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Determination of Phytochemicals in Medicinal Plants Collected from Adjoining Areas of Lahore through Fourier Transform Infrared Spectroscopy

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Abstract

In the present research work, some medicinal plants from the adjoining areas of Lahore were investigated for their phytochemical screening and FTIR analysis. Four samples of medicinal plants Cichorium intybus (Kasni), Foeniculum vulgare (Sonf), Solanum nigrum (Makoh)and Polygonum aviculare(Anjbar)were selected. The main objective of the present study is to identify the phytochemicals through FTIR instrumentation, which encourages Sustainable Development Goals (SDGs) by minimising waste and chemical usage. Phytochemical testing of extracts of leaves of C. intybus, S. nigrum and roots of F. vulgare, and P. aviculare was carried out in four different solvents (Methanol, chloroform, n-hexane and aqueous solutions). The purpose of this study is to help in the formulation of herbal medicines and their quality assurance, and to make innovations to support industries in developing plant-based products contributing to Sustainable Development Goals (SDGs). Phytochemicals identified were steroids, alkaloids, carbohydrates, flavonoids, phenols, tannins, saponins, cardiac glycosides, proteins and reducing sugars. Functional groups were identified in the leaves and roots of medicinal plants like esters, alcohols, alkenes, nitrites, amino acids, carboxylic acids, ethers, aromatics, organic halogens and carbohydrates. In this study, an effort was also taken to understand the importance of functional groups as bioactive components for treating various illnesses, and which functional group is responsible for a certain medicinal property of a medicinal plant. This study investigates the application of phytochemical screening and Fourier Transform Infrared (FTIR) spectroscopy for the identification of phytochemicals in a selected medicinal plant, addressing the limited analytical data available for such species, and recommends further research to explore their therapeutic potential.

Keywords: Phytochemicals Screening; FTIR Analysis; Medicinal Plants; Sustainable Development Goals (SDGs).

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1. Introduction:

In ancient times, humans used medicinal plants to treat their illnesses, driven by their experience, instincts and taste. Medicinal plants have always been used as a source of natural medicines to cure various diseases throughout history. Therefore, it is said that the history of medicinal plants is as long as the history of humans (Singh & Geetanjali, 2018).

Globally, medicinal plants are considered a vital and valuable source of new drugs. Almost 1300 medicinal plants are being utilised in European countries, and about 90% of them are obtained from wild resources. In the United States, almost 118 out of 150 drugs, which are the top prescribed, are obtained from natural sources (Chen et al., 2016).

Phytochemical analysis of plants helps in the discovery of natural medicines by identifying bioactive compounds to serve various industries like pharmaceuticals, cosmetics and neutraceuticals. This study utilises minimal chemicals with no harmful effects to meet the standards of herbal products. It also contributes to medicinal plants conservation by identifying the therapeutic potential of medicinal plants through the Fourier Transform Infrared Resolution (FTIR) (Nasr et al., 2020).

FTIR plays a vital role in advancing the Sustainable Development Goals (SDGs). By identifying phytochemicals in plant extracts, their therapeutic potential, FTIR directly supports SDG 3: Good health and well-being. It also supports life on land by conservation of biodiversity (plants on land), responsible consumption and production. This technique enhances the natural therapy development and also enhances the global efforts towards sustainable industry, health, and environmental conservation (Nasr et al., 2020).

Different parts or extracts of plants were used in ancient times for the maintenance and recovery of health and the treatment of various diseases. Even now, almost 80% of the population of the world is still using traditional medicines forcure of different diseases (Tugume & Nyakoojo, 2019).

Phytochemicals are chemical constituents that are present in various plants and isolated from plants to treat various diseases in medicinal plants. These are formed through primary or secondary metabolism in the plants. They are functionally important as they protect the plant from various predators when they attack and also help the plant in proper growth. Medicinal plants are also called Chemical goldmines (Farhan et al., 2012), as plants contain various important chemical compounds, secondary metabolites, and biologically active compounds to which plants owe their medicinal properties; these are phytochemicals. Plants are also the source of a variety of drugs, which include antimicrobials, antipyretics, antispasmodics, emetics, anti-diarrheals, etc. (Farhan et al., 2012).

In the field of medicinal plants analysis, the remarkable role of FTIR (Fourier Transform Infrared) Spectroscopy is very evident. The FTIR made very reproducible and accurate measurements. Due to FTIR, the use of infrared analysis is virtually limitless. For infrared absorption spectroscopy, the most commonly used region is about 4000 to 400cm^{-1}. This is because most organic and inorganic compounds have absorption radiations within this region. This method of analysis (FTIR) is widely used to identify and investigate chemical compounds, the structure of chemical constituents and functional groups (Nair et al., 2013).

The most powerful technique to check the presence of chemical bonds and identify the functional groups present in a compound is the FTIR. FTIR is a valuable device for the determination of different phytochemicals by identifying different functional groups (chemical bonds) present in medicinal plants. The spectra of FTIR are unique, like a "molecular fingerprint". Thin film between cells is formed by the drop. Solid samples are treated with potassium bromide (KBr), and then, using a hydraulic press, a thin pellet is formed. Liquid samples include extracts of various plants. Different samples are run at different infrared regions of 400-4000cm^{-1}. Then standard DLATGS detector is used at a mirror speed of 2.8mm/sec (Thenmozhi et al., 2021).

Cichorium intybus (Kasni)belongs to the family Asteraceae, genus Cichorium, and is commonly called Chichory. It is primarily distributed in Asia and Europe (Bais and Ravishankar, 2001). Roots of this plant contain inulin of about 40% and are suitable for diabetics due to low impact on sugar level (Judzentiene&Budiene, 2008). It has extensive applications in medicinal field, in treating diseases from wounds to diabetes (Nandagopal et al., 2007). As a medicinal plant, it was first grown by ancient Egyptian and has a long history of medicinal use in both areas (where it is indigenous and where it is introduced). In South Africa, it is used to treat jaundice (Street et al., 2013).

