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Pharmacognostic and Phytochemical Evaluation of Selected Indian Plants and Development of A Poly-Hebral Gel

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Abstract: *The present study focused on the pharmacognostic, physicochemical, and phytochemical evaluation of three well-known Indian medicinal plants—Liquorice (Glycyrrhiza glabra), Ajwain (Trachyspermum ammi), and Turmeric (Curcuma longa)—followed by the formulation and evaluation of a polyherbal gel. Macroscopic and microscopic studies revealed distinct diagnostic features, such as fibrous roots and abundant starch granules in Liquorice, stomata and trichomes on Ajwain leaves, and high lignin-starch content in Turmeric rhizomes. Phytochemical screening confirmed the presence of multiple bioactive constituents, including alkaloids, flavonoids, tannins, terpenoids, saponins, and essential oils, supporting their traditional uses. Pharmacognostic parameters like ash values (3–7%), moisture content (5–10%), crude fiber (8–20%), and extractive values complied with standard limits, ensuring raw material quality. Antioxidant studies revealed notable DPPH and ABTS radical scavenging activities and total antioxidant capacity (TAC), with the polyherbal extract outperforming individual extracts, indicating synergistic antioxidant potential. The polyherbal gel was prepared using Carbopol 940, propylene glycol, and varying concentrations of polyherbal extract (1–9%), yielding formulations (F1–F9) with desirable characteristics. Evaluation showed pH values ranging from 4.5–5.7 (close to skin pH), viscosities between 500–900 cps, and spreadability classified as moderate to excellent. Among the formulations, F5 and F8 were identified as optimal, balancing viscosity, spreadability, color, and odor. This integrative study highlights the significance of comprehensive pharmacognostic and phytochemical assessments in ensuring the quality of herbal raw materials and demonstrates the feasibility of developing a stable polyherbal gel with enhanced antioxidant potential, paving the way for future pharmacological investigations and potential clinical applications in managing oxidative stress-related skin disorders.*

Keywords: Glycyrrhiza glabra, Trachyspermum ammi, Curcuma longa, pharmacognostic evaluation, phytochemical screening, antioxidant activity, polyherbal gel, Carbopol 940, topical formulation

I. INTRODUCTION

Herbal medicines have formed the cornerstone of traditional healthcare systems for centuries, particularly in countries like India where Ayurveda, Siddha, and Unani continue to utilize a diverse array of medicinal plants for the prevention and treatment of various ailments.[1,2] The resurgence of global interest in phytotherapy and natural products is largely attributed to the growing recognition of the limitations and side effects associated with synthetic drugs, coupled with the increasing scientific validation of herbal remedies. Among the myriad of Indian botanicals, Liquorice (Glycyrrhiza glabra), Ajwain (Trachyspermum ammi), and Turmeric (Curcuma longa) stand out due to their extensive ethnopharmacological relevance and robust profiles of bioactive compounds. Liquorice, primarily valued for its roots, contains glycyrrhizin and flavonoids that exhibit anti-inflammatory, antioxidant, and wound-healing properties.[3,4] Ajwain, characterized by its aromatic leaves rich in thymol and other essential oils, is traditionally employed for its carminative, antimicrobial, and antioxidant activities. Turmeric, a hallmark of Indian traditional medicine, owes its therapeutic efficacy to curcuminoids and volatile oils present in its rhizomes, widely recognized for their potent anti-inflammatory, antioxidant, and dermoprotective effects.[5,6]

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Despite individual documentation of these plants' pharmacological benefits, their combined use in polyherbal formulations offers a promising strategy to harness synergistic interactions among their diverse phytoconstituents, potentially leading to enhanced therapeutic efficacy.[7,8] However, the quality, safety, and efficacy of herbal formulations are intrinsically linked to the authenticity and standardization of their constituent raw materials, necessitating rigorous pharmacognostic and phytochemical investigations. Moreover, the formulation of these extracts into suitable delivery systems, such as topical gels, further expands their applicability, providing targeted local action, sustained release, and improved patient compliance. Gels, owing to their high water content, ease of application, and aesthetic appeal, are particularly suited for incorporating herbal actives aimed at managing oxidative stress-induced skin disorders. [9,10]

