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Pteridophytes: Ethnobotanical use and active chemical composition

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The ethnobotanical use of ferns, such as higher spore plants which are considered to be among the earliest plants has a very long history and most of them as medicinal plants are widely used among ethnic groups in many countries around the world. Some species have even been included in the official pharmacopoeia. The purpose of this study was to examine the ethnobotanical properties of ferns in the flora of the Azerbaijan Republic and also to determine their active pharmacological composition and effects as medicinal plants. These plants are found to be rich in secondary metabolites. Indicating that ferns are an important source of raw materials for the search and development of new herbal medicines. Ethnobotanical study of medicinal plants used by local population was carried out. Information was obtained through conversations with the aid of semi-structured questionnaires. During the survey, interviews were conducted on 102 local informants. Data were analyzed using suitable statistical tools such as informant consensus factor (ICF) and Fidelity Level (FL).

Keywords: Bioactive substances, Efficacy, Ethnobotanical use, Ferns

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Ferns (Pteridophytes) are the most valuable ancient higher plants in nature, most of which date back to the relict Mesozoic. There are about 12,000 species of 250 genera on Earth[1]. Most of these plants are of decorative, medicinal and ethnobotanical importance and even ferns are mentioned as medicinal plants in Galen preparations (150-200 years of our era). 78 species and 19 species diversity of 31 genera of 22 families of 3 orders were distributed in the flora of Azerbaijan according to recent researches of A. Asgarov[2,3]. Some species of ferns have already entered the official state pharmacopoeia in many countries around the world. Some species have been used in folk medicine among local ethnic groups and tribes as insecticides, antipyretics, expectorants and for bleeding, trauma, diarrhea, and colds[4-7]. Antioxidant, anticancer, antimicrobial and antiviral effects of various bioactive secondary metabolic compounds of ferns have also been studied[8-13].

This study is devoted to the identification, treatment purposes and methods of use of higher spore plants which are widespread and traditionally used in the Azerbaijan Republic. Importance of these species as a source of natural bioactive food supplements in addition to their use as medicine have also been shown.

Materials and Methods

The research was conducted in the Greater Caucasus (Zagatala, Gakh and Sheki regions) and Lesser Caucasus (Goy-Gol region), Lankaran and Masalli regions of Azerbaijan on the basis of ethnobotanical surveys in 2019. Species were determined using the Herbarium fund (BAK) of the Institute of Botany of ANAS and according to the fundamental flora of Azerbaijan and the works of A. M. Askerov. Data were collected from more than 100 people (Azerbaijan, Talish, Avar, Ingiloy, Russian and Sahur ethnic groups living in regions between the ages of 50-105) and recorded using a survey method[14,15] (Fig. 1). Methods such as observation, questionnaire and interviews[16] were used during ethnobotanical study.

Out of a total of 102 informants, 58 were women and 44 were men. The selection of individual informants was random, with important information obtained through interviews with local elders, teachers and housewives.

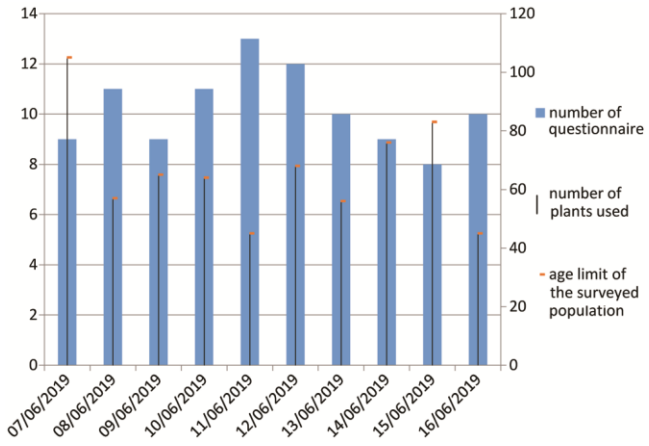

Fig. 1 — Assessment of population surveys

Statistical analysis of the data was performed in MS Excel spreadsheet. Fidelity level (FL)[16] and Informant consensus factor (ICF)[17] and of species were calculated and then presented using tables, graphs and percentages. The ICF is calculated to determine the consistency between the use of plant species in the treatment of any disease and the citations (reminders) of the informants:

$FL= S_f/T_f$ (%)

-here S_t – frequency of citations in any disease, T_f - the total number of citations to that species.

