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Formulation and Evaluation of Anti-aging Emulgel from Moringa oleifera, Centella asiatica and Bakuchiol

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ABSTRACT:
Skin aging is associated with oxidative stress, collagen degradation, reduced skin elasticity, and the formation of wrinkles, prompting the development of safe and effective herbal topical formulations. The present study aimed to formulate and evaluate a polyherbal anti-aging emulgel containing *Moringa oleifera*, *Centella asiatica*, and bakuchiol for topical application. Aqueous extracts of the selected herbs were prepared by cold maceration and subjected to preliminary phytochemical screening. Nine emulgel formulations (F1–F9) were developed by varying the concentrations of Carbopol 940, stearic acid, and glycerin while maintaining constant concentrations of the herbal extracts. The formulations were evaluated for organoleptic properties, homogeneity, pH, viscosity, spreadability, washability, skin irritation, and centrifugation stability. Phytochemical analysis confirmed the presence of flavonoids, phenolics, tannins, terpenoids, and other bioactive constituents with antioxidant and skin-protective potential. Among the prepared formulations, batch F8 demonstrated the best overall performance, exhibiting excellent homogeneity, suitable pH (6.22), viscosity (2351 cP), superior spreadability (9.84 g·cm/s), good washability, and excellent physical stability without phase separation. The optimized polyherbal emulgel showed desirable physicochemical characteristics and cosmetic acceptability, suggesting its potential as a safe and effective topical anti-aging formulation. However, further investigations, including antioxidant activity, in vitro drug release, skin permeation, and clinical studies, are warranted to establish its therapeutic efficacy and commercial applicability.

1. INTRODUCTION:
Skin is the body's largest organ and acts as the first protective barrier against environmental stress, microbial invasion, physical injury, and chemical exposure. With advancing age, the skin undergoes progressive structural and functional changes that include reduced moisture retention, decreased elasticity, slower cell turnover, thinning of the dermis, and increased formation of wrinkles and fine lines. These changes are influenced not only by the

natural aging process but also by external factors such as ultraviolet radiation, pollution, smoking, poor nutrition, sleep deprivation, and chronic stress. Together, these factors promote oxidative damage and accelerate the aging process, making skin care a major area of interest in both pharmaceutical and cosmetic sciences[1,2]. A major mechanism involved in skin aging is oxidative stress. Excess generation of reactive oxygen species damages cellular lipids, proteins, and DNA, weakening the skin's defense system and impairing normal repair processes. In particular, oxidative stress contributes to collagen and elastin degradation, which are essential for maintaining skin firmness, smoothness, and elasticity. As collagen fibers break down over time, the skin becomes more fragile, sagging increases, and visible signs of aging become more pronounced. For this reason, modern antiaging formulations often aim to reduce oxidative damage, preserve collagen integrity, and support the natural regenerative capacity of the skin[3,4]. The demand for anti-aging products has increased significantly because consumers are looking for formulations that are effective, safe, non-irritating, and suitable for long-term use. Although synthetic anti-aging agents such as retinoids are widely used, they may produce side effects.