Foeniculum vulgare (Sonf) belongs to familyApiaceae and is the oldest valid name in Foeniculumgenus. This plant grows in the Mediterranean region originally, and by cultivation or as a wild plant, it is also found in Northern, Western and Eastern hemispheres, Asia, America and Europe. All plant parts are aromatic (Badgujar et al., 2014). F. vulgare is very famous for its pharmacological activities and is used in many medicines and in phytotherapy, such as anti-microbial, anti-inflammatory, cytotoxic, antioxidant, antithrombic and ant-mutagenic activities (Rahimi and Ardekani, 2013). It is useful in treating diseases related to the respiratory, digestive, endocrine and reproductive systems. More than 40 types of disorders can be treated by this widely used herb. For lactating mothers, it is used as a lactagogue agent (Badgujar et al., 2014). The seeds of this plant are used for flavourings in baked items, fish, meat, herbal mixtures, ice creams and beverages. This plant is medicinally and aromatically important and also exhibits hepato-protective activities and various other therapeutic uses (Rather et al., 2012).

Solanum nigrum, commonly called "Makoh", belongs to the family Solanaceae and is widely distributed in temperate and tropical regions of Asia, Europe and America, but is native to Southeast Asia (Kumar et al., 2020). It is an edible and medicinal herb which is traditionally used for treating diseases like cancer, dermatitis, sore throat, toothache, carbuncles, acute nephritis, urethritis and eczema (Yang et al., 2021). It is also known for its therapeutic potential, like antioxidant, antibacterial, antitumor, anti-inflammatory and neuroprotective activities (Gao et al., 2021). The whole plant is very effective in dispersing blood stasis, detoxification and clearing heat. This herb is commonly used for treating various ailments like canker sores, bacterial dysentery, urinary tract infections and treating in combination with other drugs various cancers like breast cancer, cervical cancer, lung cancer, stomach cancer, liver cancer, bladder cancer, etc. (Gao et al., 2021).

Polygonum aviculare (Anjbar) belongs

to familypolygonaceae and its common name is knotgrass. Commonly found in many countries of temperate regions and Mediterranean coastal regions in Egypt, but it is native to Eurasia (Larijani et al., 2023). It is effective and safe to use astringent and diuretic herbs that are used for the treatment of various diseases like haemorrhoids and dysentery (Robu et al., 2008). Phytochemicals present in P. aviculare, like flavonoids and phenolics, are thought to be very efficient for antitumor and antioxidant activities. It has the capacity to kill or remove free radicals and is efficient in DNA protection (Yuan et al., 2007). Knot weed is also known for its healing effects in case of cancer and other diseases in which free radicals are abundant and DNA damages are also prominent (Essick et al., 2010).

The Essick study aims to use phytochemical screening and Fourier Transform Infrared (FTIR) spectroscopy to identify and characterise the phytochemicals present in knotweed, thereby providing a scientific basis for its medicinal use and informing future pharmacological research.

2. Materials and Methods:

2.1.Collection of Plant Samples:

The plant samples Polygonum aviculare, Foeniculum vulgare, Cichorium intybus, and Solanum nigrum were collected from adjoining areas of Lahore, Pakistan. The samples used for the study were identified by Dr Uzma, Chairperson of the Department of Botany, Government College University Lahore.

2.2. Collection and Drying of Plant Material:

After the collection of samples, these were washed with tap water. They were all carefully rinsed with tap water to avoid dust particles on their surface and to get rid of insects' eggs and larvae, as well as other filthy things that stuck to the leaves. After washing, different parts of the plant, like the root, stem and leaves, were separated. Filter paper was used to immediately cover the freshly washed leaves to remove moisture. Samples were monitored for dryness at regular intervals in shady places for a few days. The drying process of leaves was ensured by manually crushing the leaves. Keep checking, and when the plants were fully dried, it was finely powdered with the help of a mechanical grinder. Then the powder of each plant part was separately packed into air-tight bags.

2.3.Extract Preparation:

Each powder sample of plants was extracted with four different solvents, which were methanol, chloroform, n-hexane and aqueous (distilled water). For the preparation of the extract of different parts of plants, the 5g powder samples of each plant were soaked in 50 ml of methanol, chloroform, n-hexane and aqueous individually in different conical flasks and kept at room temperature for about 24 hours after shaking (Lingegowda et al., 2012). Then extracts were filtered with Whatman's No. 1 filter paper, and the obtained extracts were stored in a refrigerator at 4°C in closed containers for further phytochemical screening (Plates 3.1 and 3.2).

2.4.Phytochemical Analysis:

The following chemical tests were carried out on aqueous extracts using the standard procedures to identify chemical constituents.

Test for Phenols:

Ferric chloride test: To 2 ml of plant extract, 2 ml of 1% $FeCl_3$ was added. The appearance of green or blue colour indicated the presence of phenol.

Test for Alkaloids:

Mayer's test: 2 ml of filtrate was taken, and after adding 2ml of 1% HCl, it was kept in a boiling water bath for about 5 minutes. Mayer's reagent was added to the 2ml of each extract separately, and it was observed for the appearance of brown/orange-red precipitates.

Test for Carbohydrates:

Molisch's test: 3 ml of each extract was taken separately, and 2ml of Molisch's reagent was added. It was vigorously shaken, and along the walls of the test tubes, 2ml of conc. H_2SO_4 was added carefully. The occurrence of carbohydrates was indicated by the appearance of a reddish-purple ring at the junction of two layers.