$ICF = (N_{uc}–N_s)/(N_{uc}– 1)$,

-here N_{uc} - number of citations used, N_s – the number of species for each usage citation.

Also, the fidelity level (FL) of medicinal plants allows to determine the effectiveness of plants in terms of bioactivity in the treatment of diseases:

Results and Discussion

Ethnobotanical features of some ferns

Since centuries, people have gathered parts of the plants (leaves, tubers, rhizomes, shoots, fruits etc.) and used them in their daily diet. The useful properties of wild plants are studied through ethnobotanical studies[4,5,18].

Most ferns have been used since ancient times in folk medicines, traditionally not the raw, but rather in the cooked form. The carcinogenic thiaminase enzyme found in most ferns is broken down by heat during cooking[19,20]. No adverse effects have been identified yet in this regard. However, studies should be continued to determine the dosage rate and treatment efficacy.

***Adiantum capillus-veneris* L.** (BAK 85383) - is a perennial plant up to 30 cm in height. Plant grows in humid places, rock crevices, gravelly and stony places by the river. These species were found on the highlands in the territory of Lankaran, Masalli, Yardimli districts and in Katekhchay hollow under 500-2800 m above seal level during the expeditions.

The leaves and the rhizomes of the plant have been collected from nature since ancient times for medicinal purposes. The dried plant is used as a refreshing, tonic tea, as well as a diuretic, cholagogue, laxative, in bronchial asthma, cystitis, spleen and liver tumors in folk medicine. Herbal infusions are used to brighten hair and fight dandruff as a technical remedy.

The plant is included in the official pharmacopoeia. An anti-narcotic drug "Tosifron" containing flavaspid acid derived from the leaves of the plant and was proposed against alcoholism and nicatinism in Italy[19]. It is also included in "Capillaire Syrup"[20,21].

***Polypodium vulgare* L**. (BAK 85943)- a small plant up to 10-50 cm in height. It is mainly distributed in the forests, mountain forests, subalpine zones, rocks, rocky gravel deposits, forest edges. It is widespread in the Greater Caucasus, Lesser Caucasus, Kur-Araz lowland, Lankaran region and Nakhchivan AR.

Leaves and rhizomes are used in folk medicines. The leaves of the plant are used as a expectorant, appetite suppressant, as well as in jaundice, dermatoses. An ointment is made from the leaves with wax and olive oil use during the peeling of the hair and other parts of the skin. Usually applied to the part with the shell. Herbal tea made from rhizomes is used to treat inflammation, sore throats and stomach aches.

***Pteridium aquilinum* (L.) Kuhn** – up to 30-100 cm height and sometimes up to 150 cm. Widespread in the Greater Caucasus.

The leaves and roots of the plant are collected from nature and used for diuretic, antipyretic, hepatitis. Infusion of leaves used as a spleen cleanser in the Indian medicine[22]. Extract made from nodules is used in folk medicine as a worm repellent, in the treatment of rickets in children and the infusion is used for cough, laxative, tonic, wound healing, dermatitis, eczema. Aqueous and alcoholic extracts of the plant also have a bacteriostatic effect.

***Asplenium trichomanes* L**. (BAK 85499)- 30 cm in length, creeping rootstock fern. It grows mainly in mild zones, in forests from the middle to the middle belt, on rocky, rocky slopes, in cracks in walls and rocks. Found in the Greater Caucasus, Gobustan, Absheron, Lankaran.

The plant is used in the treatment of kidney stones, dandruff of the scalp and prevention of hair loss in folk medicine. It is also used to treat rheumatoid arthritis in Chinese medicine[23].

***A. septentrionale* (L.) Hoffm**. (BAK 85327)– up to 3-10 cm in height. It can be found on rocks, rocky slopes, beyond fences, in ruins, in shady pine forests, up to the upper mountain range. In the territory of Greater Caucasus, it was found in the Zagatala and Lankaran districts of Azerbaijan.

Infusions made from the leaves are used in respiratory infections, expectorants, astringents, jaundice, scurvy among various ethnic groups[24].

***A. adiantum-nigrum* L**. (BAK 85131) - up to 30-80 cm in height. The plant grows in carbonate, sometimes peat soils, rocks, moist shady places. It is distributed in the forest zone of the lower and middle mountain belt, in the subalpine zone in beech, maple and coniferous forests. It is found in the Greater Caucasus, Lesser Caucasus, Kur-Araz lowland, Lankaran and Gobustan districts of Azerbaijan.