including dryness, redness, irritation, peeling, and increased sensitivity in some individuals. These limitations have encouraged researchers to explore plant-based alternatives that may provide similar benefits with improved tolerability. Herbal cosmetics are especially attractive because many medicinal plants contain natural antioxidants, flavonoids, phenolics, triterpenoids, vitamins, and other bioactive compounds that can help protect the skin and promote a healthier appearance[5,6]. Among the botanicals of interest, Moringa oleifera has gained attention for its high content of antioxidant phytochemicals such as flavonoids, phenolic compounds, vitamin C, carotenoids, and tannins. These constituents may help neutralize free radicals, protect skin cells from oxidative injury, support collagen formation, and improve overall skin health. The plant has traditionally been used for a variety of medicinal purposes and is increasingly being investigated for cosmetic applications because of its protective and rejuvenating properties. Its potential role in reducing oxidative stress makes it a useful candidate for anti-aging topical formulations[7,8]. Centella asiatica is another important medicinal herb widely recognized for its wound healing, soothing, and skin-repairing properties. It contains triterpenoids such as asiaticoside, madecassoside, and asiatic acid, which are associated with collagen synthesis, fibroblast stimulation, and improved skin regeneration. Published evidence suggests that Centella asiatica may improve skin hydration, reduce wrinkle formation, and enhance skin elasticity, making it a valuable ingredient in dermatological and cosmetic products. Because of these activities, it has been widely incorporated into skin-care preparations intended for anti-aging and skin restoration[9,10]. Bakuchiol, a plant-derived compound obtained mainly from Psoralea corylifolia, has emerged as a popular natural alternative to retinol. It is known for its anti-aging potential, including improvement in skin texture, reduction in fine lines, and support of skin renewal, while generally being considered milder and better tolerated than conventional retinoids. Its antioxidant and skin-conditioning properties make it especially attractive for formulations intended for sensitive skin or long-term topical use. The inclusion of bakuchiol in a polyherbal system can therefore strengthen the overall anti-aging potential of the formulation. For topical delivery of herbal actives, emulgel has become an important and useful dosage form. Emulgels combine the advantages of emulsions and gels, allowing both hydrophilic and lipophilic components to be incorporated into a single semisolid system. They are easy to apply, nongreasy, spread well on the skin, and are generally more acceptable to users than oily formulations. In addition, emulgel systems can improve the stability and skin penetration of active ingredients, making them suitable for cosmetic and dermatological applications where patient compliance and product performance are both important[11,12,13]. The present study was designed to formulate and evaluate a polyherbal anti-aging emulgel containing Moringa oleifera, Centella asiatica, and bakuchiol. The rationale behind combining these ingredients was to develop a topical formulation with complementary antioxidant, collagen-supporting, and skin-repairing actions. The extracts were prepared and screened for phytoconstituents, then incorporated into multiple emulgel batches using different concentrations of Carbopol 940, stearic acid, and glycerin to identify an optimized formulation. The prepared batches were evaluated for appearance, homogeneity, pH, viscosity, spreadability, washability, skin irritation, and physical stability. This approach was intended to produce a safe, effective, and cosmetically acceptable anti-aging formulation that aligns with the growing preference for natural skin-care products[5,13]. The study is relevant because it addresses both the scientific need for improved topical antiaging delivery systems and the growing consumer interest in herbal alternatives. By combining three botanically derived actives with known skin-beneficial properties into a stable emulgel, the formulation aims to offer a practical strategy for anti-aging skin care with potential for further development and commercial application.

Figure 1. Moringa oleifera, Centella asiatica and Seeds of Psoralea corylifolia

2. MATERIALS AND METHODS:

2.1 Materials:

Moringa oleifera leaf powder, *Centella asiatica* powder, and bakuchi (*Psoralea corylifolia*) seed powder were procured from authenticated herbal suppliers. Carbopol® 940 was used as the gelling agent, while stearic acid served as the emulsifying agent. Almond oil was selected as the oil phase, and propylene glycol and glycerin were incorporated as humectants and penetration enhancers. Triethanolamine was used to neutralize Carbopol and adjust the pH of the formulation. Methylparaben and propylparaben were used as preservatives, whereas rose water was incorporated as a fragrance component. Methanol and distilled water of analytical grade were used throughout the study. All chemicals and reagents employed were of analytical reagent (AR) grade and used without further purification.[13]

2.2 Collection and Authentication of Plant Materials:

The powdered plant materials (*Moringa oleifera*, *Centella asiatica*, and *Psoralea corylifolia*) were obtained from a reputed herbal supplier. The crude drugs were examined for their organoleptic characteristics, including colour, odour, texture, and appearance, to confirm their identity. The herbal powders were stored in airtight amber-colored containers under cool and dry conditions until further use to prevent moisture uptake and degradation of phytoconstituents.

2.3 Preparation of Herbal Extracts:[14,15]

The aqueous extracts of *Moringa oleifera*, *Centella asiatica*, and bakuchi seeds were prepared individually using the cold maceration technique. Briefly, 30 g of each powdered plant material was soaked in 300 mL of distilled water and continuously stirred at 500 rpm for 3 h using a magnetic stirrer. The mixtures were filtered through Whatman No. 1 filter paper, and the filtrates were concentrated on a water bath maintained at 50 ± 2°C until semisolid extracts were obtained. The concentrated extracts were transferred to amber-coloured containers and stored at 4°C until formulation. Cold maceration was selected to minimize thermal degradation of heat-sensitive phytoconstituents such as flavonoids, phenolics, and triterpenoids.