Test for Steroids:

Salkowski test: 2 ml of extract or sample solution was taken and added with 2ml of chloroform and 2ml of conc. HCL. Presence of steroids was indicated by the appearance of red colour in the chloroform layer, and the acid layers had a greenish-yellow colour.

Test for Flavonoids:

Alkaline Reagent test: To 5ml of extract, 5 mL of 20% NaOH was added. The addition of sodium hydroxide to the extract showed colourations and decolouration by the addition of acids, showing the presence of flavonoids in each extract.

Test for Glycosides:

Keller Killiani's test: 2 ml of sample solution was taken in the test tube, 2 ml of 5% ferric chloride solution and 1 ml of conc. Sulphuric acid was added carefully along the sides of the test tube. Then, a few drops of glacial acetic acid were also added. Appearance of a brown ring at the interface of two layers or appearance of violet or blue colour at the upper layer indicated the presence of glycosides.

Test for reducing sugars:

Fehling's test: To 1 ml of filtrate, 2 ml of Fehling's solution (A: 7% $CuSO_4$ in distilled water containing 2 drops of dil. H_2SO_4), (B (Mixture of 12% KOH and 35% sodium potassium tartrate in distilled water) were added in equal volumes to each extract and boiled for 5 minutes. The presence of reducing sugars was indicated by the advent of brick-red precipitates.

Test for Proteins:

Biuret test: To 2 ml of extract, 1 ml of 4% NaOH and 1 to 2 drops of 1% CuSO4 were added to the solution, slowly. The appearance of violet or pink colour indicated the presence of peptide linkages in the solution.

Test for Saponins:

Foam test: 0.5 ml of plant extract was thoroughly mixed with 0.5 ml of distilled water and shaken vigorously for 30 seconds. The presence of saponins was indicated by the formation of foam (Karer et al., 2008).

Test for tannins:

Ferric chloride test: 2ml of filtrate was taken in the test tube, and 1ml of 5% $FeCl_3$ was added to it. Formation of blue-black and green precipitates indicated the presence of tannins.

2.5.Fourier Transform Infrared Spectrophotometer (FTIR) Analysis:

Fourier Transform Infrared Spectrophotometer (FTIR) is the most powerful tool used for the identification of functional groups of biologically active components present in plants based on the peak values in infra-red radiation region (Hemmalakshmiet al., 2017). The wavelengths seen in the spectrum are characteristic of the light absorbed. Chemical bonds in a molecule can be identified by interpreting infrared spectra.

In the present study, dried powder of each plant material was used for FTIR analysis. Dried extract powder of 10 mg

was encapsulated in a 100 mg KBr pellet for the preparation of translucent sample discs (Gomare et al., 2018). The powdered plant samples of Cichorium intybus, Foeniculum vulgare, Solanum nigrum and Polygonum aviculare were loaded in an FTIR spectroscope and scanned at a spectral range of 4000-400 cm^{-1} at room temperature. The FTIR spectrometer recorded the FTIR spectra. In the present, intensities of absorption bands can be directly related to the concentration of corresponding functional groups.

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directly related to the concentration of corresponding functional groups.

4. **Results**:

The leaf extracts of Cichorium intybus, Solanum nigrum and root extracts of Foeniculum vulgare and Polygonum aviculare were prepared in different solvents: methanol, chloroform, n-hexane and distilled water. All these extracts were subjected to phytochemical screening for the detection of various phytochemicals in different plant extracts.

The results of the phytochemical screening of different extracts and the FTIR Analysis of powdered plant samples, obtained through the present research are compiled as follows:

The FTIR analysis of the leaf of C. intybus revealed that peaks at 3321 cm^{-1} corresponded to the O-H stretch, peaks at 2917 cm^{-1} and 2846 cm^{-1} corresponded to the C-H stretch, and peaks at 1727 cm^{-1} corresponded to the C=O stretch. The peak at around 1614 $cm^{-1}$was associated with the C=C bond, the peaks around 1238 cm^{-1} and 1025 cm^{-1} corresponded to C-O-C functional groups. The last peak indicated the presence of halogens at 607 cm^{-1}, shown in Figure 4.1 and Table 4.1.

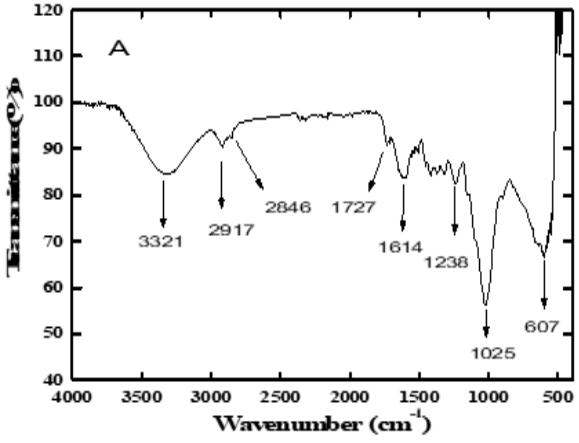

Figure 4.1: FTIR Spectrum of a powdered sample of Cichorium intybus leaf.

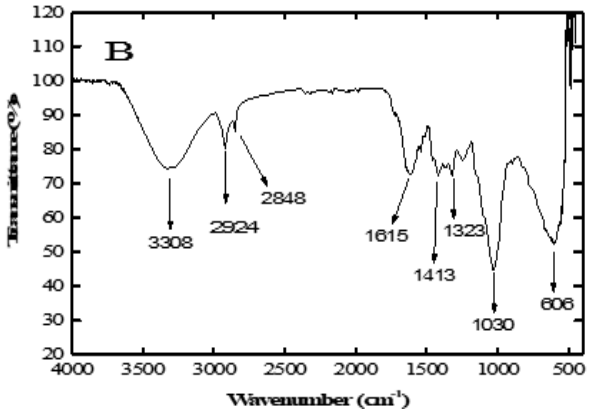

Figure 4.2: FTIR Spectrum of a powdered sample of Foeniculum vulgare root.

