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Formulation and Evaluation of Polyherbal Moisturizing Cream

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Abstract: *The developed polyherbal moisturizing cream containing hydroalcoholic extracts of Carica papaya, Aloe barbadensis, and Azadirachta indica demonstrated satisfactory physicochemical quality and formulation performance. The crude drugs exhibited acceptable moisture content, ash values, extractive values, and phytochemical constituents, confirming their purity and suitability for formulation. Preliminary phytochemical screening revealed the presence of bioactive compounds such as flavonoids, phenolics, tannins, alkaloids, terpenoids, glycosides, and saponins, supporting the antioxidant, antimicrobial, anti-inflammatory, and moisturizing potential of the selected herbal extracts. Among the nine prepared formulations (F1–F9), all showed acceptable organoleptic properties, skin-compatible pH (5.68–6.27), suitable spreadability, viscosity, extrudability, washability, and stable oil-in-water emulsion characteristics. Formulation F6 demonstrated the best overall performance, exhibiting optimum pH (6.27), highest spreadability (7.02 g•cm/s), maximum viscosity (17,640 cP), excellent extrudability (535 g/cm²), and superior cosmetic acceptability. Stability studies conducted over three months confirmed the physical and chemical stability of all formulations without phase separation or significant changes in appearance, odor, texture, or pH, with F6 showing the least variation during storage. These findings indicate that the synergistic combination of Papaya, Aloe vera, and Neem extracts successfully produced a stable, skin-compatible, and cosmetically acceptable herbal moisturizing cream, identifying formulation F6 as the optimized formulation with promising potential for routine skin care applications.*

Keywords: Polyherbal cream, Moisturizing cream, Carica papaya, Aloe barbadensis, Azadirachta indica, Herbal cosmetics, Skin hydration, Topical formulation.

I. INTRODUCTION

The skin is the largest organ of the human body and serves as the primary protective barrier against physical, chemical, microbial, and environmental insults. Besides providing mechanical protection, the skin plays essential roles in thermoregulation, immune defense, sensory perception, and maintenance of body fluid balance. Continuous exposure to ultraviolet (UV) radiation, environmental pollutants, harsh climatic conditions, and chemical irritants accelerates skin dehydration, oxidative stress, inflammation, and premature aging. These factors impair the integrity of the epidermal barrier, leading to dryness, roughness, irritation, reduced elasticity, and increased susceptibility to various dermatological disorders. Consequently, maintaining adequate skin hydration through the regular use of moisturizers has become an important aspect of preventive skincare and dermatological therapy.[1,2]

Moisturizers are topical formulations specifically designed to restore and maintain the water content of the stratum corneum, the outermost layer of the skin. They improve skin softness, elasticity, and barrier function while reducing transepidermal water loss (TEWL). Conventional moisturizing creams generally contain synthetic emollients, humectants, preservatives, fragrances, and stabilizers that effectively hydrate the skin. However, prolonged use of products containing synthetic ingredients may cause allergic reactions, irritation, contact dermatitis, and other adverse effects in sensitive individuals. Growing consumer awareness regarding the safety of cosmetic ingredients, together with increasing demand for environmentally sustainable products, has significantly shifted the global skincare market toward herbal and naturally derived cosmetic formulations.[3,4]

Herbal cosmetics have gained remarkable attention because they combine the aesthetic benefits of cosmetics with the therapeutic properties of medicinal plants. Plant-derived phytochemicals, including flavonoids, phenolic compounds, tannins, alkaloids, terpenoids, glycosides, saponins, vitamins, and polysaccharides, exhibit antioxidant, anti-inflammatory, antimicrobial, wound-healing, and skin-protective activities. These bioactive constituents help neutralize reactive oxygen species generated by ultraviolet radiation and environmental pollutants, thereby minimizing oxidative damage to cellular proteins, lipids, and DNA. Consequently, herbal formulations are increasingly preferred due to their biocompatibility, lower incidence of adverse effects, and ability to provide multifunctional skincare benefits.[4,5]

