reflux remover, Ant diarrhea, Treatment of duodenal ulcers	21	10	0.62
7	Apiaceae	<i>Cuminum cyminum</i> L.	Zireh Sabz	Fruit	Treatment of stomach pain, Anti-flatulence	19	2	0.56
8	Apiaceae	<i>Heracleum persicum</i> Desf.	Golpar	Fruit	Stomach tonic	18	1	0.53
9	Apiaceae	<i>Ferula gummosa</i> Boiss.	Barijeh	Gum	Eliminates inflammation of the stomach, Duodenum and small intestine, eliminates gastrointestinal infections, Stomach tonic, Repel parasites, Stomach Tumor remover	13	7	0.39
10	Apiaceae	<i>Petroselinum crispum</i> (Mill.) Fuss	Jafari	Fruit	Stomach tonic, Treatment of indigestion	10	2	0.29
11	Apiaceae	<i>Pimpinella anisum</i> L.	Anison	Fruit	Carminative	9	1	0.27
12	Apiaceae	<i>Dorema ammoniacum</i> D.Don	Koma	Gum-Root	Antifungal gastric parasite, Stomach tonic	5	2	0.15
13	Arecaceae	<i>Areca catechu</i> L.	Fufel	Seed	Antidiarrhea	8	1	0.24
14	Asteraceae	<i>Tripleurospermum disciforme</i> (C.A.Mey.) Sch.Bip.	Babuneh Dashti	Flower	Laxatives, Control of symptoms of intestinal colitis, Stomach disinfectant, Fatty Liver	22	5	0.65
15	Asteraceae	<i>Achillea santolinoides</i> subsp. <i>wilhelmsii</i> (K.Koch) Greuter	Bumadaran	Shoot	Stomach tonic, Stomach pain reliever, Gastritis, Intestinal and gastric infections, Carminative, Laxatives, Liver tonic	20	9	0.59
16	Asteraceae	<i>Cichorium intybus</i> L.	Kasni	Shoot	Stomach tonic, Eliminates liver failure, Inflammation of the gallbladder, Fatty Liver	12	4	0.36
17	Asteraceae	<i>Lactuca sativa</i> L.	Kahu	Seed	Liver tonic, Laxatives	12	2	0.35
18	Asteraceae	<i>Silybum marianum</i> (L.) Gaertn.	Khare Maryam	Seed	Fatty liver remover, Gallbladder, Strong antibiotics for the liver, Jaundice treatment	11	4	0.33
19	Asteraceae	<i>Calendula officinalis</i> L.	Hamishe Bahar	Flower	Stomach tonic, Liver tonic	10	2	0.23
20	Asteraceae	<i>Arctium lappa</i> L.	Baba Adam	Leaf-Root	Stomach tonic, Liver purification	9	2	0.27
21	Asteraceae	<i>Echinops cephalotes</i> DC.	Shekar Tighal	Manna	Laxatives	7	1	0.21
22	Asteraceae	<i>Centaurea depressa</i> M.Bieb.	Gol Gandom	Shoot	Stomach disinfectant, Liver tonic	6	2	0.18
23	Asteraceae	<i>Helichrysum graveolens</i> (M.Bieb.) Sweet	Afsantin	Shoot	Anti-parasite, Laxatives	6	2	0.18
24	Asteraceae	<i>Gundelia tournefortii</i> L.	Kangar	Shoot	Stomach tonic, Liver tonic	3	2	0.09
25	Asteraceae	<i>Cynara scolymus</i> L.	Kngar Farangi	Leaf-Fruit	Liver tonic	2	1	0.06
26	Berberidaceae	<i>Berberis integerrima</i> Bunge	Zereshk Kuhi	Fruit	Liver purifier, Carminative, Gastritis	11	3	0.32
27	Berberidaceae	<i>Berberis vulgaris</i> L.	Zereshk	Fruit	Regulation of liver enzymes	9	1	0.26
28	Brassicaceae	<i>Descurainia sophia</i> (L.) Webb ex Prantl	Khakshir	Seed	Laxatives, Fatty liver purifier	25	2	0.74
29	Brassicaceae	<i>Brassica napus</i> L.	Shalgham	Seed	Laxatives, Carminative	9	2	0.27
30	Brassicaceae	<i>Eruca sativa</i> (L.) Mill.	Mandab	Seed	Stomach tonic	7	1	0.21
31	Brassicaceae	<i>Alyssum alyssoides</i> (L.) L.	Ghodumeh	Seed	Laxatives, Liver tonic	5	2	0.15
32	Brassicaceae	<i>Lepidium sativum</i> L.	Shahi	Shoot	Food digester	5	1	0.15
33	Brassicaceae	<i>Capsella bursa-pastoris</i> (L.) Medik.	Kiseh Keshish	Seed	Laxatives, Liver tonic	3	2	0.09
34	Burseraceae	<i>Commiphora mukul</i>	Maghal Azragh	Gum	Laxatives	7	1	0.21
35	Cannabaceae	<i>Cannabis sativa</i> L.	Shahdaneh	Seed	Stomach tonic	14	1	0.41
36	Combretaceae	<i>Terminalia chebula</i> Retz.	Halileh Siah	Fruit	Laxatives	13	1	0.38
37	Combretaceae	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Halileh	Fruit	Laxatives, Carminative	7	2	0.21
38	Convolvulaceae	<i>Cuscuta epithimum</i> Murray	Aftimun	Shoot	Liver cleansing, Laxatives	9	2	0.26
39	Convolvulaceae	<i>Operculina turpethum</i> (L.) Silva Manso	Torbod	Root	Liver cleansing, Laxatives, Gallstone excretion	8	3	0.24
40	Cornaceae	<i>Cornus mas</i> L.	Zoghal Akhteh	Fruit	Liver cleansing	5	1	0.15
41	Eleagnaceae	<i>Elaeagnus angustifolia</i> L.	Senjed	Fruit	Diarrhea remover, Carminative, Eliminate stomach toxins	18	4	0.53
42	Euphorbiaceae	<i>Ricinus communis</i> L.	Karchak	Seed	Laxatives	5	1	0.15
43	Fabaceae	<i>Glycyrrhiza glabra</i> L.	Shirin Bayan	Root	Eliminates gastritis, Treatment of cancer and stomach ulcers, Stomach tonic, Anti-stomach acid, Duodenal wound healing	19	7	0.56
44	Fabaceae	<i>Cassia obovate</i> Collad.	Sena	Leaf	Laxatives	19	1	0.56
45	Fabaceae	<i>Trigonella foenum-graecum</i> L.	Shanbalileh	Seed	Carminative	17	1	0.5
46	Fabaceae	<i>Alhagi graecorum</i> Boiss.	Taranjabin	Manna	Jaundice treatment, Laxatives	16	2	0.47

