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Research Article

Phytochemical, Microscopic, And Spectroscopic Evaluation Of Glycyrrhiza Glabra, Pterocarpus Marsupium, Syzygium Aromaticum, Aegle Marmelos, And Coccinia Grandis: Characterization And Medicinal Potential

Sarika Chavan ^{1*}, Dr V G. Rajurkar², Varsha Patwekar ³, Purushottam B. Rakhunde⁴

^{1*}PhD scholar at Dr Ved Prakash Patil College of Pharmacy, Chhatrapati Sambhaji Nagar, Maharashtra, India

²Principal, Dr Ved Prakash Patil College of Pharmacy, Chhatrapati Sambhaji Nagar, Maharashtra, India

³PhD scholar at Dr Ved Prakash Patil College of Pharmacy, Chhatrapati Sambhaji Nagar, Maharashtra, India

⁴Research Scholar at Dr Ved Prakash Patil College of Pharmacy, Chhatrapati Sambhaji Nagar, Maharashtra, India

***Correspondence Author:** Sarika Chavan

*PhD scholar at Dr Ved Prakash Patil College of Pharmacy, Chhatrapati Sambhaji Nagar, Maharashtra, India
chavansarikap@gmail.com

Abstract:

This study investigates the macroscopical, microscopical, and spectroscopic characteristics of five medicinal plants: *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd). The objective is to establish a comprehensive profile of these plants' identification features, phytochemical composition, and medicinal properties. Macroscopical analysis revealed distinctive characteristics that aid in plant identification, such as the fibrous texture and yellowish-brown color of *Glycyrrhiza glabra* roots, and the astringent taste of *Pterocarpus marsupium* bark.

Microscopical analysis highlighted the presence of key structures, such as fibrovascular bundles in *Glycyrrhiza glabra*, tannin cells in *Pterocarpus marsupium*, and oil glands in *Syzygium aromaticum*. UV-Vis spectroscopy demonstrated distinct absorbance peaks reflecting alkaloids, flavonoids, phenolic acids, and tannins across the plant extracts. FTIR spectra further confirmed the presence of bioactive functional groups such as hydroxyl, carbonyl, and phenolic groups. The physicochemical analysis indicated the moisture content, ash content, and extractive values, which are vital for understanding the storage and bioactive yield of the plant materials. These findings provide valuable insights into the therapeutic potential of these plants and their use in traditional medicine.

Keywords: Glycyrrhiza glabra, Pterocarpus marsupium, Syzygium aromaticum, Aegle marmelos, Coccinia grandis, Phytochemicals, UV-Vis Spectroscopy, FTIR, Microscopic Analysis, Medicinal Plants

***Author for correspondence:** Sarika Chavan **Email:** chavansarikap@gmail.com

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Introduction

Medicinal plants have played an essential role in the treatment and prevention of diseases for centuries. Traditional medicine systems, such as Ayurveda, Unani, and Traditional Chinese Medicine, have long recognized the therapeutic potential of various plant species. With an increasing interest in natural remedies, the use of medicinal plants for managing diverse health conditions has gained popularity worldwide.[1,2] These plants are a rich source of bioactive compounds, including alkaloids, flavonoids, phenolic acids, essential oils, and glycosides, which contribute to their medicinal properties. In this context, it becomes imperative to explore, document, and understand the properties of these plants in-depth to validate their uses in modern pharmacological applications. This study focuses on five such medicinal plants: *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd), with the aim to comprehensively evaluate their macroscopical, microscopical, and spectroscopic characteristics.[3]

1. *Glycyrrhiza glabra* (Licorice)

Licorice, scientifically known as *Glycyrrhiza glabra*, is a perennial herb native to the Mediterranean region and parts of Asia. The root of this plant has been used for thousands of years in various cultures for its medicinal properties. Licorice is known for its anti-inflammatory, antioxidant, and antimicrobial activities, making it a valuable component in traditional remedies. The bioactive compounds in licorice, particularly glycyrrhizin, flavonoids, and saponins, have been attributed to its therapeutic efficacy. *Glycyrrhiza glabra* is used in the treatment of respiratory ailments, gastrointestinal disorders, and as a general tonic for enhancing vitality.[5,6]

