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FORMULATION AND EVALUATION OF AN UNDER-EYE GEL FOR PERIORBITAL HYPERPIGMENTATION

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ABSTRACT

In addition to expressing the entire spectrum of human emotion, the eyes, which are also a focal point of facial expression, have a big influence on how one is viewed in terms of health and attractiveness. Periorbital hyperpigmentation is a disorder where the area surrounding the eyes produces more melanin than normal, resulting in a darker hue. Periorbital skin is a prominent target for antiaging therapy because of its high vulnerability to harm from outside sources and propensity to show early indications of aging. Because the skin on the eyelids is the thinnest in the body, the underlying blood vessels are more visible, giving the appearance of being black and swollen. In this study, an under-eye gel containing polyherbal extracts from Glycyrrhiza glabra (licorice), Camellia sinensis (green tea), and Cucumis sativus (cucumber) has been developed, characterized, and evaluated in vitro in an effort to lighten and repair dark eye contours. The decoction extraction procedure was used to prepare the polyherbal extracts. The gel basis was made with Carbopol 934 and HPMC. Following formulation, the under-eye gel was assessed for a number of physicochemical characteristics, such as homogeneity, pH, viscosity, spreadability, washability, and irritancy. In order to determine the formulation's potential efficacy, an antimicrobial study against Staphylococcus aureus was carried out. The

developed under-eye gel showed acceptable physicochemical qualities, indicating its potential as a natural and efficient skincare product, according to the results.

KEYWORDS: HPMC, Carbopol 940, under-eye gel, dark circles.

INTRODUCTION

The physiology of periorbital skin is distinct since it is the thinnest and most active part of the body. In certain individuals, the skin's thickness is as little as 0.2 mm. There is very little subcutaneous fat between the muscle and skin layers because the orbicularis oculi muscle and the eyelid dermis are closely entwined.[1] Smoking, pollution, contact dermatitis, and prolonged rubbing from seasonal allergies are among the extrinsic factors that can cause injury to periocular skin.[1]

One of the most sensitive and fragile areas of the face is the area beneath the eyes, which frequently exhibits early indicators of age, exhaustion, and stress, including wrinkles, puffiness, dark circles, and fine lines. Dehydration, oxidative stress, and inadequate microcirculation are the main causes of these disorders. Despite their effectiveness, synthetic cosmetic formulations frequently cause long-term skin damage, allergic responses, or discomfort. Because of their safety, biocompatibility, and variety of therapeutic activities, polyherbal-based formulations are receiving a lot of attention as a solution to these problems.[2]

A semi-solid mixture of many herbal extracts distributed in an appropriate aqueous base is known as a polyherbal gel. It offers long-term topical distribution by encasing a condensed bulk of herbal actives in a liquid medium. These formulas don't have the negative effects of chemical cosmetics and are lightweight, safe, and appropriate for daily usage. To sum up, under-eye gels offer a novel, secure, and efficient natural remedy for puffiness, dark circles beneath the eyes, and weariness. To provide the best possible skin advantages, they blend the traditional knowledge of herbal therapy with contemporary pharmaceutical manufacturing methods. These compositions offer a comprehensive approach to repairing the sensitive under-eye area due to their antioxidant, anti-inflammatory, and rejuvenating qualities, making them a suitable substitute for synthetic treatments in cosmetology.[2] For people of all ages, dark eye circles are a significant periocular skin problem. Dark under-eye circles can be caused by age, hypervascularity, and tear trough depression.[3] It has been demonstrated that eye gels containing green tea, cucumber, licorice, and aloe vera reduce periocular

hyperpigmentation. Additionally, it has been demonstrated that potato-based eye lotions brighten the area under the eyes.[3]

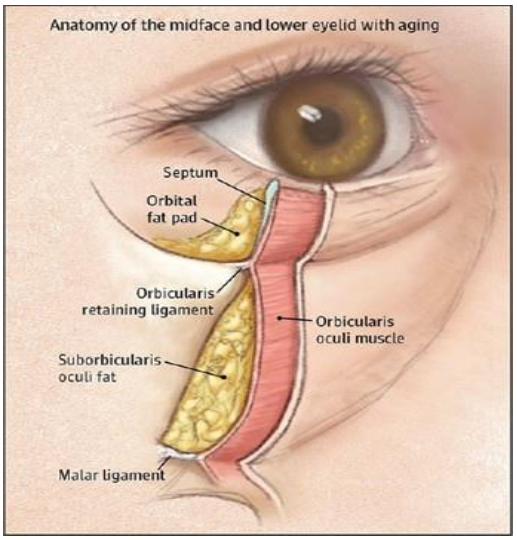

Figure 1: Age-related changes involving the osseous, ligamentous and soft tissue anatomy in the ageing eyelid resulting in infraorbital dark circles.[3]

Under-eye puffiness is another typical periocular skin issue. Photodamage, fluid buildup, hollow tear troughs, and cheek decline are some of the causes of puffiness.[1] Eye creams with active ingredients, including green tea, improve skin laxity, strengthen vasculature, and decrease fluid retention, all of which help minimize puffiness.[4]

The goal of the current study was to create and assess a under-eye gel using extracts of licorice (Glycyrrhiza glabra), green tea (Camellia sinensis), and cucumber (Cucumis sativus) based on these traditional claims. The Herbal Pharmacopoeia of India was used to examine each herb's standard specification.[5] Extracts were made using a standard protocol. Carbopol 934, HPMC, and herbal extracts of licorice, cucumber, and green tea were used in varying amounts to create three batches of under-eye gel formulations (F1–F3). The natural coloring additive in formulation F2 was beetroot extract. pH, viscosity, homogeneity, spreadability, and stability tests were among the physicochemical properties that were assessed for the developed formulations. Based on the evaluation results, formulation F3 showed better consistency, firmness, and skin adherence compared to the other batches and was considered as the optimized formulation.