In this context, the present study was undertaken with multiple objectives: to conduct a detailed pharmacognostic assessment—including macroscopic and microscopic characterization—of Liquorice, Ajwain, and Turmeric to ensure the authenticity and purity of these botanicals; to perform comprehensive physicochemical analyses and preliminary phytochemical screenings to identify and confirm the presence of bioactive constituents; to evaluate the in vitro antioxidant potential of individual and combined plant extracts through well-established radical scavenging assays; and finally, to develop and assess a series of polyherbal gel formulations with varying concentrations of these extracts, aiming to optimize their physicochemical properties such as pH, viscosity, spreadability, and overall stability. By integrating traditional knowledge with modern analytical and formulation approaches, this study seeks to contribute valuable insights into the standardization and rational development of effective polyherbal therapeutics, ultimately supporting their potential role in complementary and alternative dermatological care.

II. MATERIAL AND METHODS

The study utilized authenticated samples of Liquorice (Glycyrrhiza glabra) roots, Ajwain (Trachyspermum ammi) leaves, and Turmeric (Curcuma longa) rhizomes, each selected based on their well-documented medicinal properties such as anti-inflammatory, antimicrobial, and antioxidant activities. Various analytical grade reagents were employed, including chloral hydrate for clearing, glycerin for mounting, ethanol and distilled water as solvents for extractive tests, dilute hydrochloric acid for ash analysis, sodium hydroxide, Mayer's and Wagner's reagents for alkaloid detection, dinitrobenzene for glycosides, ferric chloride for phenolics, concentrated sulfuric acid, α-naphthol, Benedict's reagent for carbohydrates, vanillin-HCl and gelatin solutions for tannins, lead acetate and magnesium turnings for flavonoids, pyridine and sodium nitroprusside for glycosides, chloroform and acetic acid for steroids, as well as biuret, ninhydrin, and Sudan III reagents for proteins, amino acids, and fats, respectively. The macroscopic evaluation involved detailed observation of morphological traits: Liquorice roots were found to be long, cylindrical, brown externally and pale internally with fibrous texture; Ajwain leaves were small, dark green, smooth, and glossy; Turmeric rhizomes were knobby, with brown outer surfaces and vivid yellow interiors. Microscopic studies entailed powdering samples, clearing with chloral hydrate, mounting in glycerin, and examining under a compound microscope at 10× and 40× magnification to confirm diagnostic features. Physicochemical parameters including moisture content (by loss on drying at 105°C), total ash, acid-insoluble ash, and water-soluble ash were determined using standard pharmacopeial procedures. Alcohol- and water-soluble extractive values were assessed by macerating powdered samples in ethanol or water for 24 hours, followed by filtration and evaporation to constant weight. Preliminary phytochemical screening was performed through specific colorimetric and precipitation tests to detect the presence of alkaloids, glycosides, carbohydrates, tannins, flavonoids, resins, steroids, proteins, amino acids, fats, phenols, diterpenes, and saponins. Each reaction, such as Mayer's and Wagner's tests for alkaloids, Raymond's and Killer Killani tests for glycosides, Molisch's and Benedict's tests for carbohydrates, vanillin-HCl and gelatin tests for tannins, Shinoda and alkaline reagent tests for flavonoids, Libermann–Burchard and Salkowski tests for steroids, as well as Sudan red, spot, and saponification tests for fats, was carefully performed and interpreted based on characteristic color changes or precipitate formation. This multi-tiered methodological approach ensured thorough quality assessment and authentication of the selected plant materials prior to their prospective formulation and pharmacological investigations.[11,12]

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In vitro Antioxidant Activity