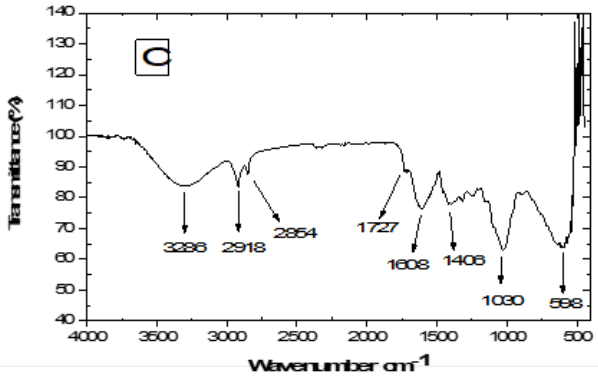

Figure 4.3: FTIR spectrum of a powdered sample of Solanum nigrum leaf.

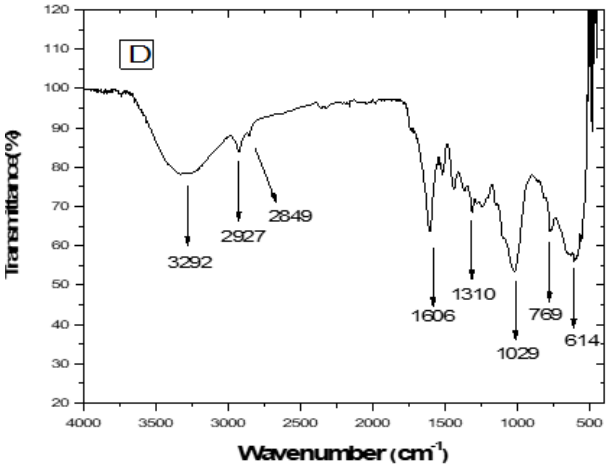

Figure 4.4: FTIR spectrum of a powdered sample of Polygonum aviculareroots.

Table 4.1: FTIR peak values and their assigned functional groups present in leaves of Cichorium intybus.

Sr. No.	Wavenumber cm-1 (Test Sample)	Wavenumber cm-1 Range	Assigned functional groups	Phytochemicals identified
1	3321	3000-3700	O-H stretch	Hydrogen-bonded alcohols, Phenols
2	2917	2850-2970	C-H (sp^2) stretching	Alkanes
3	2846	2850-2970	C-H (sp^2) stretching	Alkanes
4	1727	1712-1763	C=O stretch	Carbonyl group, Ketones, Esters
5	1614	1600-1680	C=C group	aromatics
6	1238	1050-1255	C-O-C stretching vibration	Carbohydrate of polysaccharide
7	1025	1050-1255	C-O-C stretching vibration	Carbohydrate of polysaccharide
8	607	490-620	C-I, C-Cl	Halogen Compounds (Chloro compound, Iodo compound)

The FTIR analysis on a powder sample of the roots of Foeniculum vulgare revealed that peaks at 3308 cm^{-1} corresponded to the O-H stretch and indicated the presence of alcohols and phenols (Hussein et al., 2016). The peaks at 2924 cm^{-1} and 2848 cm^{-1} corresponded to the C-H stretch. The peak around 1323 cm^{-1} was associated with the presence of nitro compounds (NO_2), and 1030 cm^{-1} was related to the C-F stretch, and the last peak at around 606 cm^{-1} corresponded to the C-Cl or C-I compounds or the alkyl halides, shown in Figure 4.2 and Table 4.2.

Table 4.2: FTIR peak values and their assigned functional groups present in roots of Foeniculum vulgare.

Sr. No.	Wavenumber cm-1 (Test Sample)	Wavenumber cm-1 Range	Assigned functional groups	Phytochemicals identified
1	3308	3200-3600	O-H	Hydrogen-bonded alcohols, Phenols
2	2924	2850-2970	C-H	Alkanes
3	2848	2850-2970	C-H	Alkanes
4	1615	-	Unknown	Unknown
5	1413	-	Unknown	Unknown
6	1323	1300-1370	NO2	Nitro compounds
7	1030	1000-1150	C-F stretch	Aliphatic fluoro compounds
8	606	490-620	C-I, C-Cl	Halogen Compounds

The FTIR analysis on a powder sample of leaves of Solanum nigrum revealed that peaks at 3286 cm^{-1} corresponded to the O-H stretch, peaks at 2918 cm^{-1} and 2854 cm^{-1} corresponded to the C-H stretch, and peaks at 1727 cm^{-1} corresponded to the C=O stretch. The peak at around 1608 cm^{-1} was associated with the C=C bond, the peak around 1406 cm^{-1} was associated with the C-H stretching, and 1030 cm^{-1} corresponded to C-O functional groups. The last peak indicated the presence of

halogens at 598 $cm^{-1,}$ as shown in Figure 4.3 and Table 4.3.

Table 4.3: FTIR peak values and their assigned functional groups present in leaves of Solanum nigrum.