Continue of Table 1.

No	Family	Scientific name	Local name	Part used	Uses	FC	NU	RFC
47	Fabaceae	<i>Astragalus</i> spp.	Katira	Gum	Anti-bile, Laxatives	14	2	0.41
48	Fabaceae	<i>Cassia fistula</i> L.	Folus	Fruit	Laxatives ,Relieve stomach pain Jaundice treatment	12	3	0.35
49	Fabaceae	<i>Tamarindus indica</i> L.	Tamr Hendi	Fruit	Laxatives, Excretion of gallstones	5	2	0.15
50	Fabaceae	<i>Astragalus adscendens</i> Boiss.	Gazangabin	Manna	Relieve stomach pain, Laxatives	2	2	0.06
51	Juglandaceae	<i>Juglans regia</i> L.	Gerdu	Fruit-Leaf	Stomach tonic, Antidiarrhea	9	2	0.26
52	Lamiaceae	<i>Melissa officinalis</i> L.	Badranjbuyeh	Flower-Leaf	Eliminates gastric infection	24	1	0.71
53	Lamiaceae	<i>Zataria multiflora</i> Boiss.	Avishan Shirazi	Shoot	Antidiarrhea, Elimination of gastrointestinal parasites, Analgesia of the stomach	23	4	0.68
54	Lamiaceae	<i>Mentha longifolia</i> (L.) Hudson	Puneh	Shoot	Carminative, Antifungal and stomach infection, Antinausea, Food digester, Stomach tonic, Antidiarrhea	21	6	0.62
55	Lamiaceae	<i>Mentha spicata</i> L.	Naana	Shoot	Carminative, Analgesic gastrointestinal upset, Stomach tonic	19	3	0.56
56	Lamiaceae	<i>Stachys lavandulifolia</i> Vahl	Chai Kuhi	Flower	Relieve stomach pain, Stomach tonic, Intestine tonic	16	3	0.47
57	Lamiaceae	<i>Satureja hortensis</i> L.	Marzeh	Shoot	Carminative, Food digester	16	2	0.47
58	Lamiaceae	<i>Ziziphora clinopodioides</i> Lam.	Anokh (Avishan kohi)	Shoot	Stomach tonic, Relieve stomach pain, Carminative	14	3	0.41
59	Lamiaceae	<i>Salvia officinalis</i> L.	Maryam Goli	Shoot	Antidiarrhea, Ant nausea	11	2	0.32
60	Lamiaceae	<i>Ziziphora tenuior</i> L.	Kakuti	Shoot	Treatment of gastric colitis, Ulcers, Stomach and colon pain, Carminative	9	5	0.26
61	Lamiaceae	<i>Perovskia abrotanoides</i> Kar.	Gol Kabud	Flower- Leaf	Carminative	1	2	0.03
62	Lauraceae	<i>Cinnamomum zeylanicum</i> Nees	Darchin	Bark	Carminative, Food digester	20	2	0.59
63	Liliaceae	<i>Aloe</i> spp.	Sabr Zard	Latex	Laxatives, Ulcers	11	2	0.32
64	Linaceae	<i>Linum usitatissimum</i> L.	Katan	Seed	Laxatives, Intestinal tonic	18	2	0.53
65	Malvaceae	<i>Alcea</i> spp.	Khatmi	Flower	Laxatives, carminative	20	2	0.59
66	Nymphaeaceae	<i>Nymphaea alba</i> L.	Nilufar Abi	Flower	Laxatives	2	1	0.06
67	Pedaliaceae	<i>Sesamum indicum</i> L.	Konjed	Seed	Laxatives	17	1	0.5