The antioxidant potential of the plant extracts was assessed using three complementary in vitro assays: DPPH radical scavenging, ABTS radical cation scavenging, and total antioxidant capacity (TAC) assays. The DPPH assay was performed following the method of Blois (1958) with minor modifications, wherein a 0.1 mM solution of DPPH in methanol was freshly prepared. To 1 mL of this DPPH solution, 1 mL of plant extract at varying concentrations (0.1, 0.5, and 1.0 mg/mL) was added, and the mixture was incubated in the dark at room temperature for 30 minutes. The reduction in absorbance was recorded at 517 nm using a UV-Visible spectrophotometer, with ascorbic acid serving as the positive control. The ABTS radical scavenging activity was evaluated as per the protocol described by Re et al. (1999). The ABTS radical cation ($ABTS^{\bullet+}$) was generated by reacting 7 mM ABTS solution with 2.45 mM potassium persulfate, allowing the mixture to stand in the dark at room temperature for 16 hours. This $ABTS^{\bullet+}$ solution was then diluted with ethanol to achieve an absorbance of 0.70 ± 0.02 at 734 nm. A volume of 1 mL of this solution was mixed with 1 mL of plant extract at different concentrations, incubated for 10 minutes, and the absorbance was measured at 734 nm. The percentage inhibition for both DPPH and ABTS assays was calculated using the standard formula: % inhibition = [(A_control – A_sample) / A_control] × 100. Furthermore, total antioxidant capacity (TAC) was determined by the phosphomolybdenum method. Here, 0.3 mL of plant extract was mixed with 3 mL of reagent solution containing 0.6 M sulfuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate. The reaction mixtures were incubated in a water bath at 95°C for 90 minutes, cooled to room temperature, and absorbance was measured at 695 nm. Results were expressed as mg ascorbic acid equivalents (AAE) per gram of extract, establishing a comparative measure of the extracts' antioxidant capacities.[13,14]

Preparation and Evaluation of Polyherbal Gel Formulations

Polyherbal gel formulations (F1 to F9) were prepared by first dispersing Carbopol 940 (1% w/w) in purified water under continuous stirring to allow complete hydration. Propylene glycol (5% w/w) was incorporated as a humectant and co-solvent to facilitate dissolution of the polyherbal extracts, which were added in graded concentrations ranging from 1% to 9% w/w across the formulations. Methylparaben (0.1% w/w) was included as a preservative to prevent microbial growth, and the pH of each formulation was carefully adjusted to the range of 6.5–7.5 using triethanolamine (0.5% w/w) to ensure optimal gel consistency and skin compatibility. The final mixtures were stirred thoroughly to achieve homogeneity and then filled into sterile containers for storage at ambient temperature. [15]

Table 1: Poly-herbal Gel Formulations

Component	F1	F2	F3	F4	F5	F6	F7	F8	F9
Polyherbal Extract (%)	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Carbopol 940 (%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Propylene Glycol (%)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Triethanolamine (%)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Methylparaben (%)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Purified Water (q.s. to 100% w/w)	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

The prepared gels were evaluated for key physicochemical parameters to ensure their suitability for topical application. Color was visually assessed against a white background under natural light by three independent evaluators to confirm

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uniform appearance and absence of discoloration. Odor was examined by gently inhaling the formulations placed in Petri dishes, with descriptors such as mild, pleasant, or herbal recorded by consensus. Viscosity measurements were performed using a Brookfield digital viscometer (Model DV-E) with Spindle No. 64 at 100 rpm and 25 ± 2°C, recording mean values in centipoise (cps) from triplicate determinations. The pH was determined by dispersing 1 g of gel in 10 mL of distilled water and measuring with a calibrated digital pH meter, with readings taken in triplicate. Spreadability was assessed using a glass slide method where 1 g of gel was placed between two slides under a 500 g weight for 5 minutes, followed by measuring the time required for the upper slide to move a fixed distance upon application of horizontal force. Spreadability was calculated using the formula $S = (M \times L)/T$, where M is the applied weight, L is the distance moved, and T is the time taken, allowing comparative classification of formulations as excellent, moderate, or poor. This comprehensive methodological approach ensured robust preparation and systematic evaluation of the polyherbal gel formulations for further therapeutic assessment.[16]