Sr. No.	Wavenumber cm^{-1} (Test Sample)	Wavenumber cm^{-1} Range	Assigned functional groups	Phytochemicals identified
1	3286	3200-3600	O-H stretching	Hydrogen-bonded alcohols, Phenols
2	2918	2850-2970	C-H stretching of alkyl halides	Alkanes
3	2854	2850-2970	C-H stretching of aldehydes	Alkanes
4	1727	1712-1763	C=O stretching	Carbonyl group, ketone
5	1608	1583-1709	C=C, amine I vibration	Aromatics stretch
6	1406	1300-1370	C-H stretching	-
7	1030	1000-1150	C-O stretching	-
8	598	490-620	C-I, C-Cl	Halogen Compounds (Chloro compound, iodo compound) OR alkyl halide

The FTIR analysis on a powder sample of roots of Polygonum aviculareshowed that peaks at 3292 cm^{-1} corresponded to the O-H stretch, peaks at 2927 cm^{-1} and 2849 cm^{-1} corresponded to the C-H stretch, and peaks at 1606 cm^{-1} corresponded to the aromatic stretch due to C=C amine I vibration. The peak at around 1310 cm^{-1} was associated with nitro compounds, the peak around 1029 cm^{-1} was associated with C-O stretching, and 769 cm^{-1} corresponded to C=H bending. The last peak indicates the presence of halogens at 614 cm^{-1}, shown in Figure 4.4 and Table 4.4.

Table 4.4: FTIR peak values and their assigned functional groups present in the roots of Polygonumaviculare.

Sr. No.	Wavenumber cm-1	Wavenumber cm-1 Range	Assigned functional groups	Phytochemicals identified
1	3292	3200-3600	O-H stretching	Hydrogen-bonded alcohols, Phenols
2	2927	2850-2970	C-H alkyl	Alkanes
3	2849	2850-2970	C-H aldehydes	Alkanes
4	1606	1583-1709	C=C, amine I vibration	Aromatics stretch
5	1310	1300-1370	Unknown	Unknown
6	1029	1000-1150	C-O stretching	_
7	769	675-1000	=CH, bending	alkene
8	614	490-620	C-I, C-Cl	Halogen Compounds (Chloro compound, iodo compoun

				d) OR alkyl halide

Phytochemical Screening:

The phytochemical testing of the leaf extracts of C. intybus has revealed the presence of steroids in all four extracts through Salkowaski test. The alkaloids and carbohydrates were also detected in all the extracts by Mayer's test and Molisch's test, respectively. Flavonoids were identified in three extracts, except the n-hexane extract. Proteins, tannins and cardiac glycosides were present in all four extracts. Phenols were absent in n-hexane extract but present in the other three extracts; their presence was detected by the Ferric chloride test. Saponins were present in chloroform and n-hexane extracts and detected by the froth test.

Table 4.5 Phytochemical screening of different leaf extracts of Cichorium intybus.

Phytochemicals	**Tests**	**Methanol**	**Chloroform**	**n-Hexane**	**Aqueous solution**
Steroids	Salkowaski Test	+	+	+	+
Alkaloids	Mayer's Test	+	+	_	+
Carbohydrates	Molisch's Test	+	+	+	+
Flavenoids	Alkaline Reagent Test	+	+	_	+
Phenols	Ferric Cl Test	+	_	_	_
Tannins	Ferric Cl Test	+	+	+	+
Saponins	Froth Test	_	_	+	+
Cardiac Glycosides	Keller Killiani's Test	_	+	+	+
Reducing sugars	Fehling's Test	_	_	_	+
Proteins	Biuret Test	_	_	+	+

Table 4.6 Phytochemical screening of different root extracts of Foeniculum vulgare.

Phytochemicals	**Tests**	**Methanol**	**Chloroform**	**n-Hexane**	**Aqueous solution**
Steroids	Salkowaski Test	+	+	+	+
Alkaloids	Mayer's Test	+	+	+	+
Carbohydrates	Molisch's Test	+	+	+	+
Flavenoids	Alkaline Reagent Test	+	+	_	+
Phenols	Ferric chloride	+	+	_	+
Tannins	Ferric Chloride Test	+	+	+	+
Saponins	Froth Test	_	+	+	_
Cardiac Glycosides	Keller Killiani's Test	+	+	+	+
Reducing sugars	Fehling's Test	_	_	_	_
Proteins	Biuret Test	+	+	+	+

Table 4.7 Phytochemical screening of different leaf extracts of Solanum nigrum.

Phytochemicals	Tests	Methanol	Chloroform	n-Hexane	Aqueous solution
Steroids	Salkowaski Test	+	+	+	+
Alkaloids	Mayer's Test	_	+	+	+
Carbohydrates	Molisch's Test	_	+	+	+
Flavenoids	Alkaline Reagent Test	_	+	+	+
Phenols	Ferric chloride	+	+	+	+
Tannins	Ferric Chloride Test	+	+	+	+
Saponins	Froth Test	+	_	+	_
Cardiac Glycosides	Keller Killiani's Test	+	+	_	+
Reducing sugars	Fehling's Test	_	_	_	+
Proteins	Biuret Test	+	+	_	+

Table 4.8: Phytochemical screening of different root extracts of Polygonum aviculare

Phytochemicals	Tests	Methanol	Chloroform	n-Hexane	Aqueous
Steroids	Salkowaski Test	+	+	_	+
Alkaloids	Mayer's Test	+	+	_	+
Carbohydrates	Molisch's Test	+	+	+	+
Flavenoids	Alkaline Reagent Test	_	+	_	+
Phenols	Ferric chloride	+	+	+	+
Tannins	Ferric chloride	+	+	+	+
Saponins	Froth Test	_	+	+	+
Cardiac Glycosides	Keller Killiani's Test	+	+	+	+
Reducing sugars	Fehling's Test	+	_	_	+
Proteins	Biuret Test	+	_	_	+

Discussion:

Medicinal plants have always been used in traditional medicines and ethno-medicines worldwide, and different plant extracts have been used to determine their therapeutic potential from ancient times (Tugume and Nyakoojo, 2019).