Among medicinal plants widely used in dermatological preparations, **Carica papaya** (Papaya) occupies an important position because of its rich phytochemical composition and traditional medicinal value. Papaya leaves and fruit contain flavonoids, phenolic acids, alkaloids, carotenoids, vitamins A, C, and E, papain enzyme, and various antioxidant compounds. These constituents exhibit potent free-radical scavenging activity, promote collagen synthesis, facilitate removal of damaged epidermal cells, and accelerate tissue regeneration. The proteolytic enzyme papain gently exfoliates dead skin cells, thereby improving skin smoothness and enhancing the penetration of beneficial phytochemicals into the epidermis. Owing to these properties, papaya has been extensively investigated for skin rejuvenation, wound healing, pigmentation disorders, and anti-aging applications.[6]

Aloe barbadensis Miller (Aloe vera) is another highly valued medicinal plant recognized worldwide for its moisturizing and wound-healing properties. Aloe vera gel contains more than 75 biologically active constituents, including polysaccharides (particularly acemannan), amino acids, vitamins, enzymes, minerals, glycoproteins, sterols, and phenolic compounds. The polysaccharides present in Aloe vera possess exceptional water-retaining capacity, enabling prolonged hydration of the stratum corneum. Additionally, Aloe vera stimulates fibroblast proliferation, collagen synthesis, angiogenesis, and epithelial regeneration, thereby promoting wound repair and maintaining skin elasticity. Its anti-inflammatory, antioxidant, antimicrobial, and immunomodulatory properties further enhance its usefulness in cosmetic and pharmaceutical formulations intended for dry, irritated, or damaged skin.

Azadirachta indica (Neem) is widely recognized in traditional Ayurvedic medicine for its broad spectrum of pharmacological activities. Different parts of the neem plant contain numerous bioactive compounds, including azadirachtin, nimbin, nimbolide, quercetin, flavonoids, limonoids, tannins, and essential oils. These phytoconstituents exhibit potent antimicrobial, antifungal, antibacterial, antioxidant, anti-inflammatory, and antiseptic activities. Neem effectively inhibits the growth of pathogenic microorganisms commonly associated with skin infections while simultaneously reducing inflammatory responses and oxidative damage. These properties make neem an excellent herbal ingredient for skincare products intended to protect the skin from microbial contamination while maintaining healthy skin physiology.[7,8]

The therapeutic effectiveness of polyherbal formulations is based on the principle of phytochemical synergy, whereby multiple medicinal plants contribute complementary mechanisms of action that collectively produce superior therapeutic efficacy compared with individual plant extracts. Combining papaya, Aloe vera, and neem provides a broad spectrum of biologically active compounds capable of simultaneously moisturizing the skin, enhancing antioxidant defense, reducing inflammation, preventing microbial growth, promoting tissue repair, and improving overall skin health. Such synergistic interactions may also permit lower concentrations of individual extracts while maintaining or enhancing biological activity, thereby improving product safety and cosmetic acceptability.[9,10]

Successful development of a topical herbal cream requires careful optimization of formulation variables to ensure desirable physicochemical characteristics and user acceptability. Parameters such as pH, viscosity, spreadability,

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extrudability, homogeneity, washability, emulsion type, and storage stability significantly influence product performance, patient compliance, and shelf life. A formulation with skin-compatible pH minimizes irritation, whereas optimum viscosity and spreadability ensure uniform application and prolonged residence time on the skin surface. Stability studies further confirm the ability of the formulation to retain its physical appearance, consistency, and therapeutic properties during storage.[11]