III. RESULTS AND DISCUSSION

The macroscopic evaluation of Liquorice (Glycyrrhiza glabra), Ajwain (Trachyspermum ammi), and Turmeric (Curcuma longa) revealed distinct morphological traits that aid in their identification and authentication. Liquorice is characterized by long, cylindrical roots reaching up to 1 meter, with a brown outer surface and a pale to creamy yellow interior, exhibiting a tough, fibrous texture typical of herbaceous plants approximately 1 meter tall. Its compound leaves and clustered flowers ranging from purple to pale blue further differentiate it. In contrast, Ajwain is an evergreen shrub standing 1 to 4 meters tall, distinguished by its small, dark green, glossy leaves that are smooth and leathery, varying from flexible when fresh to brittle upon drying. Its simple leaf arrangement and small, white to pale yellow flowers add to its diagnostic features. Turmeric displays unique knobby, tuberous rhizomes measuring 10–20 cm, brown externally with a vivid yellow-orange inner core and a firm, waxy consistency when fresh. As a perennial herb about 1 meter in height, Turmeric also possesses large, lance-shaped leaves and pale yellow to purple cone-like flowers. These clear differences in primary parts used, color, size, texture, plant structure, floral characteristics, and leaf morphology are crucial for ensuring the proper identification and quality control of these medicinal plants in herbal formulations.

Microscopic examination of Liquorice, Ajwain, and Turmeric revealed distinctive cellular and tissue features essential for their identification and quality assessment. Liquorice roots exhibited prominent parenchyma cells interspersed with well-developed vascular tissues comprising xylem and phloem, reflecting a high lignin content that imparts structural rigidity. Numerous starch granules were observed within the parenchyma cells, alongside the presence of glycyrrhizin localized in these tissues, while the thin cuticle on the root surface lacked stomata and trichomes. In contrast, Ajwain leaves displayed characteristic epidermal cells with a pronounced waxy cuticle and abundant stomata, accompanied by multicellular trichomes distributed over the leaf surface. The mesophyll region was differentiated into palisade and spongy tissues, containing minimal starch granules and harboring catechins and tannins. Turmeric rhizomes were distinguished by large parenchyma cells densely packed with starch granules and a high lignin content within the cell walls, which together contribute to the rhizome's firm texture. Sparse trichomes were noted on the rhizome surface, while the associated leaves exhibited stomata and a protective waxy cuticle. Additionally, curcumin was predominantly located within the parenchyma cells of Turmeric. These microscopic findings underline the anatomical diversity among the three plants, supporting their correct identification and serving as markers for standardization in polyherbal formulations.

The phytochemical profiling of Liquorice (Glycyrrhiza glabra), Ajwain (Trachyspermum ammi), and Turmeric (Curcuma longa) revealed a diverse array of bioactive constituents that underline their traditional therapeutic uses and potential synergistic effects in polyherbal formulations. Liquorice demonstrated a rich phytochemical spectrum, notably containing alkaloids such as glycyrrhizin, alongside abundant flavonoids (liquiritin, isoliquiritin), saponins, tannins, terpenoids, phenols, triterpenoids, glycosides, proteins, carbohydrates, and minor essential oils, while lacking significant resin content. Ajwain was characterized by the presence of flavonoids, tannins, terpenoids, phenols, proteins, carbohydrates, and essential oils, notably rich in thymol and other aromatic compounds, with alkaloids, saponins, triterpenoids, and glycosides either absent or found only in trace amounts. In contrast, Turmeric exhibited a wide phytochemical profile encompassing alkaloids, flavonoids such as curcumin and its derivatives, saponins, tannins,

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terpenoids like turmerone and ar-turmerone, phenolic compounds, triterpenoids, proteins, carbohydrates, glycosides, resins, and essential oils, reflecting its well-documented medicinal versatility. This comprehensive phytochemical distribution not only confirms the individual therapeutic potentials of these plants but also supports their combined use in polyherbal formulations aimed at enhancing antioxidant, anti-inflammatory, and wound healing activities.