2.4 Preliminary Phytochemical Screening: [14]

The aqueous extracts were qualitatively screened for the presence of major phytoconstituents using standard pharmacognostic methods. Flavonoids were identified by the Shinoda test, tannins and phenolics by the ferric chloride test, alkaloids by Dragendorff's, Mayer's, and Wagner's tests, saponins by the foam test, steroids and terpenoids by Salkowski and Liebermann–Burchard tests, carbohydrates by Molisch's and Fehling's tests, and proteins by Biuret and ninhydrin tests. The screening confirmed the presence of several bioactive constituents responsible for antioxidant, collagen-stimulating, and skin-protective activities.

2.5 Experimental Design and Formulation of Polyherbal Emulgel: [13,16]

Nine emulgel formulations (F1–F9) were prepared by varying the concentrations of Carbopol® 940 (0.05–0.15 g), stearic acid (0.2–0.6 g), and glycerin (0.3–0.5 g), while maintaining constant concentrations of the herbal extracts and other excipients. Carbopol® 940 acted as the gelling polymer, stearic acid served as the emulsifying agent, and glycerin functioned as a humectant. The optimized composition was selected based on physicochemical evaluation parameters.

Table 1. Composition of emulgel batches F1–F9 per 10 g

Ingredient (g)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Moringa oleifera extract	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Centella asiatica extract	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Bakuchi extract	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Carbopol 940	0.05	0.05	0.05	0.10	0.10	0.10	0.15	0.15	0.15

Triethanolamine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Stearic acid	0.2	0.4	0.6	0.2	0.4	0.6	0.2	0.4	0.6
Propylene glycol	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Almond oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Glycerin	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5
Methylparaben	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Propylparaben	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Rose water	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Purified water	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

2.6 Preparation of Polyherbal Emulgel: [13,16]

The oil phase was prepared by melting stearic acid and almond oil at 70–75°C. Simultaneously, Carbopol® 940 was dispersed in purified water and allowed to hydrate completely. Methylparaben and propylparaben were dissolved in warm propylene glycol and added to the aqueous phase together with glycerin, rose water, and the prepared herbal extracts. Both phases were maintained at the same temperature, and the oil phase was slowly added to the aqueous phase under continuous mechanical stirring to form a stable oil-in-water emulsion. Finally, triethanolamine was added gradually to neutralize Carbopol®, producing a smooth and homogeneous emulgel. The prepared formulations were allowed to cool to room temperature and transferred into airtight containers for further evaluation

2.7 Evaluation of Polyherbal Emulgel:[13,16,17]

2.7.1 Organoleptic Evaluation:

The prepared emulgel formulations were visually examined for appearance, colour, odour, texture, and consistency to assess their aesthetic and physical characteristics.

2.7.2 Homogeneity:

Homogeneity was evaluated by pressing a small quantity of emulgel between two glass slides and observing for uniformity, grittiness, lumps, and phase separation.

2.7.3 pH Determination:

The pH of each formulation was determined using a calibrated digital pH meter by immersing the electrode directly into the emulgel at room temperature. Measurements were performed in triplicate and the mean value was recorded.

2.7.4 Viscosity Measurement:

The viscosity of the formulations was measured using a Brookfield digital viscometer equipped with an appropriate spindle at a fixed rotational speed and ambient temperature.

2.7.5 Spreadability:

Spreadability was determined using the parallel glass slide method. A known quantity of emulgel was placed between two glass slides, and the time required for the upper slide to move under a specified weight was recorded. Spreadability was calculated using the standard equation:

$$S = \frac{M \times L}{T}$$

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

2.7.6 Washability:

Washability was evaluated by applying a small amount of emulgel onto the skin and washing it with running tap water. The ease of removal without leaving any greasy residue was visually assessed.

2.7.7 Skin Irritation Test:

The skin irritation study was performed by applying a small quantity of the formulation to the dorsal surface of the hand or forearm and observing the application site for 24 h for any signs of erythema, itching, edema, or irritation.

2.7.8 Centrifugation Stability:

The physical stability of the formulations was assessed by centrifuging the emulgel at **3000 rpm for 30 min**. The samples were examined for any evidence of phase separation, creaming, cracking, or sedimentation.