Physiochemical analysis and anatomical studies are used in determining medicinal qualities of plants, preventing and identifying any adulterations in powdered samples of Cichorium intybus and Polygonum aviculare. This study helps in determining nutritional importance and also improves the authentic commercial quantification of Kasni and Anjbar. The

number of medicinally important plants is continuously increasing, and about 10,000 to 20,000 plants have been discovered for their medicinal uses (Arshad et al., 2024).

Herbal medicines seemed to have various active compounds, inactive unknown elements and also metallic compounds. It was demonstrated that FTIR, along with PCA, is an excellent technique for quality control of herbal medicines, as characteristic peaks are of great help in identifying any herbal plants. (Singh et al., 2010).

The phytochemical constituents of plants are responsible for the medicinal properties or therapeutic potential of the medicinal plants. Cichorium intybs(Kasni), Foeniculum vulgare (Sonf), Solanum nigrum (Makoh)and Polygonum aviculare(Anjbar), collected from adjoining areas of Lahore, are locally used for their medicinal properties like anti-microbial, anti-inflammatory, antioxidants and anti-tumour properties and their traditional uses. The study of these plants by Fourier Transform Infrared Resolution determines their therapeutic potential and biomedical applications. Different bioactive and medicinally important components were present in their different solvent extracts.

An antibacterial and phytochemical study of Cichorium intybus was carried out, and it was called a multipurpose medicinal plant. Various biologically active compounds of this plant are thought to be very important medicinally against infectious diseases. This study revealed that polar and non-polar extracts of this plant were useful against infectious bacterial strains and possessed great antibacterial properties (Nandagopal and Kumari, 2007)

Through various research studies and drug discoveries, it is evident that compounds like amines, amides and amino acids are the main components of protein synthesis and present in many herbs and are used as a stimulant, herb oil and hair tonics. Disinfectants, dermal creams and other health-promoting products use sulphur derivatives. Carbohydrates, such as polysaccharides, are used as disinfectants. (Nair et al., 2013)

The presence of terpenoids and saponins was detected in medicinal plants using the FTIR technique. Saponins and terpenoids were detected by using dry crude powder of parts like root or leaves of some plants (Bañuelos et al., 2018). FTIR analysis of plant samples showed carboxylic acids, carbonyl compounds, alcohols, carbon-hydrogen and carbon-carbon bonds, characteristics of saponins and terpenoids (Karer et al., 2008).

Various carboxylic acids are an indication of their use in treating headache, liver pain, joint stiffness and curing ulcers. The role of proteins is very evident and significant in the physiology of living organisms. Any change in the protein structure can have drastic effects on biological processes, including nitrogenous compound metabolism, food intake, and the maintenance of body homeostasis.
(Santosh et al., 2013)

Functional groups like C-H, C=O, C-O, C-C and C-O-C bonding structures indicated the presence of alkyl groups, alcohols, esters, ketones, carboxylic acids and deoxyribose. These groups indicate the presence of alkenes, nitrites, amino acids, ethers, organic halogens and carbohydrates in plants (Nair et al., 2013).

The purpose of this study is to determine medicinally important bioactive components in root and leaf extracts of different plants in various solvents, highlighting the commercial value of plants in treating various diseases

Conclusion:

Medicinal plants serve as a fundamental source of therapeutic agents. Phytochemical screening and FTIR analysis of various solvent extracts of medicinal plants revealed the presence of diverse bioactive compounds, with methanolic extracts containing the highest variety. Identified phytochemicals included carbohydrates, steroids, alkaloids, phenols, tannins, saponins, cardiac glycosides, flavonoids, proteins, and reducing sugars. FTIR analysis confirmed the presence of multiple active functional groups in the roots and leaves of the plants used in this study. These findings support the potential of the studied plants as valuable sources for ethnomedicinal applications.

Recommendations need to be incorporated.

Recommendations:

1. Expand Phytochemical Characterisation – Use advanced analytical techniques such as GC-MS and LC-MS to identify and quantify specific bioactive compounds for potential agricultural and pharmaceutical applications.
2. Develop Plant-based Bioproducts – Explore the use of identified bioactive compounds for developing natural pesticides, growth enhancers, or livestock health supplements.
3. Link to Sustainable Development Goals (SDGs) – Encourage integration of such studies into public health and biodiversity conservation strategies in line with SDG 3 (Good Health and Well-being) and SDG 15 (Life on Land).