The leaves of the plant are used against coughs, in the treatment of kidney and skin diseases in folk medicine. Infusion made from the leaves is used in infertility and the ore in tuberculosis and other lung diseases, stomach, liver, spleen, gallbladder diseases, astringent, analgesic, as a means of removing toxins and toxins from the body[5,25]. Alcoholic solution of the plant has a bacteriostatic effect. Herbal infusions or syrups are used to regulate the menstrual cycle.

***A. ruta-muraria* L**. (BAK 85264)**-** is a short-rooted plant, 3-15 cm in height. The plant is widespread on rocky, stone slopes, landslides and mountain forests. It rises to an altitude of 1000 m above sea level. Collected from the Greater Caucasus, Kur-Araz lowland, Lankaran, Absheron and Gobustan. It is sometimes found among the rubble of old walls.

Infusion from the underground part is used as an astringent and diuretic, worm repellent. The leaves are used in rickets and as a laxative, infusion and tincture as a chest emollient and expectorant for respiratory diseases in traditional Indian medicine[26].

***A. ceterach* L**. (BAK 85536)**-** is a short fern up to 6-20 cm in height. Forms a complete cover on the ground mainly in shady places. It is distributed in the Greater Caucasus, Lesser Caucasus, Lankaran, Absheron, Steppe plateau and Gobustan.

The leaves of the plant are collected in summer and then dried for use and have astringent, cholagogue, diuretic, expectorant effect[27,28]. The infusion made from the leaves is taken externally as an ointment for burns and itching, and the infusion is taken internally in the treatment of diarrhea, dysentery, gallstones, restoration of liver and spleen function.

***A. scolopendrium* L**. (BAK 85815) - is a perennial herb up to 20-60 cm in height. The plant usually grows in moist, shady areas and calcareous soils. Found in the Greater Caucasus (Gakh area), Lesser Caucasus, Lankaran and Absheron.

The leaves of the plant are collected in the summer for medicinal purposes. Herbal tea made from the leaves is used as an astringent, choleretic, diuretic, expectorant. Recommended for the treatment of gastroenteritis, diarrhea, dysentery, bronchitis, tuberculosis, spleen, liver and gallbladder diseases. It is applied to the skin as a soothing agent, especially for burns.

***Dryopteris expansa* (C.Presl)** Fraser-Jenk. & Jermy (BAK 85789) - large fern up to 30-100 cm in height. Occurs in humid and shady forests. Collected from the territory of Zagatala reserve in the Greater Caucasus.

Carrots are harvested in early Autumn and then dried for use. Unopened shoots of the plant are collected and eaten in spring. Anthelmintic drugs are made from raw elephants obtained from nodule. This tool should be used with caution and only under the supervision of a qualified professional. The root is poisonous, therefore, the dose is critical[25]. It is also used for treatment of dandruff.

***D. carthusiana* (Vill.) H.P.Fuchs** (BAK 85723) **-** fern up to 80 cm in height. It grows in moist forests, bushes, shady places, swamps, spread in Lankaran. The leaves and roots are used for food. Roots are usually collected and dried in the Autumn. Curled leaves harvested in the Spring can be eaten by boiling.

The phylloxera in the root is an antihelminthic agent, useful in removing tapeworms and other internal parasites. Root of the plant eliminates parasites from the body[4,25].

***D. filix-mas* (L.) Schott**. (BAK 85760)**-** is a fern up to 120 cm in height. Grows well in moist soils, forest cover and other shady places from low to high mountain range. It is widespread in the Greater Caucasus, Lesser Caucasus, Nakhchivan and Lankaran.

Early branches of the plant are used for food purposes. Root extracts are used as analgesic, antibacterial, anti-inflammatory, astringent, antipyretic, anthelmintic and laxative[29,30]. The roots are harvested and dried in the Autumn.

***Thelypteris palustris* Schott** (BAK 85657) – grassy fern up to 60-80 cm in height. It grows in moist and wet soils, shady places, forests and swamps from flat area to the middle mountain belt. Occurs in the Greater Caucasus, Lesser Caucasus, Lerik and Astara districts of Azerbaijan.

The young leaves of the plant are collected for food in the Spring. The roots of the plant have long been used to treat of gynecological diseases for medicinal purposes.