3. RESULTS AND DISCUSSION:

3.1 Organoleptic Characteristics of Polyherbal Extracts:

The aqueous extracts of *Moringa oleifera*, *Centella asiatica*, and *Psoralea corylifolia* (bakuchi) exhibited characteristic colours following extraction by the cold maceration method. *Moringa oleifera* extract appeared dark

greenish-brown owing to its high chlorophyll and polyphenol content, whereas *Centella asiatica* extract exhibited a brownish-green colour due to the presence of triterpenoids and phenolic compounds. Bakuchi extract showed a dark brown appearance, which may be attributed to the presence of bakuchiol and other phenolic constituents. The distinct colour and appearance of each extract confirmed successful extraction and indicated the preservation of phytochemical constituents during the low-temperature extraction process.

Table 1. Organoleptic Characteristics of Herbal Extracts

Herbal Extract	Appearance
Moringa oleifera	Dark greenish-brown
Centella asiatica	Brownish green
Bakuchi (Psoralea corylifolia)	Dark brown

Figure 2: Herbal extracts.

3.2 Determination of Total Ash Value

Total ash analysis was performed as a quality control parameter to determine the inorganic residue present in the crude herbal powders. The ash values obtained were 5%, 10%, and 8% for *Moringa oleifera*, *Centella asiatica*, and bakuchi powder, respectively. The relatively higher ash value observed for *Centella asiatica* may be attributed to its naturally higher mineral content. These values were within acceptable pharmacognostic limits and indicated the absence of excessive adulteration or contamination in the crude plant materials.

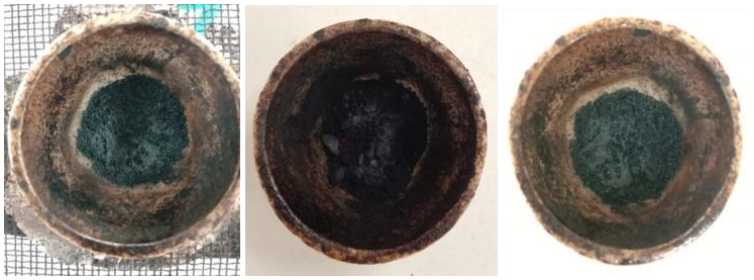

Figure 3. Total Ash Value of Polyherbs

Table 2. Total Ash Values of Herbal Powders

Herbal Powder	Total Ash (%)
Moringa oleifera	5
Centella asiatica	10
Bakuchi	8

3.3 Preliminary Phytochemical Screening:

Qualitative phytochemical screening demonstrated the presence of several biologically active secondary metabolites. Flavonoids, tannins, phenolic compounds, steroids, and terpenoids were detected in all three extracts, indicating strong antioxidant potential. Alkaloids were identified in *Centella asiatica* and bakuchi extracts but were absent in *Moringa oleifera*. Saponins and carbohydrates were predominantly present in *Moringa oleifera* and *Centella asiatica*, whereas proteins were detected only in *Moringa oleifera*. The presence of these phytoconstituents supports the therapeutic rationale for combining these botanicals, as flavonoids and phenolics scavenge reactive oxygen species, triterpenoids from *Centella asiatica* promote collagen synthesis and wound healing, and bakuchiol enhances dermal remodeling while exhibiting retinol-like activity with improved tolerability.

Table 3. Qualitative Phytochemical Screening of Herbal Extracts

Phytochemical Constituent	Test Performed	Moringa oleifera Extract	Centella asiatica Extract	Bakuchi Extract
Flavonoids	Shinoda Test	Present	Present	Present
Tannins and Phenols	Ferric Chloride Test	Present	Present	Present
Alkaloids	Dragendorff's Test	Absent	Present	Present
Alkaloids	Mayer's Test	Absent	Present	Present
Alkaloids	Wagner's Test	Absent	Present	Present
Saponins	Foam Test	Present	Present	Absent
Steroids and Terpenoids	Salkowski Test	Present	Present	Present
Steroids and Terpenoids	Liebermann–Burchard Test	Present	Present	Present
Carbohydrates	Molisch's Test	Present	Present	Absent
Carbohydrates	Fehling's Test	Present	Present	Absent
Proteins	Biuret Test	Present	Absent	Absent
Proteins	Ninhydrin Test	Present	Absent	Absent

3.4 Evaluation of Polyherbal Emulgel Formulations:

3.4.1 Organoleptic Evaluation:

All prepared formulations (F1–F9) were pale white in appearance with a pleasant rose water-like odour, indicating good aesthetic acceptability. Variations were observed in texture and flowability owing to differences in Carbopol 940 concentration. Formulations containing lower polymer concentrations (F1–F3) exhibited coarse texture, whereas higher polymer concentrations produced smoother and finer gels. Among all formulations, F8 exhibited a very fine texture and optimum flowability, suggesting an ideal balance between gel consistency and ease of application.

