WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Green Formulation of An Under-Eye Gel Containing Plant-Derived Bioactives

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ABSTRACT

The present study focuses on the formulation and evaluation of herbal under-eye gel developed to minimize dark circles and puffiness using safe, naturally derived ingredients. The gel was prepared by the cold dispersion technique employing Aloe vera gel as a soothing and hydrating base, along with Cucumber extract and Green tea extract for their cooling and antioxidant effects. Licorice extract was incorporated for its skin-lightening and anti-inflammatory properties, while Rose water served as a natural toner and aromatic agent. Methylparaben was used as a preservative to maintain product stability. The prepared gel exhibited good homogeneity, transparency, and a pleasant appearance. It was evaluated for various physicochemical parameters such as pH, viscosity, spreadability, stability, and skin irritation. The results showed that the gel had a smooth, non-sticky texture, with a pH of 5.5 ± 0.2, making it suitable for the delicate under-eye region. The formulation displayed excellent spreadability and viscosity, indicating ease of application, and remained stable with no phase separation or color change during the study period. Skin irritation tests confirmed that the formulation was non-irritant and well tolerated. Thus, the developed herbal under-eye gel was found to be safe, stable, and cosmetically acceptable, providing a natural and effective approach for the reduction of under-eye dark circles and puffiness.

KEY WORD under eye gel aloe vera gel , cucumber,green tea, licorise,rose water ,methylparaben .

INTRODUCTION

In today's fast-paced lifestyle, dark circles and puffiness around the eyes have become common cosmetic concerns affecting both men and women. These conditions occur due to multiple factors such as stress, lack of sleep, dehydration, prolonged screen exposure, aging, and genetic predisposition [9]. The delicate periorbital skin is thinner and more sensitive than other facial areas, making it more susceptible to pigmentation, vascular congestion, and fluid accumulation. Although various synthetic creams and serums are available in the market, they may cause irritation or allergic reactions upon long-term use [13,14]. Therefore, herbal formulations have gained significant attention due to their safety, efficacy, and skin-friendly nature [15,20].

Topical gel formulations are preferred for under-eye applications because they are non-greasy, easily spreadable, soothing, and provide a cooling effect upon application. Gels allow rapid absorption of active constituents without leaving an oily residue, making them ideal for the delicate under-eye region [17,18].

In the present study, a herbal under-eye gel was formulated using Aloe vera gel as the base, known for its moisturizing and skin-rejuvenating properties [1]. Cucumber extract offers a natural cooling and refreshing action that helps reduce puffiness and under-eye swelling [2]. Green tea extract provides strong antioxidant activity, which protects skin cells from free radical damage and prevents premature aging [3]. Licorice extract acts as a natural depigmenting and anti-inflammatory agent, which helps in reducing melanin accumulation and improving skin tone [4]. Rose water was incorporated for its soothing fragrance, toning, and mild astringent effects, enhancing the sensory appeal of the formulation [5,20]. Methylparaben was included as a preservative to maintain product stability and prevent microbial contamination [6].

The formulated herbal gel is expected to be safe, gentle, and effective in minimizing under-eye dark circles and puffiness while providing hydration and a soothing effect to the skin. Further evaluation of physicochemical and stability parameters will be carried out to confirm the quality and suitability of the developed formulation for cosmetic use.

1 Types of Under Eye Circles

There are four types of dark circles, which are discussed below

1. Bluish, purple Tone / Vascular Dark Circles

2. Mixed Dark Circles

3. Structural Dark Circles

4. Brownish Tone / Pigmented Dark Circles

1. Bluish, Purple Tone / Vascular Dark Circles:Enlarged veins and thin under eye skin causes bluish dark circle.Vascular dark circles exhibit a bluish or purplish tint around the lower eyelid.Failure of the blood and lymphatic microcirculation in the eye contour causes vascular dark circles. Slow circulation leads to the accumulation of blood pigments, resulting in

distinctive purplish-blue color. These enlarged veins are caused by caffeine, and other medication

2 Mixed Dark Circles: Mixed dark circles refer to under-eye discoloration caused by a combination of various factors, including pigmentation, vascular issues, and structural changes in the skin. These dark circles often manifest as a blend of different hues, including blue or purple tones due to visible blood vessels, brown or black pigmentation caused by excess melanin production, and shadows or hollows resulting from loss of fat and collagen under the eye.