68	Plantaginaceae	<i>Plantago major</i> L.	Barhang	Seed	Laxatives, Liver tonic, Cleansing the stomach and intestines	17	4	0.5
69	Plantaginaceae	<i>Plantago ovata</i> Forssk.	Esfarzeh	Seed	Laxatives	12	1	0.35
70	Portulacaceae	<i>Portulaca oleracea</i> L.	Khorfeh	Seed-Leaf	Food digester	7	1	0.21
71	Ranunculaceae	<i>Nigella sativa</i> L.	Siah Daneh	Seed	Food digester, Stomach antacids	20	2	0.59
72	Rhamnaceae	<i>Ziziphus jujuba</i> Miller	Anab	Fruit	Stomach antacids	13	1	0.38
73	Rosaceae	<i>Rosa damasena</i> Herm.	Gole Mohamadi	Flower	Carminative, Laxatives	19	2	0.56
74	Rosaceae	<i>Cotoneaster nummularius</i> Fisch. & C.A.Mey.	Shir Khesht	Manna	Jaundice treatment, Laxatives, Bile solvent	12	3	0.35
75	Rosaceae	<i>Crataegus</i> spp.	Sorkhe Valik	Fruit-Leaf	Relieve stomach pain	4	1	0.12
76	Rosaceae	<i>Rosa foetida</i> × Herrm.	Gol Zard	Flower	Stomach disinfectant	2	1	0.06
77	Salicaceae	<i>Salix excelsa</i> J.F.Gmel.	Bidkhesht	Manna	Laxatives, Jaundice treatment	4	2	0.12
78	Schisandraceae	<i>Illicium verum</i> Hook.f.	Badian Khotai	Fruit	Reduce gastric reflux	7	1	0.21
79	Scrophulariaceae	<i>Scrophularia striata</i> Boiss.	Mokhaleseh	Shoot	Laxatives	3	1	0.09
80	Scrophulariaceae	<i>Verbascum cheiranthifolium</i> Boiss.	Dom Gav	Shoot	Stomach tonic, Anti-stomach acid	2	2	0.06
81	Sterculiaceae	<i>Helicteres isora</i> L.	Bahman pich	Fruit	Carminative	2	1	0.06
82	Theaceae	<i>Camellia sinensis</i> (L.) Kuntze	Chai Sabz	Leaf	Ulcers and gastritis	13	2	0.38
83	Tiliaceae	<i>Tilia cordata</i> Mill.	Zirfun	Leaf-Fruit	Carminative	6	1	0.18
84	Verbenaceae	<i>Aloysia citriodora</i> Palau	Beh Limu	Leaf	Stomach tonic, Carminative	17	2	0.5
85	Zingiberaceae	<i>Zingiber officinale</i> Roscoe	Zanjafil	Root	Laxatives, Carminative, Antinausea	23	3	0.68
86	Zingiberaceae	<i>Elettaria cardamomum</i> Maton	Hel	Fruit	Carminative	19	1	0.56
87	Zingiberaceae	<i>Amomum subulatum</i> Roxb	Helbad	Fruit	Carminative, Food digester	14	2	0.41
88	Zingiberaceae	<i>Curcuma longa</i> L.	Zard Chubeh	Root	Food digester, Carminative	2	2	0.06
89	Zingiberaceae	<i>Alpinia galanga</i> Willd.	Ghest Shirin	Root	Eliminates bloody diarrhea	3	1	0.09
90	Zingiberaceae	<i>Curcuma zedoaria</i> (Christm.) Roscoe	Zarambad	Root	Carminative, Stomach tonic, Liver tonic	2	3	0.06