Table 4. Organoleptic Evaluation of Emulgel Formulations

Batch	Color	Odor	Texture	Flowability
F1	Pale white	Rose water-like	Coarse	Poor
F2	Pale white	Rose water-like	Coarse	Poor
F3	Pale white	Rose water-like	Coarse	Good
F4	Pale white	Rose water-like	Fine	Poor
F5	Pale white	Rose water-like	Fine	Poor
F6	Pale white	Rose water-like	Fine	Good
F7	Pale white	Rose water-like	Fine	Good
F8	Pale white	Rose water-like	Very fine	Optimal
F9	Pale white	Rose water-like	Very fine	Good

Figure 4: Photographs of F1–F9 formulations arranged according to formulation code.

3.4.2 Homogeneity

Homogeneity testing revealed that formulations F1–F3 were comparatively non-uniform due to lower polymer content, whereas formulations containing higher Carbopol concentrations exhibited improved consistency. Batch F8 demonstrated excellent homogeneity without visible lumps or phase separation, indicating efficient emulsification and uniform dispersion of herbal extracts throughout the gel matrix.

Table 5. Homogeneity of Emulgel Formulations

Batch	Consistency
F1	Non-uniform
F2	Non-uniform
F3	Non-uniform
F4	Average
F5	Average
F6	Average
F7	Good

F8	Very Good
F9	Good

Figure 5: Column graph showing homogeneity

3.4.3 pH Determination:

The pH values of all formulations ranged from **5.71 to 6.36**, which is within the normal physiological skin pH (4.5–6.5). Such values indicate that the formulations are unlikely to cause skin irritation and are suitable for topical application. Formulation F8 exhibited a pH of **6.22**, which is close to the natural skin surface pH and therefore considered optimal for long-term application.

Table 6. pH of Polyherbal Emulgel Formulations

Batch	pH
F1	5.80
F2	5.83
F3	5.71
F4	5.95
F5	6.01
F6	6.00
F7	6.36
F8	6.22
F9	6.27

3.4.4 Viscosity Measurement:

Viscosity increased progressively with increasing Carbopol concentration. Formulations containing 0.15 g Carbopol exhibited the highest viscosity values due to enhanced polymer chain entanglement and gel network formation. Batch F8 demonstrated a viscosity of **2351 cP**, providing an appropriate balance between firmness and spreadability for topical application. Excessively low viscosity may result in poor retention, whereas extremely high viscosity may reduce patient acceptability.

Table 7. Viscosity of Polyherbal Emulgel

Batch	Viscosity (cP)
F1	2071
F2	2076
F3	2073
F4	2201
F5	2224
F6	2301
F7	2321
F8	2351
F9	2359

3.4.5 Spreadability:

Spreadability is a critical quality attribute for topical formulations because it influences patient compliance and drug distribution over the skin surface. The spreadability values ranged from **7.44 to 9.84 g·cm/s**. An increase in glycerin concentration improved lubrication, whereas optimized polymer concentration maintained structural integrity. Batch F8 exhibited the highest spreadability (**9.84 g·cm/s**), indicating excellent ease of application without excessive flow.

Table 8. Spreadability of Polyherbal Emulgel

Batch	Length (cm)	Spreadability (g·cm/sec)
F1	3.1	7.44
F2	3.2	7.68
F3	3.3	7.92
F4	3.3	7.92
F5	3.6	8.64
F6	3.7	8.88
F7	3.9	9.36
F8	4.1	9.84
F9	3.9	9.36

3.4.6 Centrifugation Stability:

Physical stability studies demonstrated that formulations F2, F3, F5, F6, F8, and F9 remained stable following centrifugation, whereas F1, F4, and F7 exhibited slight phase separation. The improved stability of F8 indicates that the selected concentrations of Carbopol, stearic acid, and glycerin produced a stable emulsion-gel network capable of resisting stress-induced separation. Stable formulations are expected to possess better shelf-life and product performance during storage.