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Appendix

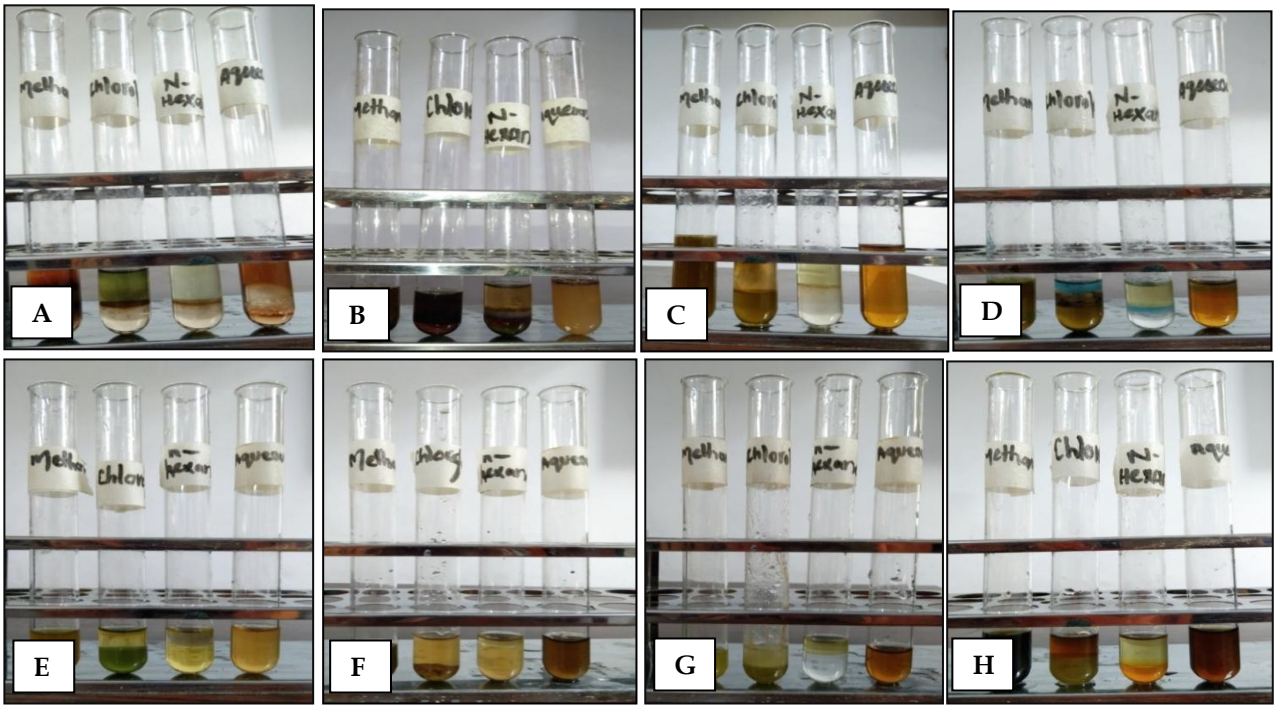

Plate 4.1: Phytochemical screening of Cichorium intybus in different extracts: A. steroids, B carbohydrates, C. flavonoids, D. proteins, E. alkaloids, and F. phenols. G. tannins, H. saponins

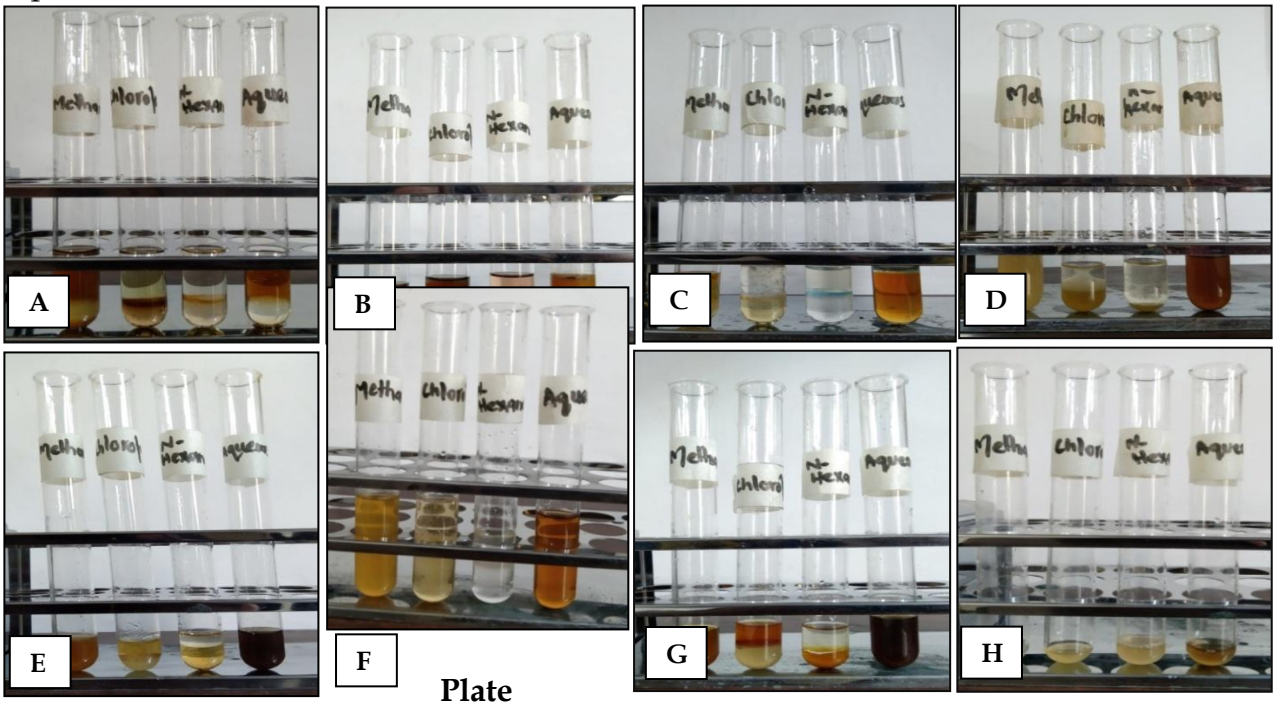

Plate 4.2: Phytochemical screening of F. vulgare in different extracts: A. steroids, B.

carbohydrates, C. proteins, D. alkaloids, E. phenols, and F. flavenoids, G. tannins, H. saponins.