Although numerous herbal creams containing individual medicinal plant extracts have been reported, comparatively fewer studies have explored the synergistic combination of **Carica papaya**, **Aloe vera**, and **Azadirachta indica** in a single moisturizing cream. Moreover, comprehensive evaluation of physicochemical properties, phytochemical composition, formulation characteristics, organoleptic attributes, and storage stability remains limited. Developing a stable polyherbal cream containing these three medicinal plants may provide a natural, effective, and cosmetically acceptable alternative to synthetic moisturizing products while offering additional antioxidant, antimicrobial, and anti-inflammatory benefits.[12]

Therefore, the present study was undertaken to formulate and evaluate a polyherbal moisturizing cream incorporating hydroalcoholic extracts of **Carica papaya**, **Aloe barbadensis**, and **Azadirachta indica**. The selected medicinal plants were subjected to physicochemical standardization and preliminary phytochemical screening, followed by preparation of multiple cream formulations using an oil-in-water emulsion system. The prepared formulations were evaluated for pH, spreadability, viscosity, extrudability, washability, emulsion type, organoleptic characteristics, and stability in order to identify an optimized formulation suitable for topical skincare applications. The findings of this investigation may contribute to the development of scientifically validated herbal cosmetic products possessing enhanced efficacy, safety, and consumer acceptability.

II. MATERIALS AND METHODS

Plant Materials

Fresh leaves of **Papaya (*Carica papaya*)**, **Neem (*Azadirachta indica*)**, and fresh **Aloe vera (*Aloe barbadensis*)** gel were collected from the local medicinal plant garden and authenticated by a qualified botanist. The collected plant materials were washed thoroughly with distilled water to remove dust and other foreign matter. Papaya and Neem leaves were shade-dried at room temperature (25–30°C) for 7–10 days until a constant weight was achieved and then pulverized into coarse powder using a mechanical grinder. Fresh Aloe vera leaves were washed, the outer rind was removed, and the inner gel was collected and homogenized before extraction.

Chemicals and Reagents

Stearic acid, cetyl alcohol, beeswax, liquid paraffin, glycerin, triethanolamine, methyl paraben, propyl paraben, ethanol, methanol, ferric chloride, Dragendorff's reagent, Mayer's reagent, Wagner's reagent, hydrochloric acid, sulfuric acid, sodium hydroxide, and other analytical-grade chemicals were procured from standard chemical suppliers. Distilled water was used throughout the study.

Preparation of Hydroalcoholic Extracts

The powdered Papaya and Neem leaves and freshly homogenized Aloe vera gel were extracted separately using a hydroalcoholic solvent (ethanol:water, 70:30 v/v) by the maceration method. Approximately 100 g of each plant material was soaked in 500 mL of hydroalcoholic solvent for 72 h with intermittent shaking. The extracts were filtered through Whatman No. 1 filter paper, and the filtrates were concentrated under reduced pressure using a rotary evaporator followed by drying in a water bath below 45°C. The dried extracts were weighed to determine percentage yield and stored in airtight containers at 4°C until further use.

Physicochemical Evaluation of Crude Drugs

The crude powdered drugs were evaluated according to WHO guidelines. The parameters evaluated included loss on drying, total ash, acid-insoluble ash, water-soluble ash, water extractive value, and ethanol extractive value. All determinations were performed in triplicate, and the results were expressed as mean ± standard deviation.

Preliminary Phytochemical Screening

The hydroalcoholic extracts were subjected to qualitative phytochemical analysis using standard procedures to detect alkaloids, flavonoids, phenolics, tannins, glycosides, terpenoids, saponins, steroids, proteins, and carbohydrates. Colour development or precipitate formation after the addition of specific reagents was considered evidence for the presence of the respective phytoconstituents.

Formulation of Polyherbal Moisturizing Cream

Nine formulations (F1–F9) of polyherbal moisturizing cream were prepared using the oil-in-water emulsion method. The oil phase consisting of stearic acid, cetyl alcohol, beeswax, and liquid paraffin was heated to 70–75°C until completely melted. The aqueous phase containing purified water, glycerin, triethanolamine, methyl paraben, and propyl paraben was heated separately to the same temperature. The hydroalcoholic extracts of Papaya, Aloe vera, and Neem were incorporated into the aqueous phase under continuous stirring. The hot aqueous phase was gradually added to the oil phase with continuous mechanical stirring until a homogeneous emulsion was formed. The cream was allowed to cool while stirring continuously, and rose water was added near room temperature. The final cream was transferred into clean, airtight containers for evaluation.