2. *Pterocarpus marsupium* (Indian Kino)

Indian Kino, or *Pterocarpus marsupium*, is a deciduous tree native to India and Southeast Asia. The tree's bark, wood, and leaves contain a wide range of bioactive compounds, including flavonoids, tannins, and glycosides. *Pterocarpus marsupium* has been used in traditional medicine for its antidiabetic, anti-inflammatory, and antimicrobial properties. Its primary bioactive compound, pterocarpin, has shown promising results in managing blood glucose levels, making it an important candidate in the treatment of diabetes. Additionally, the astringent and antiseptic properties of the plant contribute to its use in wound healing and gastrointestinal disorders.[7]

3. *Syzygium aromaticum* (Clove)

Clove, or *Syzygium aromaticum*, is a spice that originates from the Maluku Islands in Indonesia. Known for its aromatic flavor and potent medicinal properties, clove has been used extensively in both culinary and medicinal practices. The plant contains eugenol, a phenolic compound that contributes to its analgesic,

anti-inflammatory, and antioxidant effects. Clove is commonly used to alleviate dental pain, improve digestive health, and treat respiratory infections. Additionally, its antimicrobial properties make it a potent agent in preserving food and combating infections. [7]

4. *Aegle marmelos* (Bael)

Bael, or *Aegle marmelos*, is a tropical fruit-bearing tree native to the Indian subcontinent. The fruit, leaves, and bark of the Bael tree are used for their medicinal properties. Bael is known for its digestive benefits and is commonly used in the treatment of diarrhea, dysentery, and gastrointestinal disorders. The plant is rich in bioactive compounds, including alkaloids, flavonoids, and essential oils, which contribute to its antimicrobial, anti-inflammatory, and antioxidant properties. *Aegle marmelos* has also shown promise in managing diabetes and improving liver function. [7]

5. *Coccinia grandis* (Ivy Gourd)

Ivy Gourd, or *Coccinia grandis*, is a perennial herbaceous vine that is native to tropical Asia and Africa. Known for its medicinal and nutritional value, this plant has been used in the treatment of various ailments, including diabetes, dyslipidemia, and gastrointestinal disorders. *Coccinia grandis* contains a wide array of bioactive compounds, including flavonoids, alkaloids, and glycosides, which contribute to its antioxidant, anti-inflammatory, and hypoglycemic effects. The leaves and fruits of the plant are often used in folk medicine to regulate blood sugar levels and improve overall health. [7]

Phytochemical Composition and Medicinal Properties

Each of these plants has been identified as a rich source of bioactive compounds that contribute to their medicinal properties. Phytochemical screening of these plants has revealed the presence of important secondary metabolites such as alkaloids, flavonoids, tannins, saponins, glycosides, and essential oils. These compounds exhibit a range of pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and analgesic effects. Understanding the phytochemical composition of these plants is crucial for validating their traditional uses and exploring their potential applications in modern medicine. [7]

Importance of Macroscopical, Microscopical, and Spectroscopic Evaluation

For any medicinal plant, proper identification is the first and foremost step in its medicinal use. The macroscopical examination provides an insight into the physical characteristics of the plant, including its color, texture, shape, and size, which are essential for authenticating plant materials. Microscopical evaluation is crucial for identifying the plant's internal structures, such as the presence of trichomes, glandular cells,

vascular bundles, and other diagnostic features that aid in species identification and quality control. Additionally, spectroscopic techniques like UV-Vis spectroscopy and FTIR provide valuable information about the molecular composition of the plant extracts. UV-Vis spectroscopy is useful for identifying the presence of specific phytochemicals based on their absorption maxima, while FTIR spectroscopy provides information about the functional groups present in the plant molecules, which are responsible for their therapeutic properties. [7]