Table 2. Frequency of Citation (FC), Relative frequency citation (RFC), Use Report (UR), Number of Uses (NU), Relative Importance Index (RII), and Cultural Importance Index (CII) for species with maximum citations.

number	Species name	FC	RFC	UR	NU	RII	CII
1	<i>Bunium persicum</i>	26	0.76	43	3	1	1.265
2	<i>Anethum graveolens</i>	25	0.73	44	3	0.981	1.294
3	<i>Descurainia sophia</i>	25	0.73	33	2	0.814	0.971
4	<i>Melissa officinalis</i>	24	0.70	24	1	0.628	0.706

Table 3. Fidelity Level (FL) index for species with maximum citations.

Number	Species name	Primary use	FL
1	<i>Bunium persicum</i>	Use_1 Carminative	57.69
2	<i>Bunium persicum</i>	Use_2 Laxatives	61.54
3	<i>Bunium persicum</i>	Use_3 Stomach analgesia	46.15
4	<i>Anethum graveolens</i>	Use_1 Carminative	60.00
5	<i>Anethum graveolens</i>	Use_2 Laxative	64.00
6	<i>Anethum graveolens</i>	Use_4 Stomach tonic	52.00
7	<i>Descurainia sophia</i>	Use_2 Laxative	72.00
8	<i>Descurainia sophia</i>	Use_5 Fatty liver purifier	60.00
9	<i>Melissa officinalis</i>	Use_6 Eliminates gastric infection	100

Table 4. The predominant essential oils' composition of *Descurainia Sophia*, *Bunium persicum*, *Anethum graveolens* and *Melissa officinalis* and their amount in parenthesis (min-max).