The pharmacognostic evaluation of Liquorice, Ajwain, and Turmeric highlighted notable differences in their physicochemical properties, which are critical for authentication, standardization, and ensuring the quality of herbal raw materials. Liquorice roots exhibited an ash value of 3–4%, reflecting moderate mineral content, along with a low saponification value typically negligible due to minimal fatty acids. Its moisture content ranged from 5–10%, crude fiber content was relatively high at 10–20% owing to its fibrous root structure, and it contained low total volatile matter (0.5–2%), consistent with its limited essential oil content. In contrast, Ajwain leaves showed a higher ash value (5–7%), indicating substantial inorganic residue, and a saponification value between 100–160, suggestive of moderate levels of fatty acids and essential oils. Ajwain also displayed a comparable moisture content (5–10%), a higher crude fiber content (15–20%) due to leaf morphology, total volatile matter around 1–2%, and an alcohol extractive value of 5–10%, confirming the presence of tannins and catechins. Turmeric rhizomes revealed an ash value of 5–7%, a notably high saponification value (200–250) attributable to their rich essential oil content, moisture levels similar to the other two plants (5–10%), lower crude fiber (8–10%), and the highest total volatile matter (3–5%), in line with its well-documented volatile compounds like turmerone. Its alcohol extractive value (5–8%) affirmed the presence of curcumin and related phytoconstituents. Collectively, these pharmacognostic parameters provide essential benchmarks for the identification, purity assessment, and quality control of these botanicals when incorporated into polyherbal formulations.

The antioxidant activities of Liquorice, Ajwain, Turmeric, and their polyherbal extract were assessed through DPPH and ABTS radical scavenging assays, along with estimation of total antioxidant capacity (TAC) expressed as mg ascorbic acid equivalents (AAE) per gram. The polyherbal extract demonstrated superior antioxidant potential across all assays compared to the individual plant extracts, suggesting possible synergistic interactions among their phytoconstituents. At 1.0 mg/mL, the polyherbal extract exhibited the highest DPPH ($55 \pm 4.00\%$) and ABTS ($65 \pm 4.50\%$) radical scavenging activities among the plant samples, accompanied by a notable TAC of 35 ± 2.50 mg AAE/g. Among individual plants, Ajwain consistently outperformed Liquorice and Turmeric, showing $50 \pm 3.50\%$ DPPH and $60 \pm 4.00\%$ ABTS scavenging activities, with a TAC of 28 ± 2.00 mg AAE/g at 1.0 mg/mL, likely attributable to its rich profile of flavonoids, tannins, and essential oils. Liquorice displayed moderate activity ($45 \pm 3.00\%$ DPPH, $55 \pm 3.50\%$ ABTS, TAC 25 ± 2.00 mg AAE/g), while Turmeric, although renowned for its curcumin content, showed comparatively lower values ($38 \pm 2.30\%$ DPPH, $48 \pm 2.80\%$ ABTS, TAC 22 ± 1.30 mg AAE/g), possibly due to solubility or extractability differences under the assay conditions. The standard ascorbic acid consistently exhibited the highest antioxidant effects across all concentrations, with $76 \pm 1.86\%$ DPPH, $89 \pm 2.83\%$ ABTS scavenging, and a TAC of 64.4 ± 1.06 mg AAE/g at 1.0 mg/mL. Overall, these findings confirm that while each plant possesses intrinsic antioxidant capacity, their combination into a polyherbal extract significantly enhances radical scavenging efficiency and total antioxidant capacity, underscoring the potential of such synergistic formulations in mitigating oxidative stress-related conditions.