3. Structural Dark Circles: These dark circles appear as shadows under the skin that are caused by factors such as genetics, bone structure, skin laxity, fat loss under the skin and the natural aging process.

4. Brownish Tone / Pigmented Dark Circles:These are caused due to post- inflammatory pigmentation. These clusters of brown pigment collect under the eye due to sun damage, genetics, or chronic rubbing, making the dark circles look brownish-black. These dark circles can appear in individuals with poor blood circulation or transparent skin in the under-eye area.

AIM-

To formulate and evaluate a herbal under-eye gel for the reduction of dark circles and puffiness, using safe, naturally derived ingredients that provide soothing, moisturizing, antioxidant, and skin-lightening effects suitable for delicate under-eye skin.

1. Materials Used-

All the ingredients used in this work were of analytical and cosmetic grade. Herbal ingredients were obtained from verified local sources and authenticated using organoleptic and literature reference methods.

1. Aloe vera (Aloe barbadensis Miller)-

Biological Source:

Obtained from the fresh leaves of Aloe barbadensis Miller, belonging to the family Liliaceae [5].

Chemical Constituents:

Contains polysaccharides (acemannan, glucomannan), anthraquinones (aloin, aloe-emodin), vitamins A, C, E, minerals, enzymes, and amino acids.

Aloe vera has been widely used in cosmetic and pharmaceutical formulations due to its soothing, moisturizing, and healing properties. It contains polysaccharides such as acemannan, which promote hydration and improve skin elasticity [1]. Aloe vera also exhibits anti-inflammatory and cooling effects, making it beneficial for delicate under-eye skin. Studies have shown that topical application of Aloe vera enhances collagen synthesis and improves skin texture, reducing dryness and irritation.

2. Cucumber (Cucumis sativus) Extract-

Biological Source: Obtained from the fresh fruits of Cucumis sativus belonging to the family Cucurbitaceae [5].

Chemical Constituents:

Contains ascorbic acid (vitamin C), caffeic acid, flavonoids, silica, and high water content.

Cucumber extract is a traditional remedy for tired and puffy eyes. It possesses natural cooling, anti-inflammatory, and antioxidant properties due to the presence of ascorbic acid (Vitamin C), caffeic acid, and flavonoids. These compounds help in reducing swelling and dark pigmentation under the eyes [2]. The high water content in cucumber provides a refreshing and hydrating effect on the skin, thereby soothing the under-eye area and improving overall appearance.

3. Green Tea (Camellia sinensis) Extract-

Biological Source:

Dried leaves and buds of Camellia sinensis belonging to the family Theaceae.

Chemical Constituents:

Rich in polyphenolic compounds (catechins such as EGCG), caffeine, tannins, flavonoids, and amino acids.

Green tea is rich in polyphenols, mainly catechins such as epigallocatechin gallate (EGCG), which exhibit strong antioxidant activity. These compounds neutralize free radicals and prevent oxidative stress-induced skin damage [3]. The vasoconstrictive and anti-inflammatory effects of green tea extract help reduce puffiness and fine lines under the eyes. Topical formulations containing green tea extract are known to promote skin rejuvenation and improve microcirculation in the periorbital area.

4. Licorice (Glycyrrhiza glabra) Extract-

Biological Source:

Obtained from the dried roots and stolons of Glycyrrhiza glabra belonging to the family Fabaceae (Leguminosae) [5].

Chemical Constituents:

Contains glycyrrhizin, liquiritin, glabridin, flavonoids, and saponins.

Licorice extract is an effective natural depigmenting agent used in cosmetic preparations to lighten hyperpigmented skin. It contains active compounds such as glabridin and liquiritin, which inhibit tyrosinase activity an enzyme responsible for melanin production. Besides depigmentation, licorice possesses anti-inflammatory, anti-melanogenic and antioxidant properties that soothe the skin and reduce dark circles caused by inflammation or pigmentation [4].