Organoleptic Evaluation

All formulations were evaluated visually for colour, odour, appearance, texture, and homogeneity. Homogeneity was assessed by gently rubbing a small quantity of cream between the fingers to observe the presence of lumps or coarse particles.

Determination of pH

The pH of each formulation was determined using a calibrated digital pH meter. One gram of cream was dispersed in 10 mL of distilled water and allowed to stand for 30 min before measurement. The readings were recorded in triplicate.

Spreadability

Spreadability was determined using the parallel plate method. A fixed quantity of cream was placed between two glass slides, and a standard weight was applied for a specified time. Spreadability was calculated using the equation:

$$\mathbf{S = (M \times L) / T}$$

where S is spreadability, M is the applied weight (g), L is the length moved by the upper slide (cm), and T is the time (s).

Viscosity

The viscosity of each formulation was measured using a Brookfield digital viscometer fitted with an appropriate spindle at room temperature (25 ± 2°C). Measurements were performed at a constant rotational speed, and the viscosity was expressed in centipoise (cP).

Washability

Washability was evaluated by applying a small amount of cream onto the skin and washing it with running tap water. The ease of removal was graded qualitatively as good, very good, or excellent.

Extrudability

Extrudability was determined by filling the formulations into collapsible aluminium tubes. The force required to extrude the cream through the tube orifice was measured and expressed as g/cm². Smooth and uniform extrusion indicated good extrudability.

Determination of Emulsion Type

The emulsion type was confirmed using the dye test. A water-soluble dye was mixed with a small quantity of cream and observed under a microscope. Uniform distribution of the dye indicated an oil-in-water (O/W) emulsion.

Stability Study

The optimized and prepared formulations were stored in tightly closed containers at room temperature (25 ± 2°C) for three months. The formulations were periodically evaluated for changes in appearance, colour, odour, phase separation, and pH. Stability was assessed based on the absence of physical changes and maintenance of acceptable physicochemical characteristics throughout the storage period.

Statistical Analysis

All experimental measurements were performed in triplicate, and the results were expressed as **mean ± standard deviation (Mean ± SD)**. The data were analyzed descriptively to compare the performance of different formulations and to identify the optimized formulation based on physicochemical characteristics and stability.[13-15]

III. RESULT AND DISCUSSION

Physicochemical Characteristics, Extract Yield and Preliminary Phytochemical Screening of Selected Medicinal Plants

The physicochemical evaluation of *Carica papaya*, *Aloe vera*, and *Azadirachta indica* confirmed that all three medicinal plants possessed acceptable quality parameters suitable for herbal formulation development. The loss on drying values (6.80–8.20%) indicated low moisture content, reducing the possibility of microbial growth and improving storage stability. Total ash values ranged from 8.40% to 10.30%, reflecting the normal inorganic mineral content of the plant materials, whereas the low acid-insoluble ash values (0.82–1.40%) indicated minimal contamination with silica or earthy matter, confirming the purity of the crude drugs. Aloe vera exhibited the highest water-soluble ash and extractive values, demonstrating a greater abundance of water-soluble phytoconstituents such as polysaccharides, glycoproteins, phenolics, and flavonoids. Similarly, Aloe vera produced the highest hydroalcoholic extract yield (23.80%), followed by Papaya (18.50%) and Neem (16.90%), indicating superior extraction efficiency. Preliminary phytochemical screening revealed the presence of several bioactive metabolites, including alkaloids, flavonoids, phenolics, tannins, terpenoids, glycosides, saponins, steroids, proteins, and carbohydrates. Neem was particularly rich in phenolics, flavonoids, and tannins, suggesting strong antioxidant and antimicrobial activity, whereas Aloe vera contained abundant terpenoids and carbohydrates associated with moisturizing, wound healing, and skin hydration. The complementary phytochemical composition of the three plant extracts supports their synergistic use in the development of a polyherbal moisturizing cream with enhanced antioxidant, anti-inflammatory, antimicrobial, and skin-protective properties.

