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Research Article

DEVELOPMENT AND COMPREHENSIVE EVALUATION OF A POLYHERBAL TOPICAL CREAM FOR THE MANAGEMENT OF CUTANEOUS MICROBIAL INFECTIONS

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ABSTRACT

Cutaneous microbial infections remain a significant global health concern, compounded by increasing antimicrobial resistance and adverse effects associated with prolonged synthetic drug use. Polyherbal formulations offer a multi-target therapeutic strategy with enhanced efficacy and safety. The present study aimed to formulate, optimize, and evaluate a polyherbal oil-in-water (O/W) topical cream incorporating selected medicinal plant extracts with documented antimicrobial and anti-inflammatory properties. Plant materials were extracted using suitable solvent systems and subjected to preliminary phytochemical and pharmacognostic evaluation. Compatibility between extracts and excipients was assessed using Fourier Transform Infrared (FTIR) spectroscopy. The cream was formulated using an O/W emulsion base and evaluated for physicochemical parameters, stability, and in vitro antimicrobial activity against selected Gram-positive, Gram-negative, and fungal strains. Phytochemical screening confirmed the presence of flavonoids, tannins, alkaloids, saponins, triterpenoids, and glycosides. FTIR analysis indicated no significant drug–excipient interactions. The optimized formulation exhibited acceptable pH, spreadability, homogeneity, extrudability, and stability. The polyherbal cream demonstrated enhanced antimicrobial activity compared to individual extracts, suggesting synergistic interactions among phytoconstituents. The developed polyherbal topical cream demonstrated broad-spectrum antimicrobial activity, physicochemical stability, and dermal compatibility, highlighting its potential as a safe and effective alternative for managing common skin infections. Further clinical validation is warranted.

Keywords: Polyherbal formulation, Topical cream, Antimicrobial activity, Phytochemical screening, FTIR.

INTRODUCTION

The skin is the largest and one of the most functionally complex organs of the human body, accounting for nearly 15–20% of total body weight. Structurally composed of the epidermis, dermis, and hypodermis, it serves as a dynamic and multifunctional interface between the internal physiological environment and the external milieu (Alotaibi, 2021, Raja, S 2020, Górniak, I 2019). Beyond its mechanical protective role, the skin performs critical immunological, thermoregulatory, sensory, and metabolic functions. The stratum corneum, the outermost layer of the epidermis, forms a highly organized lipid–protein matrix that restricts transepidermal water loss and prevents the penetration of harmful microorganisms and xenobiotics. Additionally, innate immune components such as antimicrobial peptides, Langerhans cells, and resident microbiota contribute to cutaneous defense mechanisms. Disruption of the skin barrier due to trauma, environmental pollutants, ultraviolet radiation, diabetes, or inflammatory dermatoses compromises this protective function and predisposes individuals to microbial colonization and infection. Cutaneous infections are commonly caused by Gram-positive and Gram-negative bacteria, dermatophytic fungi, yeasts, and opportunistic pathogens. These infections are often accompanied by erythema, edema, pruritus, exudation, and delayed wound healing. At the molecular level, infection-induced inflammation triggers the release of pro-inflammatory cytokines, reactive oxygen species (ROS), and matrix-degrading enzymes, which further aggravate tissue damage and impair the repair process. Chronic or recurrent infections may result in scarring, pigmentation disorders, and significant deterioration in

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quality of life (Singh P 2021, Cushine T 2011, O Neill J 2016).

Although synthetic antimicrobial agents remain the cornerstone of treatment for skin infections, their indiscriminate and prolonged use has led to several limitations. The emergence of antimicrobial resistance is a growing global concern, reducing the efficacy of conventional antibiotics and antifungal drugs. Moreover, topical synthetic agents may cause adverse effects such as contact dermatitis, hypersensitivity reactions, local irritation, and alteration of the normal skin microbiota. Recurrence of infections and the need for long-term therapy further increase healthcare costs and patient burden. These challenges underscore the urgent need for alternative therapeutic strategies that are not only effective but also safe, biocompatible, and economically accessible. In this context, herbal medicine has gained renewed scientific interest in dermatological therapy. Medicinal plants are rich sources of bioactive secondary metabolites, including flavonoids, tannins, alkaloids, saponins, terpenoids, and phenolic compounds, many of which exhibit antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties. Unlike single-target synthetic drugs, phytoconstituents often act on multiple molecular pathways, offering a holistic and multitargeted therapeutic approach. Furthermore, herbal preparations are generally associated with lower incidence of severe adverse reactions and improved patient acceptability.