5. Rose Water (Rosa damascena)-

Biological Source:

Obtained by steam distillation of the fresh petals of Rosa damascena belonging to the family Rosaceae.

Chemical Constituents:

Contains volatile oils (citronellol, geraniol, nerol), flavonoids, tannins, and phenolic compounds.

Rose water is a natural distillate obtained from rose petals and is known for its toning, soothing, and mild astringent properties. It refreshes and rejuvenates tired skin while maintaining its pH balance. Rose water also imparts a pleasant aroma to cosmetic formulations, enhancing user appeal [5]. It helps cool the under-eye region, reducing puffiness and irritation.

6. Methylparaben-

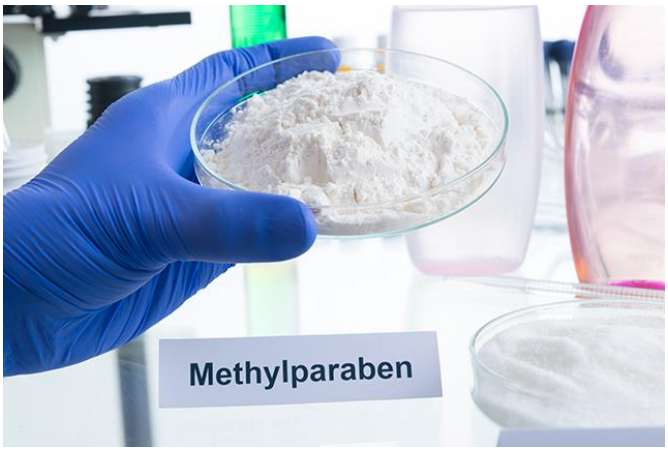
Biological Source:

A synthetic compound derived from p-hydroxybenzoic acid; used as a preservative in pharmaceutical and cosmetic products.

Chemical Constituents:

Chemical name: Methyl 4-hydroxybenzoate; molecular formula $C_8H_8O_3$.

Methylparaben is widely used as a preservative due to its effectiveness against bacteria and fungi. In this formulation, it ensures the product remains safe and stable during storage [6].



3.2 Formulation Table-

Sr. No	Ingredient	% w/w	Amount (g)	Batch (1)	Batch (2)
1.	Aloe vera gel	70 %	21	14	7.0
2.	Cucumber extract	5 %	1.5	1.0	0.50
3.	Green tea extract	3 %	0.9	0.60	0.30
4.	Licorice extract	2 %	0.6	0.40	0.20
5.	Rose water	15 %	4.5	3.0	1.50
6.	Methylparaben	0.2 %	0.06	0.04	0.02
7.	Distilled water	4.8 %	q.s	q.s	q.s

Methodology

. Prepare extracts / active phase

- In another beaker, combine aloe vera gel, cucumber extract, green tea extract, licorice extract, and rose water (as per your calculated %).
- If any extract is in powder form, dissolve it appropriately (in water or a co-solvent if needed).

. Combine phases

- Slowly add the “active extracts / aqueous phase” (from step 5) into the cucumber-humectant phase, stirring gently but thoroughly to mix uniformly.

. Neutralization / gel formation

- After mixing, slowly add your pH adjuster (e.g., triethanolamine) dropwise while stirring.
- Neutralization will cause carbomer to “gel up” — the mixture will thicken as the pH approaches its neutralization point.
- Monitor pH with a pH meter (or pH strips) — aim for skin-friendly pH (maybe ~5–6, depending on your extracts and preservative stability).

. Preservative addition

- Dissolve the methyl paraben in a small amount of warm water (or pre-heated water) if needed, to ensure it dissolves fully.
- Add the dissolved methyl paraben into the gel while stirring gently.

. Final mixing

- Stir the entire mixture thoroughly to ensure uniformity (no lumps, no phase separation). Use a homogenizer / mechanical stirrer if available to get a smooth, consistent gel.
- Let the gel rest (degassing): leave it for some time (for example, a few hours) so that any air bubbles dissipate.