No	Main Essential Oil compounds of plant species			
	<i>Descurainia sophia</i>	<i>Bunium persicum</i>	<i>Anethum graveolens</i>	<i>Melissa officinalis</i>
1	Ocimene (0.02 – 21.17%)	α - pinene (0.6 – 1.52%),	α - pinene (0.02 – 6.4%),	Citronella (8.7 – 13.7%),
2	Menthol (10.7 – 11.27%),	ρ -cymene (5.3 – 25.8%),	Myrcene (0.01 – 7.36%),	Limonene (0.11 – 2.2%),
3	Neoisomenthyl acetate (2.96 – 3.5%),	Limonene (0.16 – 6.4%),	Phellandrene (0.03 – 7.51%),	Neral (3.5 – 22.18%),
4	Longicyclene (1.69 – 2.25%),	Cuminaldehyde (11.4 – 32.81%),	imonene (0.48 – 19.89%),	Geranial (0.0 – 1%),
5	Alloaromadendrene (2.28 – 2.18%),	γ -terpinene (10.9 – 46.1%),	ρ -cymene (0.2 – 33.42%),	Caryophyllene (3.3 – 8.2%),
6	Caryophyllene (3.87 – 4.59%),	Myrcene (0.56 – 1.1%),	Carvone (0.1575.92%),	Caryophyllene oxide (2.1 – 11%)
7	Ionone (6 – 6.2%),	β -pinene (0.1 – 11.27%)	Dihydrocarvone (0.06 – 16%)	
8	Cedrol (5.89 – 4.18%),		Dill apiole (0.05 – 19.5%),	
9	Hexahydrofarnesyl acetone (8.87 – 10.79%),		Dill ether (0.08 – 14.79%)	
10	Phytol (5.52 – 7.2%)			
11	Methyl linolenate (4.21 – 5.58%)			
Ref	(Li et al., 2010)	(Keramat and Golmakani, 2016) (Stappen et al., 2017)	(Mohebodini and Farmanpour-Kalalagh, 2021) (Ozliman et al., 2021)	(Nurzyńska-Wierdaka et al., 2014); (Jalal et al., 2015)

Discussion

Iran has one of the richest plant floras in the world (Heydari et al., 2020), due to its diverse ecological conditions such as a wide range of climatic condition (Omidipour et al., 2021). Iran comprises 7300 vascular plant species (Akhani, 2006) in a 1.65 million km² area and is the second richest country of plant diversity in Southwestern Asia after Turkey. Eighty percent of human population globally depends on medicinal plants as a primary healing option, including gastrointestinal ailments (Beyene et al., 2016). Gastrointestinal diseases are the most vulnerable system with respect to the number of human disorders. Such disorders affect people regardless of age, race, and gender. There is a vital demanding to support studies regarding the treatment of gastrointestinal diseases which cause a wide range of discomforts to patients (Thakur et al., 2020). In recent years, the occurrence of gastrointestinal diseases has increased in the world (Helsel et al., 2018). On the other hand, considering the high cost of chemotherapy for these patients (Rajkumar,

2020) and also the presence of adverse effects after chemical treatment, it has made researchers to focus on knowing more about medicinal plants and their capabilities. For this reason, Iran has a privileged position in this field due to its high medical plant biodiversity. Gastrointestinal cancer as a deathful type of cancer has a high incidence rate globally, and is considered as the most dangerous prevailing gastrointestinal disease. Anti-cancerous potencies of phytochemicals have been well-documented; among them, carotenoids (e.g., lutein, lycopene, β -carotene), flavonoids (e.g., quercetin), organosulfur compounds (e.g., allicin, allyl propyl disulfide, asparagusic acid), besides from pectin, curcumin, *p*-coumaric acid, and ferulic acid have been reported as the most bioactive dietary phytochemicals (Thakur et al., 2020).

In this study, 90 species of medicinal plants were used for the treatment of gastrointestinal diseases (Table 1). This result is in line with the wide climatic diversity in Iran (Oskouei et al., 2022) whereas the abundance of medic-

inal species has been reported in most of the similar research. Ahvazi and Akbarzadeh (2017) recorded 20 and 15 species in east Mazandaran and Lorestan province, Iran for treatment of stomach disorders (Delfan et al., 2015). Salarian et al. (2022) reported 61 medicinal species in Javaherdareh Rangelands of Ramsar in north of Iran. Mehrnia et al. (2021) studied medicinal plants in central Zagros. They reported herbs in the study area mostly used for treatment of gastrointestinal disorders. Therefore, as our investigation, the use of 90 species of medicinal plants suggested that the people of Northern Khorasan Province are among the other provinces suggesting the most medicinal plants for treatment of gastrointestinal diseases based on natural compounds and traditional ethnobotanical knowledge.