Table 1. Physicochemical Characteristics, Extract Yield and Preliminary Phytochemical Screening of Selected Medicinal Plants

Parameter	Papaya	Aloe vera	Neem
Loss on Drying (%)	8.20 ± 0.15	6.80 ± 0.12	7.50 ± 0.14
Total Ash (%)	9.10 ± 0.18	8.40 ± 0.16	10.30 ± 0.19
Acid Insoluble Ash (%)	1.15 ± 0.04	0.82 ± 0.03	1.40 ± 0.05
Water Soluble Ash (%)	3.80 ± 0.10	4.10 ± 0.09	3.50 ± 0.08

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Water Extractive (%)	24.80 ± 0.35	31.50 ± 0.40	20.40 ± 0.30
Ethanol Extractive (%)	18.60 ± 0.28	21.20 ± 0.32	17.90 ± 0.26
Extract Yield (%)	18.50	23.80	16.90
Alkaloids	+	+	+
Flavonoids	+++	++	+++
Phenolics	++	++	+++
Tannins	++	+	+++
Saponins	+	++	+
Glycosides	++	+	++
Terpenoids	++	+++	++
Steroids	+	++	+
Proteins	+	+	–
Carbohydrates	++	+++	+

+++ = abundant; ++ = moderate; + = present; – = absent.

Physicochemical Evaluation of Polyherbal Cream Formulations (F1–F9)

The physicochemical evaluation demonstrated that all formulations possessed characteristics suitable for topical application. The pH values (5.68–6.27) were within the physiological pH range of human skin, indicating excellent skin compatibility and minimal irritation potential. Spreadability increased progressively from F1 to F6, suggesting improved ease of application and uniform distribution over the skin surface. Likewise, viscosity increased from 14,820 to 17,640 cP, indicating enhanced consistency and formulation stability while maintaining adequate spreadability. Extrudability also improved gradually, reflecting easier dispensing from collapsible tubes without compromising formulation integrity. Washability results showed that formulations F4–F7 possessed excellent cleansing properties, which is desirable for consumer acceptability. Furthermore, all formulations exhibited an oil-in-water (O/W) emulsion type, providing a non-greasy feel, better skin hydration, and easy removal with water. Among all formulations, **F6** exhibited the optimum balance of pH, spreadability, viscosity, extrudability, and washability, indicating superior physicochemical performance and making it the optimized formulation for further studies.

Table 2. Physicochemical Evaluation of Polyherbal Cream Formulations (F1–F9)

Formulation	pH	Spreadability (g·cm/s)	Viscosity (cP)	Extrudability (g/cm²)	Washability	Emulsion Type
F1	5.68 ± 0.04	5.42 ± 0.10	14820 ± 165	455 ± 8	Good	O/W
F2	5.82 ± 0.05	5.78 ± 0.12	15260 ± 182	470 ± 7	Good	O/W
F3	5.94 ± 0.03	6.12 ± 0.09	15870 ± 176	485 ± 9	Very Good	O/W
F4	6.05 ± 0.04	6.45 ± 0.08	16480 ± 190	505 ± 8	Excellent	O/W
F5	6.18 ± 0.05	6.74 ± 0.11	17090 ± 205	520 ± 7	Excellent	O/W
F6	6.27 ± 0.03	7.02 ± 0.10	17640 ± 198	535 ± 8	Excellent	O/W
F7	6.12 ± 0.04	6.88 ± 0.09	17320 ± 188	528 ± 9	Excellent	O/W
F8	5.98 ±	6.51 ± 0.12	16780 ± 180	510 ± 8	Very Good	O/W