Research Significance and Objectives

This research aims to provide a comprehensive characterization of *Glycyrrhiza glabra*, *Pterocarpus marsupium*, *Syzygium aromaticum*, *Aegle marmelos*, and *Coccinia grandis* through macroscopical, microscopical, and spectroscopic techniques. The objectives are to examine the morphological and microscopic features for plant identification and quality control, identify and quantify the bioactive compounds using UV-Vis and FTIR spectroscopy, assess the phytochemical profiles to link bioactive compounds with their traditional medicinal uses, and provide crucial data for the development of future pharmacological studies and herbal formulations. [7]

MATERIALS AND METHOD

Macroscopical Characteristics

The macroscopical traits of the studied plant materials provide essential identification features. *Glycyrrhiza glabra* roots are cylindrical, yellowish-brown, fibrous, and sweet. *Pterocarpus marsupium* bark is rough, dark reddish-brown, woody, and astringent. *Syzygium aromaticum* flower buds are reddish-brown, hard, aromatic, and spicy. *Aegle marmelos* fruits are greenish-yellow with woody shells, sweet to acidic, and rounded. *Coccinia grandis* leaves are smooth green, while stems are fibrous with a fresh herbaceous odor. These characteristics ensure accurate identification for therapeutic uses.[8,9]

Microscopical Characteristics

Microscopical analysis revealed diagnostic internal features of the plants. *Glycyrrhiza glabra* showed fibrovascular bundles, lignified fibers, and elliptical starch grains. *Pterocarpus marsupium* bark contained tannin cells and fibers in bundles. *Syzygium aromaticum* flower buds had oil glands and calcium oxalate crystals. *Aegle marmelos* displayed parenchymatous cells with tannin bodies and oil globules, while *Coccinia grandis* showed anisocytic stomata, trichomes, and spiral xylem vessels.[10-15]

Ultra Violet -Visible Spectroscopy

UV-Vis spectra exhibited characteristic absorbance peaks reflecting phytochemical composition. *Glycyrrhiza glabra* showed peaks at 270–290 nm for alkaloids and flavonoids, while *Pterocarpus marsupium* peaked at 330–350 nm, linked to phenolic acids. *Syzygium aromaticum* had a peak at 360–380 nm, and *Aegle marmelos* exhibited absorbance near 300 nm. *Coccinia grandis* peaked around 290 nm, indicating phenolic compounds. [16-22]

FTIR Spectroscopy

FTIR analysis highlighted the presence of bioactive functional groups. *Glycyrrhiza glabra* revealed O-H, C-H, and C=O stretching vibrations. *Pterocarpus marsupium* exhibited O-H, C≡C, and C=O peaks. *Syzygium aromaticum* was rich in aromatic and polyphenolic groups. *Aegle marmelos* displayed hydroxyl, aldehyde, and aromatic groups, while *Coccinia grandis* showed aldehydic and conjugated double bonds. These spectra confirm the diversity of phytoconstituents contributing to the plants' medicinal properties.[23-25]

Physicochemical Analysis of Powdered Herbs

Physicochemical properties provided insights into composition and stability. Moisture content was highest in *Glycyrrhiza glabra*, suggesting careful storage needs, while *Pterocarpus marsupium* showed better stability. Ash content indicated higher minerals in Licorice. Acid insoluble content highlighted the presence of insoluble materials, while water-soluble and extractive values reflected extractability. *Pterocarpus marsupium* exhibited the highest water and ethanol extractive values, emphasizing its potent bioactive yield.[26-30]

RESULTS AND DISCUSSION:

Macroscopical Characteristics

The macroscopical characteristics of the studied plant extracts reveal distinct visual and sensory properties that aid in their identification and quality assessment. *Glycyrrhiza glabra* roots are identified by their yellowish-brown color, fibrous texture, and sweet taste, typical of licorice. The dark reddish-brown bark of *Pterocarpus marsupium* is rough, woody, and exudes an astringent taste, aligning with its traditional use in treating various ailments. The conical, reddish-brown flower buds of *Syzygium aromaticum* are aromatic and spicy, a signature feature of clove. *Aegle marmelos* fruits are noted for their greenish-yellow, woody shells and sweet-to-acidic taste, while the leaves and stems of *Coccinia grandis* exhibit a fresh green color with a mix of smooth and fibrous textures. These distinctive traits not only ensure accurate identification but also validate the authenticity of the plant material for therapeutic use.