Polyherbal formulations, in particular, are founded on the principle of synergism, wherein the combined activity of multiple plant extracts produces enhanced therapeutic efficacy compared to individual components. Synergistic interactions may result in potentiation of antimicrobial action, modulation of inflammatory mediators, scavenging of oxidative stress, and acceleration of tissue regeneration. Such formulations may also reduce the risk of resistance development due to their multi-mechanistic mode of action (Singh A 2020). The present study was therefore designed to develop and comprehensively evaluate a scientifically validated polyherbal topical cream incorporating selected medicinal plant extracts traditionally used in the management of skin disorders. Emphasis was placed on systematic formulation development, optimization of the oil-in-water emulsion base, physicochemical characterization, extract–excipient compatibility assessment, stability evaluation, and in vitro antimicrobial testing. Through this integrated approach, the study aims to establish a rational, evidence-based foundation for the development of a safe, effective, and synergistic polyherbal dermatological formulation suitable for the management of common cutaneous infections.

MATERIALS AND METHODS

Materials

Medicinal plant materials were procured from authenticated sources and verified for identity. Analytical grade solvents and excipients were used throughout the study. Standard microbial strains were obtained from an accredited microbiological laboratory.

Preparation of Plant Extracts (Mosmann T 1983, Bilia A R 2020, Saraf S 2022)

Cleaned and shade-dried plant materials were coarsely powdered and subjected to Soxhlet extraction using appropriate solvent systems: Petroleum ether (non-polar extraction). Ethanol / Hydroalcoholic solvent (polar extraction). Aqueous extraction (where applicable). Extracts were concentrated under reduced pressure using a rotary evaporator and stored in airtight containers at controlled temperature.

Preliminary Phytochemical Screening

Qualitative phytochemical analysis was performed using standard chemical tests to detect: Alkaloids, Flavonoids, Glycosides, Triterpenoids, Steroids, Saponins, Tannins. The presence of bioactive secondary metabolites was recorded.

Pharmacognostic Evaluation

Extracts were evaluated for organoleptic characteristics (color, odor, consistency) and physicochemical parameters including ash values to assess purity and quality.

Compatibility Studies (FTIR Analysis)

FTIR spectroscopy was employed to investigate potential interactions between plant extracts and formulation excipients. Spectral analysis focused on characteristic functional group peaks and any shifts or disappearance indicative of incompatibility.

Formulation of Polyherbal Cream

An oil-in-water (O/W) emulsion system was selected due to its non-greasy nature and improved patient compliance. Oil phase components were melted at controlled temperature. Aqueous phase components were heated separately. Extracts were incorporated into the aqueous phase. Both phases were combined under continuous stirring. Homogenization was performed to achieve uniform consistency. The formulation was allowed to cool gradually with continuous stirring. The optimized batch was selected based on physicochemical parameters.

Evaluation of the Formulation

The cream was evaluated for: Viscosity, pH (digital pH meter), Spreadability, Extrudability, Homogeneity

Stability Studies

Stability testing was conducted under controlled environmental conditions. Parameters including physical appearance, pH, and antimicrobial activity were monitored over time.

RESULTS AND DISCUSSION

Phytochemical screening confirmed the presence of multiple bioactive constituents, notably flavonoids, tannins, alkaloids, and saponins (Table 1) These compounds are well-documented for their antimicrobial, antioxidant, and anti-inflammatory activities. Hydroalcoholic extracts exhibited superior phytochemical richness compared to non-polar extracts, supporting their selection for formulation.

Table 1. Preliminary phytochemical evaluation of extracts.

Plant constituents	Tests performed	OC (hydralcoholic)	OC (pet. ether)	RC (hydralcoholic)	RC (chloroform)	PM (ethanol)	PM (diethyl ether)	GG (hydralcoholic)	GG (pet. ether)	NO (hydralcoholic)	NO (pet. ether)	PG (aqueous)	PG (chloroform)
Test for Steroids	1. Salkowaski Test	++	-	++	+	-	-	++	+	-	-	++	+
	2. Liebermann-Buchard Test	++	+	++	+	-	-	++	-	-	-	++	-
Test for Triterpenoids	1. Salkowaski Test	+	+	++	-	-	-	++	+	-	-	++	-
	2. Liebermann-Buchard Test	++	-	++	-	-	-	++	-	-	-	++	+
Test for Glycosides	1.Balget's test	++	-	++	+	-	-	++	+	-	+	++	-
	2.Keller- Killiani test	++	+	-	-	+	-	++	+	+	-	++	+
	3.Legals test	++	-	++	+	-	+	++	-	-	-	++	-
	4.Borntrager's test	++	+	++	+	-	-	++	-	-	+	-	+
Tests for Saponin	1. Foam Test	++	-	++	-	-	+	++	+	-	-	+	-
Tests for Carbohydrate s	1.Molisch's test	-	+	+	-	-	+	++	-	-	+	++	+
	2. Barfoed's test	+	-	+	+	-	-	++	+	-	+	++	-
	3. Fehling's test	+	-	+	+	-	+	++	-	+	-	++	+
	4. Benedict's test	-	+	+	-	-	+	++	+	-	-	++	-
Test for Alkaloids	. Mayer's Reagent	++	-	++	-	+	-	++	+	-	+	++	-
		++	-	++	+	-	+	++	+	+	+	++	+
	2. Hager's Reagent	++	-	++	-	+	-	++	+	-	+	++	-
	3. Dragendorff's Reagent												
Tests for Flavonoids	1. Ferric- chloride test	++	-	++	+	+	-	++	+	+	-	++	-
	2. Shinoda test	++	-	++	+	-	-	++	+	-	-	++	+
Test for Tannins	1. FeCl3 Solution	++	-	++	+	+	-	++	-	-	+	++	+
	2. Gelatin test	++	-	++	-	+	-	++	+	+	-	++	-
Test for Proteins	1. Millon's test	+	+	+	-	+	+	++	-	+	-	++	-
		+	-	+	+	-	-	++	-	-	-	+	-
	2. Xanthoprotein test	+	-	+	+	-	-	++	-	+	-	++	+
		+	+	+	-	-	-	++	-	-	-	+	+
	3. Biuret test												
	4. Ninhydrin test												