In a similar research on effective medicinal plants for digestive diseases, Toghranegar et al. (2020) reported the existence of 88 medicinal species in Mahneshan area of Zanjan. The Venn diagram between Mahneshan and Bojnord indicates that among all medicinal plants consumed for the treatment of gastrointestinal diseases, only 20 number shared common species. This result indicates that the type of medicinal plants and the amount of their use in each region depends a lot on the environmental conditions and the type of diseases prevalent in that region. In other words, in many regions of Iran, depending on the type of existing diseases, the local people discovered and identified the effects of different plants and this information was recorded as local knowledge of that region.

Based on the results, the Asteraceae family had the greatest therapeutic effect on gastrointestinal diseases (12 species with FIV = 35). In line with this finding, Sharafatmandrad and Mashizi (2020) reported that Asteraceae, Lamiaceae, Apiaceae, and Fabaceae were the most abundant families in terms of medicinal species in southeastern Iran. Similarly, other floristic scientists in Northern Khorasan reported similar findings (Nadaf, 2021; Asaadi, 2022). Thakur et al. (2020) investigated the medicinal plants used for gastrointestinal ailments in Kishtwar plateau in the Northwestern Himalaya, India. They showed that among the medicinal plants used, the Asteraceae was the dominant family (12.5%). This result is related to the diverse topographic-climatic zones in this region, such as warm low elevation plains in the south to snow-capped mountains and cold high elevation plains in the north. In addition, Asteraceae is one of the main medicinal families in Iran (Sharafatmandrad and Mashizi, 2020). The high rate of seed production and dispersal, high tolerance to harsh condition and low palatability of species of Astraceae resulted in the dominance of this family in Northern Khorasan (Nadaf, 2021). In addition, the widespread distribution of Astraceae in Northern Khorasan led to diverse traditional medicinal uses for different groups of people, such as pastorals.

In the present survey, the fruit and shoots of medicinal plants were recorded as the most used parts for the treatment of gastrointestinal diseases (figure 3). Comparing to similar studies, aerial parts, leaves and fruit are reported as the most used plant parts in southeastern Iran (Sharafatmandrad and Mashizi, 2020). Toghranegar et al. (2020) also showed the leaves of medicinal species had the most frequency. This

finding is related to easy accessibility of aerial plant tissue for harvesting such as fruit while this approach could endanger sustainable use of medicinal plants.

Among the 90 species introduced in the treatment of gastrointestinal diseases, the species *T. copticum*, *A. wilhelmsii*, *F. gummosa*, *G. glabra* and *M. pulegium* had the highest number of uses, which are shown in Table 1. *B. persicum* and *A. graveolens* have the most NU index among four species with high FC. In the present study, RFC values ranged from 0.02 – 0.76. In addition, *B. persicum*, *A. graveolens*, *D. sophia*, and *M. officinalis* had the highest RFC (Table 1 and 2). The ethnomedicinal plant species having high RFC values indicate their abundant use and widespread knowledge among the medicinal markets in Bojnord. Amiri and Joharchi (2016) showed these four species are effective in treating gastrointestinal disease. *D. sophia* is recorded by Toghranegar et al. (2020) with the same effect (Laxatives, Fatty liver purifier) as the treatment of gastrointestinal diseases. Arvin and Firuzeh2022 (2022) investigated the ethnobotany of medicinal plants in Razo Gargalan in Northern Khorasan, Iran, identifying three species, *B. persicum*, *D. sophia* and *M. officinalis* for the treatment of gastrointestinal diseases. As shown in Table 2, *A. graveolens* had the highest UR (UR = 4). Whitney et al. (2018) also calculated this index for the valuation of plants in the home gardens of southwestern Uganda. The highest RII values were calculated for *B. persicum* (RI = 1) (Table 2). This species had high FC and NU. Accordingly, formula RII index is the most for this species. Cultural importance index (CI) takes the spread of the use (number of informants) for each species along with its versatility, i.e. the diversity of its uses, into account (Mosaddegh and Naghibi, 2002). *A. graveolens* had the highest CI (1.294).