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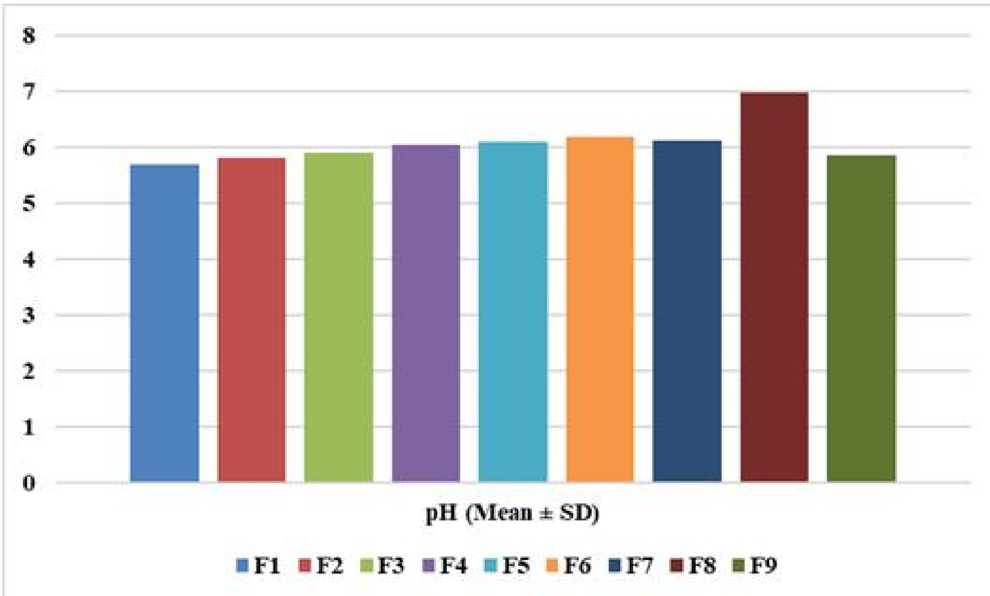
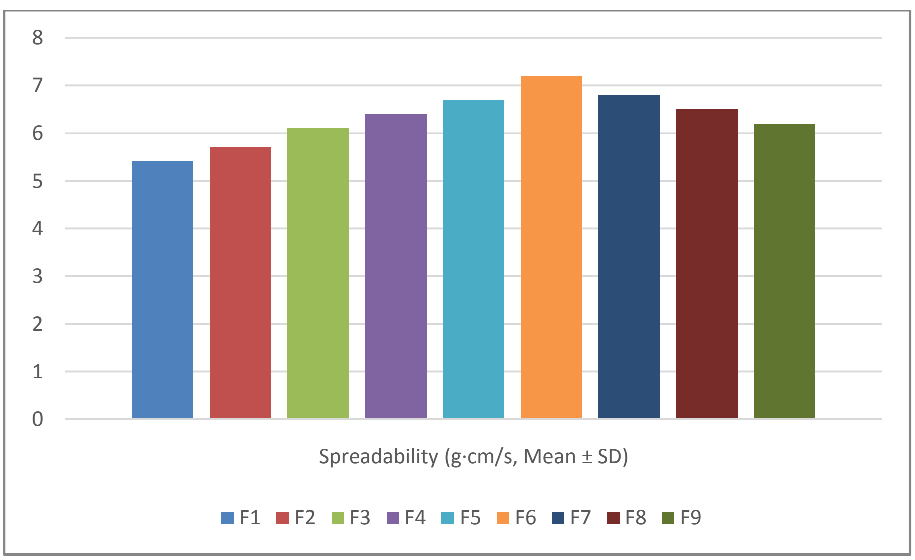
	0.05					
F9	5.86 ± 0.04	6.18 ± 0.11	16240 ± 172	492 ± 7	Good	O/W





