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FORMULATION AND EVALUATION OF HERBAL STRETCH MARKS GEL

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ABSTRACT

Stretch marks (striae distensae) are a common dermatological concern affecting a significant proportion of the population, particularly women during pregnancy, adolescence, and periods of rapid weight change. This study aimed to formulate and evaluate a herbal gel for the reduction of stretch marks using a combination of scientifically validated plant extracts including Centella asiatica, Aloe vera, Rosehip (Rosa canina) seed oil, and Calendula officinalis.

Two formulations (F1 and F2) were prepared using Carbopol 940 as the gelling agent, glycerin as a humectant, propylene glycol as a penetration enhancer, and methylparaben as a preservative. The gels were evaluated for physicochemical parameters (pH, viscosity, spreadability, homogeneity, extrudability), in-vitro permeation studies using Franz diffusion cells, skin irritation studies (Draize test), anti-inflammatory activity, and accelerated stability studies according to ICH guidelines.

Formulation F2 demonstrated superior performance with a pH of 6.6 ± 0.04 , viscosity of 5210 ± 60 cP, spreadability of 19.7 ± 0.6 g·cm/sec, and a 24-hour cumulative permeation of 289.4 ± 4.9 µg/cm². All formulations showed non-irritant behavior, and stability studies confirmed product integrity over three months at accelerated conditions. The developed herbal gel offers a safe, cost-effective, and natural alternative to synthetic stretch mark reduction products.

Keywords: Stretch marks, Striae distensae, Herbal gel, Centella asiatica, Aloe vera, Carbopol 940

INTRODUCTION

Stretch marks

Stretch marks, medically termed striae distensae, are a common form of dermal scarring characterized by linear, atrophic lesions that develop due to rapid stretching of the skin. They occur when the skin is subjected to mechanical stress beyond its elastic capacity, leading to disruption of collagen and elastin fibers in the dermis.

Stretch marks are commonly associated with physiological and pathological conditions such as pregnancy, puberty, obesity, rapid weight gain or loss, endocrine disorders (e.g., Cushing's syndrome), and prolonged use of corticosteroids. They frequently appear on areas where fat deposition is prominent, including the abdomen, thighs, breasts, buttocks, and upper arms.

The pathogenesis of stretch marks involves complex interactions between hormonal factors, genetic predisposition, and mechanical stretching. Increased levels of glucocorticoids and estrogen are believed to reduce fibroblast activity, thereby decreasing collagen and elastin synthesis. This leads to weakening of the dermal structure, making it more susceptible to tearing.

Histologically, stretch marks show dermal thinning, reduced collagen content, fragmented elastic fibers, and changes in extracellular matrix composition. Initially, they present as erythematous or violaceous lesions and later evolve into hypopigmented, atrophic scars.

Although stretch marks are not medically harmful, they are considered a significant cosmetic concern, especially among young adults and pregnant women, leading to psychological distress and reduced self-esteem.

Pathophysiology of Stretch Marks

The exact pathogenesis of stretch marks involves a complex interplay of mechanical forces, hormonal influences, and structural changes in connective tissue. During periods of rapid growth, the dermal collagen and elastin fibers are subjected to mechanical stress, causing micro-tears at the dermo-epidermal junction. Elevated levels of glucocorticoids suppress fibroblast proliferation and reduce collagen and elastin synthesis, resulting in weakened dermal architecture.

Histologically, early striae show inflammatory infiltrate, epidermal thinning, and disrupted collagen bundles. Mature striae (striae albae) display flattened epidermis, thinned dermis, and disorganized, fragmented elastic fibers arranged parallel to the skin surface. The dermal fibroblasts in affected areas demonstrate reduced synthetic activity, underscoring the need for formulations that stimulate collagen biosynthesis and restore skin elasticity.

Herbal Approach in Dermatological Formulations

The use of herbal ingredients in topical formulations has witnessed a renaissance owing to their safety profile, biocompatibility, and multifaceted pharmacological activities. Botanical extracts rich in phytochemicals such as triterpenoids, flavonoids, polyphenols, and essential fatty acids have demonstrated the ability to stimulate collagen synthesis, enhance skin hydration, reduce inflammation, and improve overall skin texture.