The prepared polyherbal gel formulations (F1–F9) were comprehensively evaluated for their color, odor, viscosity, pH, and spreadability, which are critical parameters influencing their stability, application, and consumer acceptability. Color varied from white and opaque (F1, F3, F6), to yellowish or pale yellow tones (F2, F4, F5, F9), reflecting differences in polyherbal extract concentration and inherent phytoconstituents, while F7 and F8 displayed translucent and off-white appearances respectively, indicating good uniformity. The odor profile ranged from mild herbal (F1, F6, F8), earthy (F4, F9), floral (F5), to pleasant citrus and fruity notes (F2, F7), with F3 maintaining a neutral scent—suggesting successful masking of any undesirable raw extract odors, which is important for user compliance. Viscosity readings showed an increasing trend with higher extract concentration, with F4 and F8 exhibiting the highest viscosities (800–900 cps and 750–800 cps, respectively), indicating a thicker consistency that may prolong retention on the skin. In contrast, F5, with the lowest viscosity (500–550 cps), demonstrated excellent spreadability, making it particularly suitable for ease of application over larger surface areas. The pH values of all formulations ranged between 4.5 and 5.7,

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remaining close to the physiological pH of the skin, thereby minimizing the risk of irritation. Notably, F2, F5, and F8 were rated with excellent spreadability, balancing ease of application with desirable rheological properties. These collective results suggest that while all formulations maintained acceptable organoleptic and physicochemical profiles, F5 and F8 stood out as optimal candidates, combining appealing color and odor, skin-friendly pH, appropriate viscosity, and superior spreadability, making them promising for effective topical application.

Table 2: Macroscopically characteristics of Liquorice, Ajwain, and Turmeric

Characteristic	Liquorice	Ajwain	Turmeric
Primary Part Used	Roots	Leaves	Rhizomes
Root/Leaf/Plant Color	Brown outer, pale/creamy yellow inner	Dark green (leaves)	Brown outer, yellow-orange inner
Size	Roots: Long, cylindrical, up to 1 meter	Leaves: Small, glossy, shrub up to 3-4 meters tall	Rhizomes: Knobby, tuberous, 10-20 cm
Texture	Tough, fibrous roots; leafy plant	Smooth, leathery leaves; flexible to brittle	Firm, waxy rhizomes; dense when fresh
Plant Structure	Herbaceous, 1 meter tall	Evergreen shrub, 1–4 meters tall	Perennial herb, 1 meter tall
Flowers	Purple to pale blue, in clusters	Small, white to pale yellow	Pale yellow to purple, cone-like
Leaf Arrangement	Compound leaves, multiple leaflets	Simple, glossy leaves	Large, lance-shaped leaves

Table 3: Microscopically characteristics of Liquorice, Ajwain, and Turmeric

Characteristic	Liquorice	Ajwain	Turmeric
Primary Cells/Tissues	Parenchyma cells, xylem, phloem	Epidermal cells, stomata, mesophyll (palisade & spongy)	Parenchyma cells, vascular tissues (xylem & phloem)
Starch Presence	Starch granules in parenchyma cells	Minimal starch granules in mesophyll	Starch granules in rhizome cells
Lignin Content	High in xylem and phloem cells	Not significant	High in the cell walls of rhizomes
Trichomes (Hair-like structures)	Absent	Present (on leaf surface)	Present on the rhizome surface
Key Bioactive Compounds	Glycyrrhizin (in parenchyma cells)	Catechins, tannins (in mesophyll)	Curcumin (in parenchyma cells)
Stomata	Absent (root structure)	Present (on leaf epidermis)	Present (on leaf epidermis)
Cuticle	Thin cuticle on root surface	Waxy cuticle on leaf surface	Waxy cuticle on leaf surface