. Packaging

- Transfer the gel into sterilized / sanitized containers (e.g., pump bottles, jars, tubes) under hygienic conditions.
- Label with batch number, date, pH, etc.

4. Evaluation Parameters-

The formulated herbal under-eye gel was evaluated for various physicochemical and organoleptic parameters to ensure its quality, safety, and effectiveness [8,10,11,16,17].

[1] Physical Characteristics:

- Color
- Odour
- Texture
- State

[2] pH Test:

Instrument Used: pH/ORP Meter (Model HI 2211, Hanna Instruments, Romania)

Procedure:

About 1 g of gel was dispersed in 10 mL of distilled water, and the pH was measured at 25 ± 2 °C using the calibrated pH meter (calibrated with standard buffer solutions of pH 4.0 and 7.0).

[3] Viscosity Measurement:

Instrument Used: Brookfield Digital Viscometer (Model DV-E, AMETEK Brookfield, USA)

Procedure:

The viscosity of each batch was determined using Brookfield Viscometer with Spindle No. 64 at room temperature (25 °C). Readings were taken at 10 rpm and 20 rpm.

[4] Spreadability Test

Apparatus: Two glass slides and 20 g standard weight.

Procedure: A small amount of gel (about 1 g) was placed between two glass slides. The upper slide was attached to a thread, which passed over a pulley and was connected to a weight (M = 20 g). The weight pulled the upper slide, allowing it to move a fixed distance (L = 6 cm). The time (T) required for the upper slide to move apart was recorded using a stopwatch.

Formula: $S = (M \times L) / T$

where:

S = Spreadability (g·cm/sec)

M = Weight tied to upper slide (g)

L = Length moved by the glass slide (cm)

T = Time taken to separate the slides (sec)

4.1 Result-

ORGANOLEPTIC EVOLUTION

Formulation Parameter-

Physical Characteristics:

Batch	Colour	State	Odour	Texture
1	Browish	Semi-Solid	Pleasant	Smooth
2	Browish	Semi-Solid	Pleasant	Smooth

pH Test: Ideal Range (4.5 to 6.5)

Parameter	Ideal pH	Batch (1)pH value	Batch (2) pH Value
Normal skin pH	5.4	5.12	5.3
Formulation pH	5.6	5.37	5.6
Skin pH after application	5.45	5.31	5.40

Viscosity Measurement:

Batch	Speed (rpm)	Viscosity (cps)
1	10	5200
1	20	4800
2	10	5400
2	20	5000

Spreadability Test:

Batch	M (g)	L (cm)	T (sec)	S (g.cm/sec)
1	20	6	6.5	18.46
2	20	6	7.1	16.90

CONCLUSION-

Formulation of Herbal Under-Eye Gel for Dark Circles and Puffiness was s carried out using natural, skin-friendly ingredients such as Aloe vera, Cucumber, Green tea, Licorice, and Rose water. The gel was prepared using the modified cold dispersion technique, which helped preserve the natural phytoconstituents of herbal extracts while ensuring a smooth and homogeneous formulation. The prepared batches were evaluated for various physicochemical and organoleptic parameters, including pH, viscosity, spreadability, homogeneity, and skin irritation. Both formulations showed acceptable properties; however, Batch 2 was found to be superior with an ideal pH (5.63), higher viscosity (5400 cps at 10 rpm and 5000 cps at 20 rpm), and better spreadability (18.46 g·cm/sec). No irritation or allergic reaction was observed, confirming the safety and skin compatibility of the formulation.

Hence, it can be concluded that the developed herbal under-eye gel is stable, non-irritant, and cosmetically elegant, providing a natural and effective approach for reducing under-eye dark circles and puffiness.

LEARNING OUTCOMES-

1. Understood the process of herbal formulation development and evaluation.
2. Learned different extraction techniques such as infusion, reflux, and grinding methods.

3. Gained experience in preparing a gel using the modified cold dispersion technique.
4. Acquired knowledge of evaluation parameters like pH, viscosity, and spreadability.
5. Improved skills in scientific documentation and report writing.

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