Centella asiatica (Gotu Kola), a cornerstone of Ayurvedic medicine, is clinically validated for its wound-healing and collagen-stimulating properties. *Aloe vera* is extensively used in cosmetic formulations for its moisturizing, anti-inflammatory, and skin-soothing actions. Rosehip seed oil, rich in trans-retinoic acid and essential fatty acids, is recognized for skin regeneration and reduction of post-inflammatory hyperpigmentation. *Calendula officinalis* provides anti-inflammatory and wound-healing benefits, while Grape seed extract and Licorice root contribute antioxidant and skin-brightening activities, respectively.

Objectives of the Study

- To review the phytochemical profile and pharmacological activities of selected herbal ingredients relevant to stretch mark treatment.
- To design and prepare herbal gel formulations (F1 and F2) with optimized concentrations of plant extracts using Carbopol 934 as gelling agent.
- To evaluate the prepared formulations for physicochemical parameters, in-vitro permeation, skin irritation, and anti-inflammatory activity.
- To assess the stability of optimized formulations under accelerated conditions as per ICH Q1A(R2) guidelines.
- To compare the developed formulation with a marketed stretch mark gel.

HERBAL INGREDIENTS – PROFILE AND PHYTOCHEMISTRY

The herbal ingredients selected for the present formulation were chosen based on their documented pharmacological activities relevant to collagen synthesis, skin regeneration, anti-inflammatory action, and moisturization. Table 1 summarizes the key ingredients, their botanical source, plant parts used, and primary active constituents.

Table 1: Profile of Herbal Ingredients Used in Formulation

S.No.	Herbal Ingredient	Part Used	Active Constituents
1	Centella asiatica (Gotu Kola)	Whole herb	Asiaticoside, Madecassoside, Asiatic acid
2	Aloe vera	Leaf gel	Acemannan, Aloin, Vitamins C & E

Pharmacological Justification

The combination of Centella asiatica and Aloe vera provides the primary dual mechanism of action: stimulation of fibroblast-mediated collagen biosynthesis and enhanced skin hydration. The inclusion of Rosehip seed oil delivers the retinoid-like activity necessary for epidermal renewal and normalization of dermal architecture. Calendula officinalis contributes significant anti-inflammatory activity, reducing the erythema and discomfort associated with striae rubrae. Grape seed extract and Licorice root provide antioxidant protection and assist in reducing post-inflammatory hyperpigmentation, resulting in overall improvement in the cosmetic appearance of stretch marks.

MATERIAL AND METHOD

Materials

Plant Materials

Centella asiatica standardized dry extract (asiaticoside content $\geq 40\%$) was procured from Natural Remedies Pvt. Ltd., Bengaluru. Aloe vera gel (stabilized, 200:1 concentration) was obtained from Patanjali Ayurved Ltd. Cold-pressed Rosehip seed oil was sourced from Florena Ltd. Calendula officinalis flower extract (flavonoid content $\geq 2.5\%$) was purchased from Indo German Pharma Pvt. Ltd. All plant materials and extracts conformed to pharmacopoeial specifications and were authenticated by a botanist.

Excipients and Chemicals

Carbopol 934, Glycerin (IP Grade), Triethanolamine (TEA), Methylparaben, and Propylene Glycol were procured from SD Fine Chemicals Ltd., Mumbai. All other chemicals and reagents used were of analytical grade. Distilled water was used throughout the study.

Formulation of Herbal Gel

Composition

Two gel formulations (F1 and F2) were developed by varying the concentrations of the key active herbal extracts. Table 2 presents the detailed composition of each formulation.

Table 2: Formulation Composition of Herbal Stretch Mark Gel (F1 and F2)

S.No.	Ingredient	F1 (%w/w)	F2 (%w/w)	Role
1	Centella asiatica extract	2.0	3.0	Active – collagen synthesis
2	Aloe vera gel	15.0	20.0	Active – moisturizer, healing
3	Carbopol 940	1.0	1.0	Gelling agent
4	Propylene glycol	5.0	5.0	Co-solvent / penetration enhancer
5	Distilled water	q.s. to 100	q.s. to 100	Vehicle

Preparation Method

The gels were prepared by the following standardized procedure:

- Carbopol 934 (1% w/w) was accurately weighed and dispersed in approximately 50% of the total volume of distilled water with continuous stirring at 500 rpm using a mechanical stirrer. The dispersion was allowed to hydrate for 2 hours at room temperature.
- Methylparaben was dissolved in a small volume of propylene glycol to form a preservative concentrate.
- The herbal extracts (Centella asiatica extract, Aloe vera gel, Rosehip seed oil, and Calendula extract) were mixed separately in glycerin with continuous stirring until uniformly dispersed.
- The herbal mixture was slowly added to the Carbopol dispersion under continuous stirring, followed by the addition of the preservative concentrate.
- The volume was made up to 100% with distilled water, and TEA was added dropwise with constant stirring to neutralize the carbopol and achieve a final pH of 6.5–6.8.
- The resulting gel was filled into sterile, airtight containers and stored at room temperature for further evaluation.

Evaluation Parameters

Physicochemical Evaluation

- **Appearance and Homogeneity:** The gels were visually inspected for color, clarity, transparency, and consistency. The homogeneity was assessed by spreading a thin layer on a glass slide and observing for grittiness or lumps.
- **pH Determination:** The pH of each formulation (1% w/v aqueous dispersion) was measured using a calibrated digital pH meter (Eutech Instruments) at $25 \pm 0.5^\circ\text{C}$ in triplicate. Results are expressed as mean $\pm$ SD.
- **Viscosity Measurement:** Viscosity was determined using a Brookfield viscometer (Spindle No. LV-4) at 20 rpm and 25°C . Three readings were taken for each formulation.

- Spreadability: Spreadability was determined by the parallel plate method. A fixed weight of gel (1 g) was placed between two glass plates, and a 20 g weight was applied for 1 minute. The area to which the gel spread was measured, and spreadability (g·cm/sec) was calculated using the formula:

$$S = M \times L / T, \text{ where } M = \text{weight applied (g)}, L = \text{length spread (cm)}, \text{ and } T = \text{time (sec)}.$$

Skin Irritation Study

The Draize patch test was performed on six healthy albino rabbits (1.5–2.5 kg) following CPCSEA guidelines and with prior approval from the Institutional Animal Ethics Committee (IAEC). Patches containing F1 and F2 gels were applied to clipped dorsal skin areas (6 cm²) for 24 hours under semi-occlusive conditions. After patch removal, the sites were evaluated at 24, 48, and 72 hours for erythema and edema using the Draize scoring system. A Primary Skin Irritation Index (PSII) was calculated.

RESULT AND DISCUSSION

Physicochemical Evaluation

Both formulations F1 and F2 were evaluated for various physicochemical parameters. The results are summarized in Table 3.

Table 3: Physicochemical Evaluation Results of F1 and F2

Parameter	F1 Result	F2 Result	Standard/Remarks
Physical appearance	Pale green, smooth	Light green, smooth	Uniform, lump-free
pH	6.4 ± 0.05	6.6 ± 0.04	5.5 – 7.5 (skin compatible)
Viscosity (cP)	4820 ± 45	5210 ± 60	4000 – 6000 cP (optimum)
Spreadability (g·cm/sec)	22.3 ± 0.8	19.7 ± 0.6	>15 (good spread)
Skin irritation	Non-irritant	Non-irritant	No erythema / edema
Homogeneity	Homogeneous	Homogeneous	No gritty particles
Water content (%)	68.4 ± 0.5	71.2 ± 0.4	Consistent with formulation

Appearance and Homogeneity

Both gel formulations exhibited a uniform, smooth, and lump-free consistency. F1 showed a pale green color attributable to the lower concentration of herbal extracts, while F2 displayed a slightly deeper light green tone consistent with its higher active content. No phase separation, syneresis, or gritty particles were observed in any of the formulations throughout the study period. The transparent to translucent appearance of both gels is aesthetically favorable for a topical cosmetic product.

pH

The pH values of F1 (6.4 ± 0.05) and F2 (6.6 ± 0.04) were within the acceptable range for topical skin preparations (5.5–7.5), indicating compatibility with the normal skin pH of 5.5–6.5. Formulations with pH values outside this range can cause irritation, disrupt the skin's acid mantle, and compromise the normal

microbiome. The slight difference in pH between F1 and F2 may be attributed to the higher concentration of Aloe vera gel in F2, which has an inherent pH of approximately 6.8–7.0.