***Onoclea struthiopteris (L.)* Roth** (BAK 85808)- large perennial fern up to 150-200 cm in height with fleshy roots. Plant grows in forests and mountain-forest zones, in wet areas under ravines, on the banks of rivers and streams. It is widespread in the Greater Caucasus and Lankaran.

Infusion made from nodule is used as a deworming, antipyretic in traditional medicine of some countries, Young shoots (raxis) are eaten as vegetables in some countries[25]. Tuber and leaves are used as antispasmodics, against seizures and from epilepsy, anti-malignant, sedative, astringent, anti-tussive in medicine. Shredded and dormant leaves and spores are used as wound healing, anti-inflammatory and antiseptic in burns, frostbite and dermatoses.

***Cystopteris fragilis* (L.) Bernh**. (BAK 85625)– up to 10-50 cm in height. It grows in the lower and upper mountain ranges, in shady, moisture-rich forests, rock crevices. It was found in Kur-Araz lowland, Lankaran and Zagatala districts of Azebaijan.

The plant is used in intestinal and lung diseases, as a tonic, emollient, expectorant, antipyretic. Rhizomes are used as a worm repellent in the form of infusion in Indian medicine[22,25]. Aqueous extract of rhizomes and leaves has a bacteriostatic effect. Fume of plant is used for bronchial asthma in some areas.

***Athyrium filix-femina* (L.) Roth** (BAK 85379)- short-rooted plant up to 150 cm in height. It grows in moist shady forests, bushes, meadows, river banks and sometimes in swamps. Widespread in the Greater Caucasus, Lesser Caucasus and Lankaran.

The underground part of the plant and young leaves are collected and dried for medicinal purposes in folk medicine. Infusion of rhubarb is taken as an anthelmintic, diuretic, in disorders of the gastrointestinal tract, alcoholic solution of rhubarb is used in gynecological diseases, hemorrhoidal bleeding[31]. Aqueous extracts of germ leaves are recommended in the treatment of chronic bronchitis, as well as a painkiller for headaches. The first sprouts are used as vegetables during the growing season.

Fidelity level of the use of plants

The fidelity level (FL) of a particular species was calculated in order to determine the repetition frequency of the disease by the number of people reporting the use of any plant in exactly the same disease (Table 1). The highest FL was recorded for *Asplenium trichomanes* and *A.adiantum-nigrum* (100%), *Phyllitis scolopendrium* (87.5%). The highest FL value was set for dry cough, gynecological diseases and diarrhea, and the lowest FL was observed for abdominal pain and skin diseases (60-66,7%).

Informant consensus factors (ICF)

During the study year, a total of 53 types of diseases were registered during discussions among the population. Bronchitis, gastrointestinal, liver, kidney and worm diseases are among the most common health problems. The informants consensus factor was assessed on 6 disease categories (Table 2). ICF value was highest in dermatological, urological and rheumatic diseases (more than 0.90 for each).

Table 1 — Fidelity level (FL) values

No	Sickness category	Ailment	T_f	S_f	FL
1.	*Adiantum capillus-veneris* L.	Refreshing	7	5	71,4
2.	*Polypodium vulgare* L.	Pharyngitis	11	8	72,7
3.	*Asplenium trichomanes* L.	Dry coughing	9	9	100
4.	*A. adiantum-nigrum* L.	In gynecological diseases	5	5	100
5.	*A. scolopendrium* L.	Diarrhea	8	7	87,5
6.	*Dryopteris expansa* (C.Presl) Fraser-Jenk. & Jermy	Intestinal worms	13	10	76,9
7.	*D. filix-mas* (L.) Schott.	Skin diseases	24	16	66,7
8.	*Athyrium filix-femina* (L.) Roth	Abdominal pain	15	9	60

Table 2 — Informant consensus factors (ICF) values for 6 ailment categories

No	Sickness category	Number of species (N_s)	Number of use reports (N_{uc})	ICF
1.	Gastro-intestinal and parasitic	13	98	0,88
2.	Respiratory	12	100	0,89
3.	Dermatological	4	36	0,91
4.	Urological	7	71	0,91
5.	Revmatic	6	68	0,93
6.	Others	10	76	0,88

Table 3 — Pharmacological properties and active composition of some medicinal species of ferns