Table 4: Phytochemical evaluation

Phytochemical	Liquorice (Glycyrrhiza glabra)	Ajwain (Trachyspermum ammi)	Turmeric (Curcuma longa)
Alkaloids	Present (e.g., Glycyrrhizin)	Absent or in trace amounts	Present
Flavonoids	Present (e.g., Liquiritin, Isoliquiritin)	Present	Present (e.g., Curcumin, Demethoxycurcumin)
Saponins	Present (e.g., Glycyrrhizin, Glycyrrhizic acid)	Absent or in trace amounts	Present (e.g., Sapogenins)
Tannins	Present (e.g., Glycyrrhizic acid, Flavonoids)	Present	Present (e.g., Curcumin and other polyphenols)
Terpenoids	Present (e.g., β-sitosterol,	Present	Present (e.g., Turmerone, Ar-

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	Lupeol)		turmerone)
Phenols	Present (e.g., Flavonoids, Glycyrrhizic acid)	Present	Present (e.g., Curcumin, Phenolic acids)
Triterpenoids	Present (e.g., Glycyrrhizic acid)	Absent or in trace amounts	Present (e.g., Beta-sitosterol)
Proteins	Present (e.g., Glycoproteins)	Present (e.g., Tea proteins)	Present (e.g., Curcuma proteins)
Carbohydrates	Present (e.g., Starch, Polysaccharides)	Present	Present (e.g., Starch, Polysaccharides)
Glycosides	Present (e.g., Glycyrrhizin, Flavonoid glycosides)	Absent	Present (e.g., Curcumin glycosides)
Resins	Absent	Absent	Present (in small amounts)
Essential Oils	Absent or minimal	Present	Present (e.g., Turmerone, Aromatic compounds)

Table 5: Pharmacognostic parameters

Characteristic	Liquorice (Glycyrrhiza glabra)	Ajwain (Trachyspermum ammi)	Turmeric (Curcuma longa)
Ash Value	3-4% (indicative of the mineral content in the root)	5-7% (indicative of the mineral content in the leaves)	5-7% (indicative of the mineral content in the rhizomes)
Saponification Value	N/A (typically not a major feature in liquorice)	100-160 (indicative of the amount of fatty acids and oils)	200-250 (higher due to essential oils in the rhizomes)
Moisture Content	5-10% (depends on the preparation and drying method)	5-10% (dry leaf content)	5-10% (dry rhizome content)
Total Volatile Matter	0.5-2% (low due to lower volatile oil content in roots)	1-2% (due to volatile oils in the leaves)	3-5% (due to volatile oils like turmerone)
Alcohol Extract	5-10% (indicating presence of soluble compounds like flavonoids and glycyrrhizin)	5-10% (indicating presence of catechins and tannins)	5-8% (curcumin and other bioactive compounds)
Crude Fiber	10-20% (due to the fibrous nature of the root)	15-20% (due to leaf structure)	8-10% (due to fibrous nature of the rhizomes)

Table 6: In Vitro Antioxidant Activity

Sample	Concentration (mg/mL)	DPPH Radical Scavenging (%)	ABTS Radical Scavenging (%)	Total Antioxidant Capacity (mg AAE/g)
Liquorice (Glycyrrhiza glabra)	0.1	25 ± 2.00	35 ± 2.50	18 ± 1.20
	0.5	35 ± 2.50	45 ± 3.00	22 ± 1.50
	1.0	45 ± 3.00	55 ± 3.50	25 ± 2.00
Ajwain (Trachyspermum ammi)	0.1	30 ± 2.50	40 ± 3.00	20 ± 1.50
	0.5	40 ± 3.00	50 ± 3.50	24 ± 1.80
	1.0	50 ± 3.50	60 ± 4.00	28 ± 2.00
Turmeric (Curcuma longa)	0.1	18 ± 1.20	28 ± 1.80	14 ± 0.90
	0.5	28 ± 1.80	38 ± 2.30	18 ± 1.10
	1.0	38 ± 2.30	48 ± 2.80	22 ± 1.30
Polyherbal extract	0.1	35 ± 3.00	45 ± 3.50	25 ± 2.00