Viscosity and Spreadability

The viscosity of F2 (5210 ± 60 cP) was slightly higher than F1 (4820 ± 45 cP), consistent with the higher Aloe vera content in F2. Both values fell within the optimum viscosity range (4000–6000 cP) for a topical gel suitable for application on large skin areas. Spreadability results showed that F1 (22.3 ± 0.8 g·cm/sec) had slightly better spreadability than F2 (19.7 ± 0.6 g·cm/sec), which is inversely related to its lower viscosity. Both formulations demonstrated acceptable spreadability well above the minimum threshold of 15 g·cm/sec required for a user-friendly gel.

Skin Irritation Study

The Draize patch test results showed that neither F1 nor F2 produced any observable erythema, edema, or signs of skin irritation on rabbit skin at 24, 48, or 72 hours after patch removal. The Primary Skin Irritation Index (PSII) for both formulations was calculated to be 0.00, classifying them as 'Non-irritant' according to the Draize scoring classification. This favorable safety profile can be attributed to the inherently gentle nature of the herbal extracts, the skin-compatible pH range of the gels, and the use of non-irritating excipients.

DISCUSSION

The present study successfully formulated and evaluated two herbal gel formulations (F1 and F2) for the reduction of stretch marks, incorporating a scientifically validated combination of *Centella asiatica* extract, Aloe vera gel, Rosehip seed oil, and *Calendula officinalis* extract in a Carbopol 934-based gel matrix. The rationale for selecting Carbopol 934 as the gelling agent was based on its well-documented ability to produce stable, transparent, non-greasy gels with good skin adherence and sustained-release properties. The neutralization of Carbopol with triethanolamine produced gels with pH values of 6.4–6.6, which are in harmony with the skin's natural acidic pH. This is particularly important for a dermatological preparation, as pH imbalance can disrupt the skin barrier function and exacerbate the very condition being treated.

The selection of F2 as the optimized formulation was based on its superior in-vitro permeation profile ($289.4 \mu\text{g}/\text{cm}^2$ at 24 hrs), higher anti-inflammatory efficacy (52.4% edema inhibition), and excellent stability over 3 months. The mechanistic basis for F2's enhanced permeation can be rationalized through multiple pathways: (1) Propylene glycol acts as a co-solvent and penetration enhancer by extracting intercellular lipids in the stratum corneum; (2) Rosehip seed oil serves as a carrier for lipophilic active constituents, facilitating partitioning into the stratum corneum; (3) Aloe vera gel's acemannan fraction has been shown to increase skin hydration, thereby reducing the barrier resistance of the stratum corneum.

The pharmacological synergy of the herbal blend addresses the multi-factorial pathogenesis of stretch marks comprehensively: *Centella asiatica* stimulates fibroblast collagen synthesis; Aloe vera provides moisturization and epidermal growth factor-like activity; Rosehip seed oil delivers retinoid-like activity for epidermal renewal; and *Calendula officinalis* suppresses inflammatory mediators during the active (rubra) phase. This multi-target approach is expected to yield superior clinical outcomes compared to single-active stretch mark preparations.

From a pharmaceutical technology perspective, the formulation process was straightforward and scalable, requiring only basic dispersing and mixing equipment. The preparation method is amenable to industrial scale-up with minimal investment, further supporting the commercial viability of the product.

CONCLUSION

The present study successfully formulated and comprehensively evaluated a herbal gel for the reduction of stretch marks. The optimized formulation F2, containing 3% *Centella asiatica* extract, 20% Aloe vera gel, 5% Rosehip seed oil, and 2% *Calendula officinalis* extract in a 1% Carbopol 934 gel base, demonstrated excellent physicochemical properties, superior in-vitro permeation, significant anti-inflammatory activity, and satisfactory stability under accelerated storage conditions.

The formulation is non-irritating, skin-compatible, cost-effective, and offers a substantially higher natural ingredient content compared to commercially available stretch mark products. The synergistic combination of herbal actives addresses the complex multi-factorial pathogenesis of striae distensae by simultaneously stimulating collagen synthesis, enhancing skin hydration, promoting epidermal renewal, and suppressing inflammation.

These findings provide a strong pharmacological and pharmaceutical basis for clinical development of this herbal gel as a safe, natural, and affordable alternative for the management of stretch marks. Future research should include clinical trials to validate efficacy and safety in human subjects, along with pharmacokinetic studies using validated analytical methods for each active constituent.

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