Species	Pharmacological effects and ailments	Chemical compound(s)	Useful parts	Cited reference(s)
Pteris cretica L.	Antileishmanial, anti-inflammatory, anti-cancer and antioxidant	Flavonoids and other phenolic compounds	Rhizomes, leafs	11, 12
Adiantum capillus-veneris L.	Anti-inflammatory, antioxidant, antimicrobial, hypocholesterolemic and antidiabetic, analgesic	Glycosides, flavonoids, tannins, saponins and alkaloids Steroids and triterpenoids	whole plant	6, 32,33
Polypodium vulgare L.	Analgesic, anti-inflammatory antioxidant, diuretic, insecticidal, expectorant	Steroids, triterpenoids phenols, tannins Essential oils	Rhizomes Leafs	34, 35
*Pteridium aquilinu*m (L.) Kuhn	Antihelmintic diuretic, antipyretic Expectorant infiltrative	Flavonoids, Steroids and triterpenoids Phenols carbohydrates, aromatic compounds and lipids	Whole plamt	36, 37, 38
Asplenium trichomanes L.	antitussive, laxative, antihelmintic, regulation of the menstrual cycle antioxidant	Triterpene, phenolic content , Aldehydes essential oil	Rhizome, leaf	13, 39
Asplenium adiantum-nigrum L.	anti-inflammatory, anti-cancer and antioxidant	Triterpene, phenolic content, Fatty acid, Aldehydes, Quercetin bleaching, Flavonoids	Rhizome, leaf	12, 13, 39
Asplenium ceterach L.	diuretic, expectorant, against spleen complaints, kidney stones and hemorrhoids	Phenolic acids and their derivatives Flavonoids and their derivatives Xanthones	Leaf	27, 28, 39, 40
Asplenium scolopendrium L.	astringent, cholagogue, diaphoretic, diuretic, expectorant, antidiarrheal, antioxidant	Tannins, mucus, carbohydrates, phenols, flavanoids	Leaf, rhizome	5, 12
Dryopteris filix-mas (L.) Schott.	Antihelmintic anti-inflammatory, rheumatism, cramps and hemorrhoids, skin diseases, anti-dandruff	filixinic and flavaspidic acid, Saponins, alkaloids, phenols phloroglucinol, filmaron, albaspidine and aspidinol essential oil and starch	Rhizome, leaf	23, 29
Polystichum lonchitis (L.) Roth.	anticarcinogenic anti-inflammatory, and antibacterial effects	Phenols, Flavonol glycosides	Rhizome, leaf	12, 26
Polystichum woronowii Fomin	anticarcinogenic anti-inflammatory, and antibacterial effects	Phenols, diterpenes and triterpenes	Rhizome, leaf	12, 35
Athyrium filix-femina (L.) Roth.	anticarcinogenic anti-inflammatory, and antibacterial effects, anti-viral	Triterpenes and alkaloids, Phenols	Rhizome, leaf	12, 38
Onoclea struthiopteris (L.) Roth.	Anticarcinogenic, anti-inflammatory, laxative, expectorant	steroids, vitamins C, B1, niacin, flavonoids, fatty acids	Whole plant	41, 42

Bioactive composition and effects of some ferns as a medicinal plant

The biological activity and phytochemical composition of some ferns, which are valuable as medicinal plants, have been studied by many scientists around the world. Secondary metabolic compounds - terpenoids, phenols, flavonoids and alkaloids have been evaluated as active biological components of ferns. The composition, biological activity and used parts of these ferns are shown in (Table 3).

Conclusion

The medicinal potentials of fern-like species common in the territory of Azerbaijan were identified and appropriate to use which diseases to treat was established as a result of the studies. The studies assessed the informant consensus factor (ICF) and fidelity level (FL). On this basis, the effectiveness of the ethnobotanical use of the species among local communities, as well as the experience gained over many years, can be confirmed. Secondary metabolic compounds derived from ferns can be used in the development of new drugs or new mixtures with antioxidant, anthelmintic, antiviral, antioxidant and expectorant effects considering the work to identify the phytochemical composition of ferns done by most scientists.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Contributions

Sayyara Jamshid Ibadullayeva participated in the compilation and editing of the article, Nuri Vagif Movsumova in the compilation of the article and performance of mathematical calculations on the basis of the queries, Gulnara Shirali Shiraliyeva in the fulfillment of ethnobotanical queries, Hasret Chanbala Mammadova in the collection of herbarium of materials, Naile Aligulu Askerova in the preparation of herbarium materials.

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