Table 1: Macroscopical Characteristics

Plant Name	Part Used	Color	Texture	Odor	Taste	Shape/Size
<i>Glycyrrhiza glabra</i>	Root	Yellowish-brown	Fibrous	Characteristic	Sweet	Cylindrical, ~10–20 cm long
<i>Pterocarpus marsupium</i>	Bark	Dark reddish-brown	Rough	Woody	Astringent	Irregular fragments, ~5–10 cm wide
<i>Syzygium aromaticum</i>	Flower buds	Reddish-brown	Hard, woody	Aromatic	Spicy	Conical, ~1–2 cm in length
<i>Aegle marmelos</i>	Fruit	Greenish-yellow	Woody shell	Mild, fruity	Sweet to acidic	Rounded, ~5–10 cm in diameter
<i>Coccinia grandis</i>	Leaves, stems	Green	Smooth (leaves), fibrous (stems)	Fresh herbaceous	Bitter	Oval (leaves), cylindrical (stems)

Microscopical Characteristics

The microscopical analysis provides deeper insights into the internal structural features of the plant materials. *Glycyrrhiza glabra* displays fibro-vascular bundles, lignified fibers, and elliptical starch grains, which are diagnostic markers of its root. *Pterocarpus marsupium* bark exhibits fibers in bundles and tannin cells, confirming its high tannin content—a characteristic linked to its medicinal properties. The flower buds of *Syzygium aromaticum* reveal oil glands and rhomboidal

calcium oxalate crystals, emphasizing its aromatic and antimicrobial attributes. *Aegle marmelos* showcases parenchymatous cells with abundant oil globules and tannin bodies, supporting its role in treating gastrointestinal disorders. Lastly, the anisocytic stomata, trichomes, and spiral-thickened xylem vessels in *Coccinia grandis* indicate its adaptability and bioactive potential. These microscopical features are crucial for ensuring the consistency, quality, and efficacy of the plant extracts in herbal formulations.

Table 2: Microscopical Characteristics of Plant Extracts

Plant Name	Key Microscopical Features	Observation/Measurements
<i>Glycyrrhiza glabra</i>	Fibro-vascular bundles, lignified fibers, starch grains	Starch grains: Elliptical, ~10–20 µm; Calcium oxalate crystals: Needle-shaped
<i>Pterocarpus marsupium</i>	Fibers in bundles, medullary rays, tannin cells	Medullary ray width: ~40–60 µm; Tannin cells: Dense in cortical region
<i>Syzygium aromaticum</i>	Epidermal cells with oil glands, calcium oxalate crystals	Oil glands: Prominent, round; Crystals: Rhomboidal, ~10–15 µm
<i>Aegle marmelos</i>	Parenchymatous cells with oil globules and tannin bodies	Tannin content: High; Oil globules: Small, spherical
<i>Coccinia grandis</i>	Anisocytic stomata, trichomes, vascular bundles in stem	Stomatal size: ~20–25 µm; Trichomes: Multicellular, ~50–70 µm; Xylem vessels: Spiral thickening

Ultra violet -Visible spectroscopy

The UV spectra of the extracts from *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd) reveal distinct absorbance peaks corresponding to their phytochemical

compositions. Licorice extract exhibits a peak around 270–290 nm, indicating high concentrations of UV-absorbing compounds like alkaloids, flavonoids, or phenolic acids, while Indian Kino shows a significant peak at 330–350 nm, characteristic of flavonoids and phenolic acids with antioxidant properties.