The analysis value of FL indicated *M. officinalis* accounts for maximum fidelity level (FL = 100%) for the treatment of gastrointestinal diseases (Table 3). The value obtained indicates eliminating gastric infection was the most significant ailment treated using *M. officinalis*. The high value of FL (near 100%) represented the use of a particular species for all the use categories in the same way, whereas low value of FL represented the use of plants for many different purposes (Thakur et al., 2020). One of the most important species listed in Table 1, *Ziziphora clinopodioides*, is consumed as a drink with the local name (Anekh/Kakoti). This species is collected by the locals themselves and is considered as a vulnerable plant (Nadaf, 2021). *F. gummosa* (Gasni, Barijeh) is another species possessing an important role in the treatment of gastrointestinal diseases and is collected by the local people. Barijeh (*F. gummosa*) is also one of the native Iranian plants, extensively consumed for medicinal and industrial purposes while it is being harvested every year due to its important applications. Due to inappropriate methods in extracting its leachate, the condition for the destruction of this plant has been provided and no action has been taken to protect it. The genus *Ferula* is known for its various chemical compounds including coumarin terpenoids, mixtures of aromatic esters, terpenic acids and alcohols, and terpene lactones. Traditional applications of Barijeh for the treatment of many diseases, in addition to

its bioactive phytoconstituents, may unravel discovery of drugs by natural origin for optimistically production of therapeutic medicines (Ahmadi et al., 2020).

The results of the main essential oil indicate that in the case of *D. sophia*, ocimene has protective properties for the liver, as listed in Table 4. The major volatile chemicals of *D. sophia* (in China) were previously characterized as β -ocimene and menthol (Li et al., 2010). An in vitro study performed by Jalilzadeh-Amin et al. (2011) on its extract found that its seed extract was able to increase the movements of smooth muscles. In this way, it can be effective in the organs of the digestive system. Two bioactive volatile compounds of *A. graveolens* dihydrocarvone and limonene formerly indicated antioxidant effects and stabilizing liver cell membranes and reducing enzyme release into the bloodstream (Table 4). The *A. graveolens* seed extract exhibited a protective effect on gastric mucosa due to its flavonoid compounds. Moreover, the glucose-lowering effect of the extract is related to quercetin as the main plant's flavonoid composition. The antioxidant compounds of *A. graveolens* reduce glucose uptake into the intestine (Alebrahim-Dehkordy et al., 2017). *M. officinalis* was also studied as a medicinal plant in this report (Table 4). This plant is used to treat gastrointestinal, cardiovascular, and neurological diseases and its ointment is consumed as anti-herpes. The geographical conditions can have impact on the essential oil content as well as the composition. Moreover, many studies proved abiotic and biotic effects on biosynthesis of plant volatile constituents (Nadaf et al., 2022).

Conclusion

In this study, based on an ethnobotanical survey, medicinal plants consumed for the treatment of gastrointestinal diseases were identified from the herbal markets of Bojnord, Northern Khorasan Province, Iran. To the best of our knowledge, this is the first quantitative ethnomedicinal study. Data were statistically analyzed using R software using ethnobotanical quantitative indices of Frequency of Citations (FC), Relative Frequency Citation (RFC), Use Report (UR), Cultural Importance Index (CII), Number of Uses (NU), Relative Importance Index (RII), Fidelity Level (FL), and Family Importance Value (FIV). The existence of 90 plant species for the treatment of gastrointestinal diseases showed the high ethnobotanical knowledge of the people of the region. The results clearly indicate that the higher number of medical plants in the herbal markets of Bojnord is related to diverse topo-climatic in this region. It underlines the importance of documentation of traditional ethnomedicinal knowledge and to prevent its extinction in the study area. Also, phytochemical studies of all reported species, in addition to the most cited species, are vital for identifying the bioactive compounds of these medicinal plants which can be used in phytopharmaceutical industries for the development of novel herbal drugs. Complementary phytochemical investigations of *D. sophia*, *B. persicum*, *A. graveolens*, and *M. officinalis*, followed by preclinical experiments and clinical trials targeting assessment of gastrointestinal tract treatment can promisingly lead to introducing premier plant-base medications.

Authors contributions

Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials

The authors declare that the data supporting the findings of this study are available within the paper.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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