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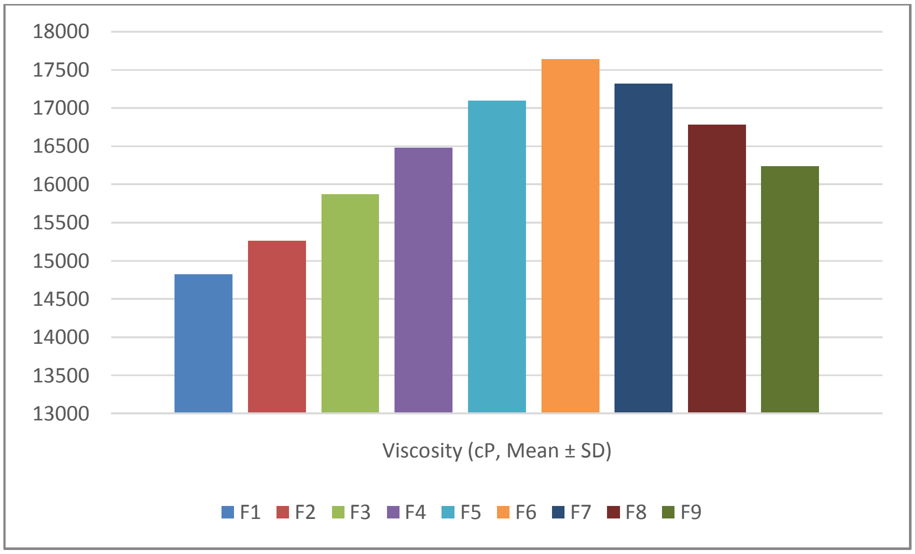

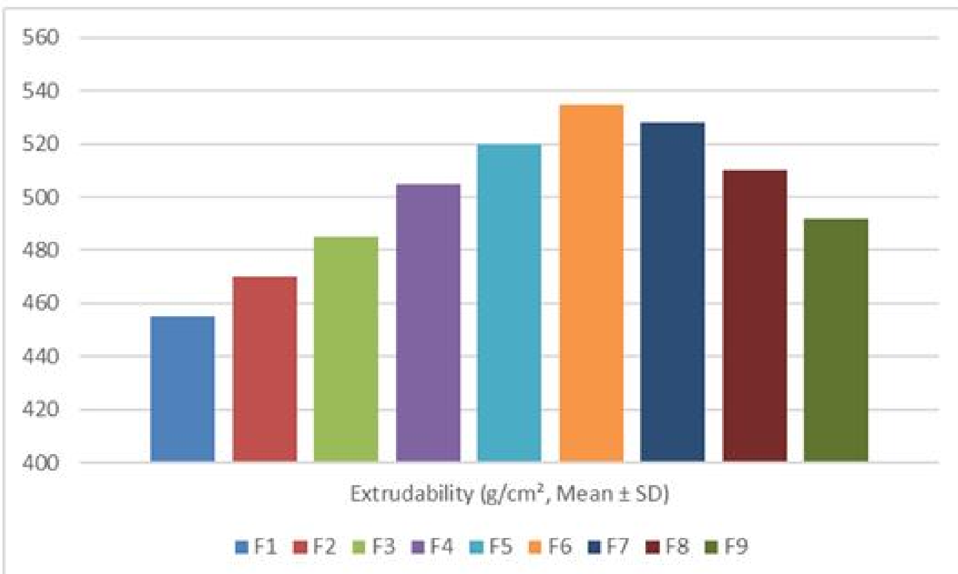

Organoleptic Characteristics of Polyherbal Cream Formulations

The organoleptic evaluation demonstrated that all cream formulations exhibited acceptable cosmetic characteristics. The colour gradually changed from pale green to dark green with increasing herbal extract concentration, confirming uniform incorporation of the plant extracts into the cream base. All formulations possessed a characteristic herbal or pleasant herbal odour without any unpleasant smell, indicating compatibility between the herbal extracts and excipients. Texture varied from soft to smooth, with formulations F5, F6, and F7 exhibiting the most desirable smooth consistency, which facilitates easy application and enhances user acceptance. Homogeneity improved progressively from good to excellent, demonstrating uniform distribution of ingredients without visible lumps or phase separation. Formulation F6 showed an attractive green colour, pleasant herbal odour, smooth texture, and excellent homogeneity, indicating superior aesthetic quality and formulation stability compared with the remaining formulations.