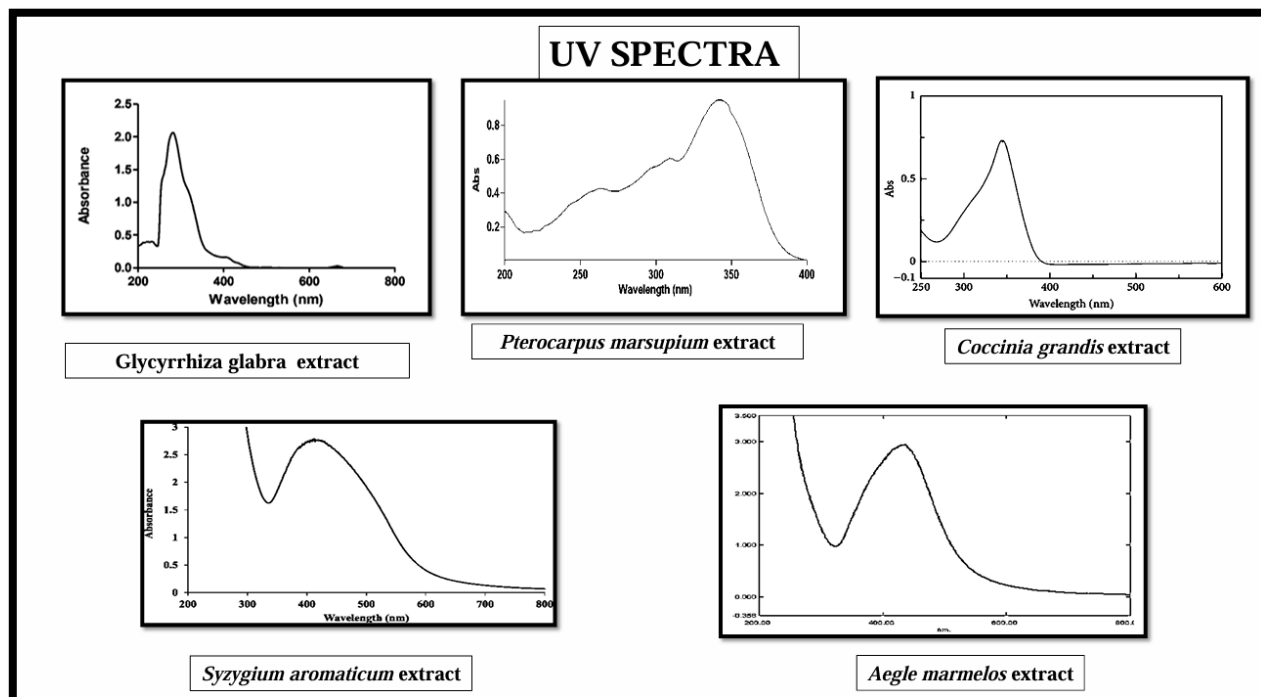


Fig 1: The UV spectra of *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd) extracts

The UV spectra of the extracts from *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd) reveal distinct absorbance peaks corresponding to their phytochemical compositions. Licorice extract exhibits a peak around 270–290 nm, indicating high concentrations of UV-absorbing compounds like alkaloids, flavonoids, or phenolic acids, while Indian Kino shows a significant peak at 330–350 nm, characteristic of flavonoids and phenolic acids with antioxidant properties. Clove extract has a prominent peak at 360–380 nm, signifying flavonoids and tannins, coupled with a complex absorbance dip between 300–350 nm, suggesting diverse phytoconstituents. Bael extract shows absorbance just before 300 nm, potentially linked to bioactive compounds such as gingerol, emphasizing its

therapeutic potential. Lastly, Ivy Gourd extract displays a peak around 290 nm, reflecting the presence of phenolic compounds like cinnamaldehyde and eugenol. Collectively, these spectral profiles highlight the dominance of UV-absorbing phytochemicals across these extracts, underlining their antioxidant and therapeutic potential while confirming the absence of significant chromophores in the visible region.