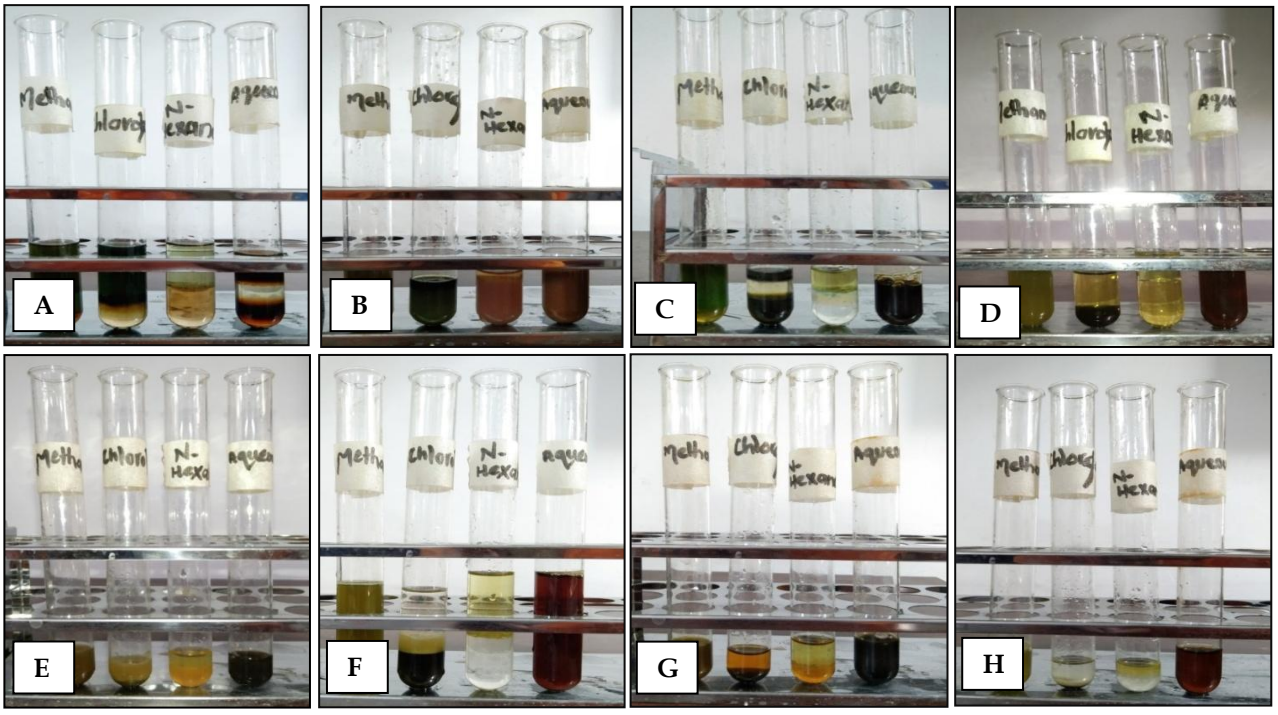

Plate4.3:Phytochemical screening of Solnum nigrum in different extracts: A. steroids, B. carbohydrates, C. flavenoids, D. proteins, E. alkaloids, and F. phenols. G. tannins, H.

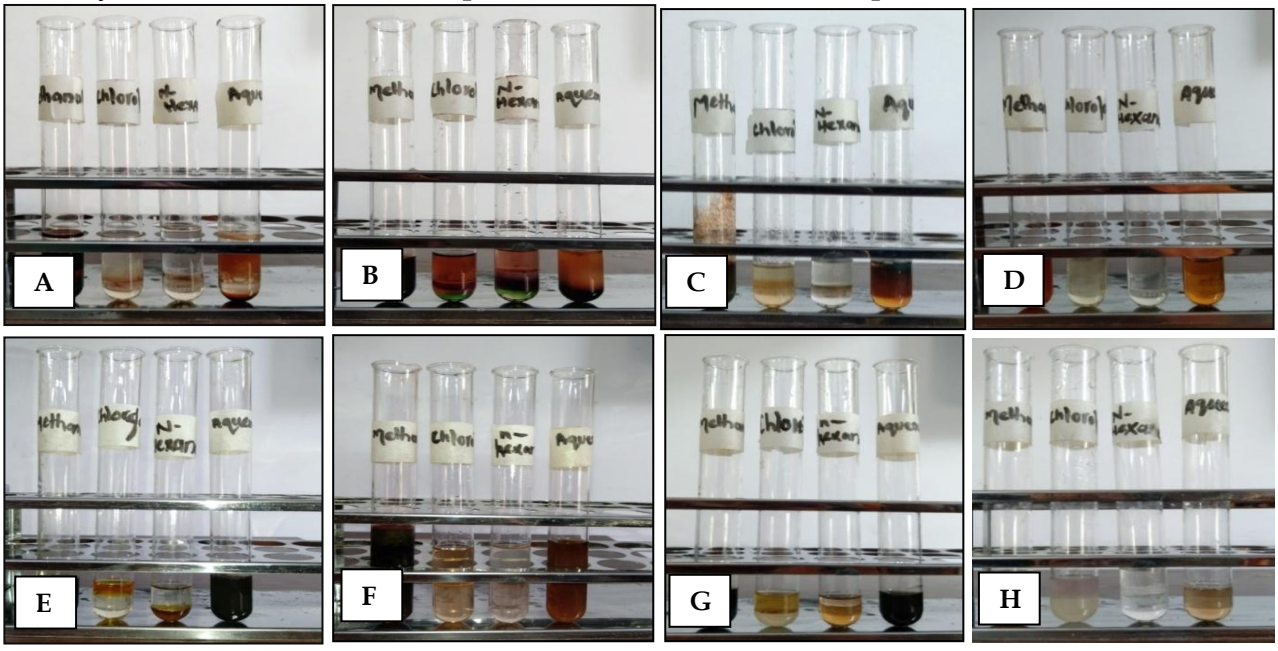

Plate 4.4: Phytochemical screening of Polygonum aviculare in different extracts: A. steroids, B. carbohydrates, C. flavenoids, D. proteins, E. alkaloids, and F. phenols. G. tannins, H. saponins.