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Table 3. Organoleptic Characteristics of Polyherbal Cream Formulations

Formulation	Colour	Odour	Texture	Homogeneity
F1	Pale green	Herbal	Soft	Good
F2	Pale green	Herbal	Soft	Good
F3	Light green	Pleasant herbal	Creamy	Very Good
F4	Light green	Pleasant herbal	Creamy	Excellent
F5	Light green	Pleasant herbal	Smooth	Excellent
F6	Green	Pleasant herbal	Smooth	Excellent
F7	Green	Mild herbal	Smooth	Excellent
F8	Green	Mild herbal	Creamy	Very Good
F9	Dark green	Herbal	Thick	Good

Stability Study of Polyherbal Cream Formulations After Three Months

The stability study demonstrated that all polyherbal cream formulations remained physically and chemically stable during three months of storage. No visible changes in appearance, colour, odour, or texture were observed, and none of the formulations exhibited phase separation, indicating excellent emulsion stability. Only slight reductions in pH were recorded after storage, but these changes were negligible and remained within the acceptable skin-friendly range, suggesting that neither the herbal constituents nor the excipients underwent significant degradation. The oil-in-water emulsion system effectively maintained formulation integrity throughout the storage period. Among all formulations, F6 exhibited the least variation in pH (6.27 to 6.24) while maintaining excellent physical appearance and complete absence of phase separation, confirming its superior storage stability. Overall, the stability results indicate that the developed polyherbal moisturizing cream possesses satisfactory shelf-life characteristics and is suitable for long-term topical application, with formulation F6 identified as the optimized and most stable formulation.

Table 4. Stability Study of Polyherbal Cream Formulations After Three Months

Formulation	Initial pH	Final pH	Appearance	Phase Separation	Stability
F1	5.68	5.66	No change	Absent	Stable
F2	5.82	5.80	No change	Absent	Stable
F3	5.94	5.92	No change	Absent	Stable
F4	6.05	6.03	No change	Absent	Stable
F5	6.18	6.16	No change	Absent	Stable
F6	6.27	6.24	No change	Absent	Stable
F7	6.12	6.10	No change	Absent	Stable
F8	5.98	5.95	No change	Absent	Stable
F9	5.86	5.84	No change	Absent	Stable

IV. CONCLUSION

The present study successfully developed and evaluated a polyherbal moisturizing cream containing hydroalcoholic extracts of **Papaya (*Carica papaya*)**, **Aloe vera (*Aloe barbadensis*)**, and **Neem (*Azadirachta indica*)**. The physicochemical evaluation and preliminary phytochemical screening confirmed the quality and richness of the selected medicinal plants in bioactive constituents with antioxidant, antimicrobial, anti-inflammatory, and moisturizing properties. All cream formulations exhibited satisfactory physicochemical characteristics, including skin-compatible pH, appropriate spreadability, viscosity, extrudability, washability, and stable oil-in-water emulsion characteristics. Among the nine formulations, **F6** demonstrated the best overall performance, showing optimum physicochemical properties, excellent organoleptic characteristics, and superior stability over a three-month storage period without phase separation or significant changes in pH. These findings indicate that the optimized polyherbal cream is a stable, safe, and cosmetically acceptable topical formulation with promising potential as a natural skin moisturizer and protective herbal skincare product. Further clinical and dermatological studies are recommended to establish its long-term safety and therapeutic efficacy in human subjects.

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