FTIR

The FTIR spectra of extracts from *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd) highlight the diversity and complexity of bioactive compounds present in these plants

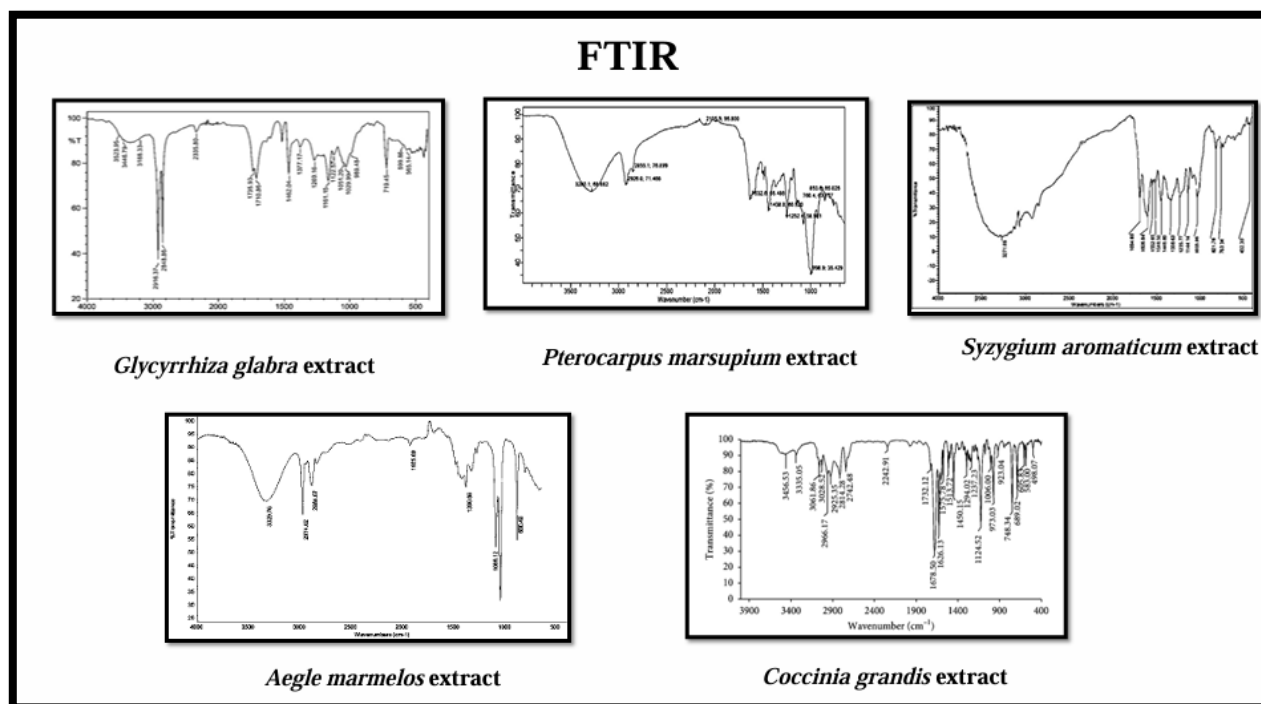


Fig 2: The FTIR spectra of *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd) extracts

Licorice extract exhibits prominent O-H, C-H, and C=O stretching vibrations, indicating the presence of hydroxyl, alkane, and carbonyl groups, which contribute to its therapeutic potential. Indian Kino displays characteristic O-H, C-H, C≡C, and C=O stretching peaks, signifying a mix of alcohols, phenols, alkynes, and carbonyl compounds, known for antioxidant and anti-inflammatory properties. Clove extract is rich in hydroxyl, carbonyl, aromatic, and polyphenolic groups, supporting its antimicrobial and antioxidant activities. Bael extract reveals hydroxyl, aliphatic hydrocarbon, aldehyde, and aromatic groups, suggesting its potential for medicinal applications. Ivy Gourd shows a complex spectrum with hydroxyl, aromatic, aldehydic, and carbonyl groups, as well as conjugated double bonds, underscoring its antioxidant and therapeutic capabilities. Collectively, the FTIR analysis confirms the presence of

diverse functional groups across these extracts, aligning with their established bioactivities and medicinal uses.