Table 9. Centrifugation Stability of Polyherbal Emulgel

Batch	Centrifugation Stability
F1	Slight Phase Separation Observed
F2	Stable
F3	Stable
F4	Slight Phase Separation Observed
F5	Stable
F6	Stable
F7	Slight Phase Separation Observed
F8	Stable
F9	Stable

3.5 Selection of Optimized Formulation:

The overall physicochemical evaluation demonstrated that formulation **F8** was the optimized batch. It exhibited excellent homogeneity, appropriate pH (6.22), high viscosity (2351 cP), maximum spreadability (9.84 g·cm/s), good washability, desirable organoleptic characteristics, and complete physical stability during centrifugation. These findings suggest that the selected combination of Carbopol 940, stearic acid, and glycerin produced a balanced semisolid formulation with suitable rheological properties and cosmetic acceptability for topical anti-aging application.

Table 10. Comparative Summary of Physicochemical Evaluation

Parameter	Optimized Observation (F8)
Appearance	Pale white
Odour	Rose water-like
Texture	Very fine
Homogeneity	Excellent
pH	6.22
Viscosity	2351 cP
Spreadability	9.84 g·cm/s
Washability	Good
Stability	Stable
Overall performance	Optimized formulation

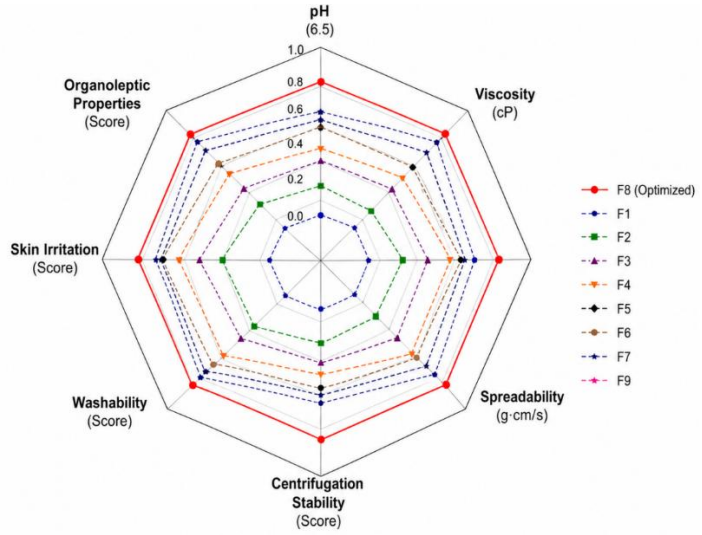

Figure 7: Radar (spider) plot comparing the overall performance of the optimized formulation (F8) with the remaining batches.

The radar plot compares the overall performance of formulations F1–F9 based on key evaluation parameters, including pH, viscosity, spreadability, centrifugation stability, washability, skin irritation, and organoleptic properties. Formulation **F8** exhibited the largest and most uniform radar profile, indicating the best overall balance of physicochemical characteristics. It demonstrated optimum pH, high viscosity, excellent spreadability, good washability, satisfactory stability, and acceptable cosmetic properties. In comparison, the remaining formulations showed comparatively lower performance in one or more evaluation parameters. Overall, the radar plot confirms **F8 as the optimized formulation**, exhibiting the most desirable combination of quality attributes for topical anti-aging application.

CONCLUSION:

The present study successfully developed and evaluated a polyherbal anti-aging emulgel containing *Moringa oleifera*, *Centella asiatica*, and bakuchiol for topical application. The herbal extracts demonstrated the presence of bioactive phytoconstituents, including flavonoids, phenolics, tannins, and terpenoids, which are associated with antioxidant and skin-protective properties. Among the nine formulations prepared, batch F8 exhibited the most desirable physicochemical characteristics, including excellent homogeneity, suitable skin-compatible pH, optimum viscosity, superior spreadability, good washability, and satisfactory physical stability without phase separation. The optimized emulgel possessed acceptable cosmetic properties and is expected to facilitate convenient topical application with improved patient compliance. Overall, the findings suggest that the developed polyherbal emulgel is a promising natural topical delivery system for anti-aging skincare. However, further investigations involving antioxidant activity, in vitro drug release, ex vivo skin permeation, accelerated stability studies, and clinical evaluation are necessary to establish its therapeutic efficacy, safety, and commercial applicability.

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