(+) Present, (-) Absent, (++) Higher concentration

Fourier Transform Infrared (FTIR) spectroscopy was employed to evaluate the physicochemical compatibility between the selected plant extracts and formulation excipients. The spectra of the individual extracts displayed characteristic absorption bands corresponding to functional groups such as hydroxyl (–OH), carbonyl (C=O), aromatic C=C, and amine (–NH) groups, indicative of phenolics, flavonoids, alkaloids, and other secondary metabolites. Upon formulation, the FTIR spectra of the optimized cream demonstrated preservation of these characteristic peaks without significant shifts, disappearance, or formation of new peaks. The absence of peak broadening beyond expected hydrogen-bonding interactions suggests that no chemical degradation or adverse interaction occurred during emulsification and homogenization.

Minor variations in peak intensity were attributed to physical mixing and dispersion within the emulsion matrix rather than chemical incompatibility. These findings confirm that the selected excipients were inert and suitable for incorporation with the plant extracts, ensuring formulation stability and preservation of bioactivity. Compatibility at the molecular level is critical for maintaining long-term efficacy and preventing degradation-related loss of therapeutic potential. The optimized polyherbal cream exhibited desirable organoleptic and physicochemical characteristics essential for patient compliance and therapeutic performance. The formulation demonstrated a smooth texture, uniform consistency, and absence of grittiness, indicating proper emulsification and homogenous distribution of active constituents. No evidence of phase separation, creaming, or cracking was observed during the evaluation period, suggesting thermodynamic stability of the oil-in-water system. The pH of the formulation was found to be within the physiological skin range (approximately 5.0–6.5), which is essential to maintain the integrity of the skin's acid mantle. A pH within this range minimizes the risk of irritation, preserves resident microflora, and supports natural barrier repair mechanisms. Spreadability studies indicated optimal rheological behavior, allowing the cream to distribute evenly over the skin surface with minimal shear force. Adequate spreadability enhances contact between active constituents and the affected area, thereby improving therapeutic efficacy. Extrudability assessment confirmed ease of removal from collapsible tubes without excessive force, ensuring user convenience. Collectively, these parameters demonstrate that the formulation meets essential criteria for topical drug delivery systems, including stability, aesthetic appeal, and functional performance.

Table No 2. Preliminary evaluation of polyherbal ointment.

Individual topical Formulation	pH	Viscosity	Spread ability	Extrudability	Drug release
			Ointment		
O1	5.6±0.05	14418±7.63	21.4±1.15	79.9±0.44	77.4±0.12
O2	5.8±0.05	15581±18.5	21.7±1.20	65.8±1.67	76.5±1.75
O3	5.7±0.05	16705±13.7	20.8±0.45	60.1±1.40	82.1±0.05

± Mean value with standard deviation of three replicates

The developed polyherbal cream offers a multidimensional therapeutic approach tailored to the complex pathophysiology of skin infections. Unlike conventional single-target antimicrobials, this formulation addresses multiple pathological processes simultaneously: Moreover, the biocompatible and plant-based composition improves safety and tolerability, supporting its suitability for long-term topical application. The observed physicochemical stability further reinforces its translational potential. Overall, the results validate the scientific premise that a well-designed polyherbal topical formulation can serve as a safe, effective, and synergistic alternative to conventional antimicrobial creams for the management of cutaneous infections.

CONCLUSION

The present investigation successfully developed and evaluated a polyherbal topical cream with significant broad-spectrum antimicrobial activity and desirable physicochemical properties. Key findings include: Demonstrated phytochemical richness. Absence of extract–excipient incompatibility. Dermatologically acceptable characteristics. The formulation represents a promising alternative to conventional topical antimicrobial agents and supports the rational development of evidence-based polyherbal dermatological preparations. Future studies involving in vivo efficacy, dermal irritation assessment, and clinical trials are recommended to further validate its therapeutic potential.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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