Physicochemical analysis of powdered herbs

The physicochemical analysis of powdered herbs provides foundational data crucial for understanding the composition and potential applications of *Glycyrrhiza glabra* (Licorice), *Pterocarpus marsupium* (Indian Kino), *Syzygium aromaticum* (Clove), *Aegle marmelos* (Bael), and *Coccinia grandis* (Ivy Gourd). Moisture content serves as a vital parameter reflecting the presence of water, essential for determining the stability and shelf-life of herbal formulations. Licorice's higher moisture content suggests a greater susceptibility to microbial growth, necessitating appropriate storage and preservation methods. Conversely, Indian Kino's lower moisture content may indicate better stability over time.

Table 3: Physicochemical Constituents of Powdered herbs

Parameter	<i>Glycyrrhiza glabra</i> (Licorice)	<i>Pterocarpus marsupium</i> (Indian Kino)	<i>Syzygium aromaticum</i> (Clove)	<i>Aegle marmelos</i> (Bael)	<i>Coccinia grandis</i> (Ivy Gourd)
Moisture content (% w/w)	8.50±0.90	6.70±0.90	7.20±1.00	7.00±0.80	6.50±0.80
Ash content (% w/w)	9.20±1.10	6.90±1.00	8.85±1.25	8.50±0.95	5.75±0.90
Acid insoluble content (% w/w)	7.80±1.00	5.80±0.70	7.36±1.35	7.00±0.75	4.80±0.70
Water soluble content (% w/w)	8.00±1.20	7.10±0.80	7.87±1.20	7.20±0.85	6.25±0.75
Water extractive value (% w/w)	15.50±1.20	16.50±1.20	15.39±1.15	15.80±1.10	12.75±1.00
Ethanol extractive (% w/w)	22.00±2.00	23.03±2.62	20.20±1.80	21.50±2.20	20.50±2.00

The ash content signifies the inorganic residue post-combustion, shedding light on the mineral composition and potential presence of impurities. Licorice's elevated ash content suggests a higher mineral concentration, possibly contributing to its therapeutic properties. Acid insoluble content provides insights into the presence of insoluble materials, influencing the herb's physical characteristics and processing requirements. The higher acid insoluble content in Licorice and Indian Kino underscores potential challenges in extracting bioactive compounds efficiently.

Water-soluble content indicates the proportion of substances soluble in water, essential for determining herbal extractability and potential solubility in aqueous formulations. Licorice's higher water-soluble content implies a greater potential for water-based extraction methods, aligning with traditional herbal preparation practices. Conversely, Ivy Gourd's lower water-soluble content suggests a reduced solubility in water, impacting its formulation versatility.

The water extractive value and ethanol extractive percentage provide crucial insights into the herb's extractability and potential yield of bioactive compounds using different solvents. Indian Kino's higher water extractive value suggests a greater affinity for water-soluble constituents, while Licorice and Indian Kino's higher ethanol extractive percentage hints at their higher extraction efficiency with ethanol, an important consideration for herbal extraction processes.

Conclusion:

The comprehensive evaluation of the macroscopical, microscopical, and spectroscopic characteristics of *Glycyrrhiza glabra*, *Pterocarpus marsupium*, *Syzygium aromaticum*, *Aegle marmelos*, and *Coccinia grandis* provides valuable insights into their identification and medicinal properties. The unique phytochemical profiles, including the presence of alkaloids, flavonoids, phenolic compounds, and tannins, support the traditional uses of these plants in various therapeutic applications. The FTIR and UV-Vis spectra reinforce the bioactive potential of these plant extracts, confirming their role in combating oxidative stress and inflammation. The physicochemical analysis further underscores the stability and extractability of bioactive components, which is crucial for developing herbal formulations. These findings contribute to a deeper understanding of these plants' therapeutic efficacy and highlight their potential for further pharmacological research and formulation development.

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