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	0.5	45 ± 3.50	55 ± 4.00	30 ± 2.20
	1.0	55 ± 4.00	65 ± 4.50	35 ± 2.50
Ascorbic acid	0.1	42 ± 2.93	56 ± 3.14	32.5 ± 1.18
	0.5	63 ± 1.76	76 ± 1.02	52.6 ± 2.07
	1.0	76 ± 1.86	89 ± 2.83	64.4 ± 1.06

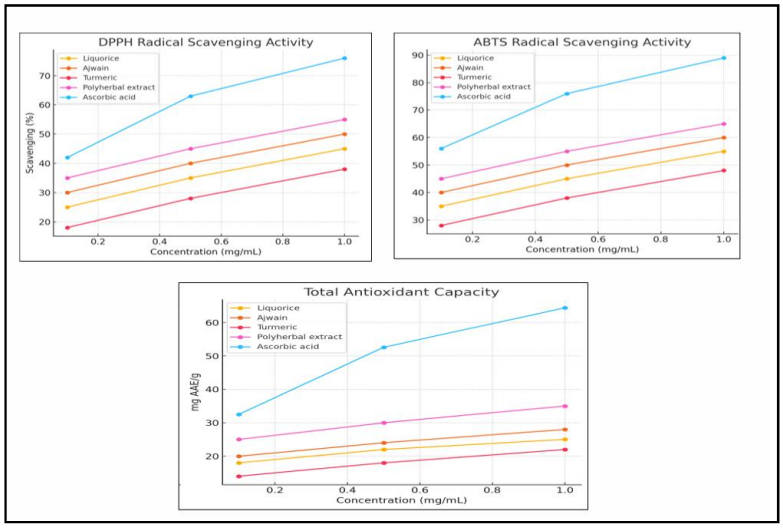

Fig 1: In Vitro Antioxidant Activity

Table 7: Evaluation of herbal gel

Formulation	Color	Smell	Viscosity (cps)	pH	Spreadability
F1	White, opaque	Mild herbal scent	500–600	5.0–5.5	Smooth, moderate
F2	Yellowish, translucent	Light citrus scent	600–700	4.8–5.2	Excellent spreadability
F3	White, opaque	Neutral scent	700–800	5.0–5.5	Smooth, thick
F4	Slightly yellow	Herbal, earthy scent	800–900	5.2–5.7	Smooth, moderate
F5	Pale yellow, opaque	Slight floral scent	500–550	4.5–5.0	Excellent spreadability
F6	White, opaque	Subtle herbal scent	600–650	5.0–5.5	Moderate, smooth
F7	Translucent white	Fruity scent	550–600	4.8–5.3	Smooth, moderate
F8	Opaque, off-white	Light, herbal scent	750–800	5.2–5.7	Excellent spreadability
F9	Yellowish, opaque	Earthy, herbal scent	600–700	4.9–5.3	Good spreadability

IV. CONCLUSION

The present study successfully established a comprehensive pharmacognostic and phytochemical profile of Liquorice, Ajwain, and Turmeric, ensuring their quality and authenticity for medicinal use. The detailed macro- and microscopic examinations, along with physicochemical analyses, confirmed the diagnostic features and compliance with pharmacopeial standards. Phytochemical investigations highlighted the rich spectrum of bioactive compounds inherent in these plants, correlating with their traditional therapeutic claims. Antioxidant assays demonstrated that the combination of these extracts in a polyherbal system produced superior free radical scavenging and total antioxidant capacities compared to individual extracts, indicating synergistic interactions. The formulated polyherbal gels exhibited favorable physicochemical properties, including acceptable pH, viscosity, and excellent spreadability in select formulations (notably F5 and F8), making them suitable for dermal application. This work underscores the importance

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of integrating pharmacognostic, phytochemical, and formulation studies in the development of effective herbal therapeutics. The findings collectively support the potential of the developed polyherbal gel as a promising candidate for managing oxidative stress-related skin conditions, warranting further in vivo studies and clinical validation.

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