AIM

To formulate and evaluate a under-eye gel containing herbal extracts of licorice, cucumber, and green tea for the management of periorbital hyperpigmentation, puffiness, and under-eye fatigue.

OBJECTIVE

- To prepare under-eye gel formulations using Carbopol 934 and HPMC as gelling agents.
- To incorporate selected herbal extracts possessing antioxidant, soothing, and depigmenting properties into the formulation.
- To evaluate the prepared formulations for physicochemical parameters including pH, viscosity, spreadability, homogeneity, washability, and organoleptic characteristics.
- To assess the formulations for skin irritancy and stability under different storage conditions.
- To compare the prepared formulations and identify the optimized batch based on evaluation parameters.

MATERIALS AND METHODS

Materials

Glycerin, propylene glycol, sodium benzoate, disodium EDTA, hydroxypropyl methylcellulose (HPMC), and carbopol 934 were obtained from the pharmaceutics lab of Siddhi College of Pharmacy, India. Green tea, cucumber, and licorice were obtained and verified locally. Every additional chemical and reagent that was utilized was of analytical (AR) grade. During the entire trial, distilled water was utilized.

Method

Green tea and cucumbers were gathered and properly cleaned with distilled water. After that, a mortar and pestle were used to break the plant ingredients into a coarse paste for extraction.

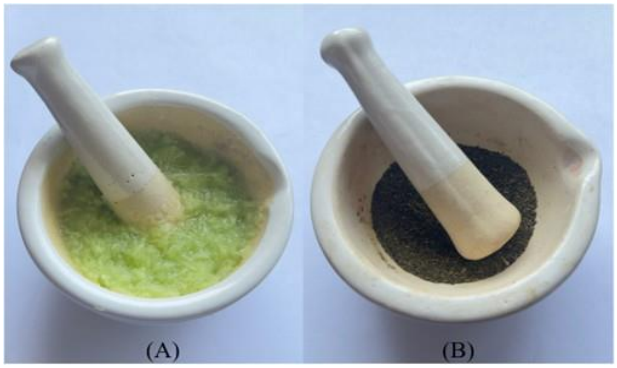

Figure 2: (A) Fresh cucumber, (B) Dried green tea crushing using mortar and pestle.

The freshly produced plant materials were extracted right away. On the other hand, licorice

was extracted aqueously by maceration using distilled water as a solvent. To make the extract, the licorice material was steeped for 24 hours at room temperature (25 ± 2°C).

Figure 3: Maceration and filtration of licorice extract.

Whatman filter paper and muslin cloth were employed to filter the extracted materials, producing clean filtrates that were utilized in subsequent formulations.

Figure 4: Filtration of Extracts.

Formulation of Gel

Three batches (F1, F2, and F3) of polyherbal under-eye gel were prepared, each having a final volume of 20 mL. The composition of the formulation is given in Table 1.

Formulation Table

Table 1: Composition of Under-Eye Gel.

Sr. No.	Ingredients	F1	F2	F3
1.	Hydroxypropyl Methylcellulose (HPMC)	0.24 g	0.26 g	0.28 g
2.	Carbopol 934	0.10 g	0.12 g	0.14 g
3.	Propylene Glycol	0.4 mL	0.5 mL	0.6 mL
4.	Glycerin	0.8 mL	0.8 mL	1.0 mL
5.	Ascorbic Acid	0.10 g	0.10 g	0.12 g
6.	Sodium Benzoate	0.08 g	0.08 g	0.08 g
7.	Disodium EDTA	0.01 g	0.01 g	0.01 g
8.	Licorice extract	1.0 mL	1.2 mL	1.5 mL
9.	Cucumber extract	1.5 mL	1.6 mL	1.8 mL
10.	Green tea extract	0.6 mL	0.8 mL	1.0 mL
11.	Beetroot extract	-	q.s	-
12.	Distilled water	q.s. to 20 mL	q.s. to 20 mL	q.s. to 20 mL

Table 2: Role of Ingredients Used in Formulation.

Sr. No.	Ingredients	Role
1.	Hydroxypropyl Methylcellulose (HPMC)	Thickening agent
2.	Carbopol 934	Gelling agent
3.	Propylene Glycol	Penetration enhancer
4.	Glycerin	Humectant
5.	Ascorbic Acid	Skin protectant
6.	Sodium Benzoate	Preservative
7.	Disodium EDTA	Chelating agent
8.	Licorice extract	Depigmenting agent
9.	Cucumber extract	Cooling agent
10.	Green tea extract	Antioxidant
11.	Beetroot Extract	Natural Colouring Agent
12.	Distilled water	Vehicle

To obtain the best possible uniformity, stability, and therapeutic efficacy, the formulation was created using specific polymers and polyherbal extracts. To guarantee consistency and repeatability of the gel, every component was precisely measured and weighed. For efficient under-eye care, the final formulation was created to offer synergistic antioxidant, depigmenting, and moisturizing properties.

Method of Preparation

Using the polymer hydration and dispersion process, herbal eye gel was prepared. Four separate stages were used in this method to provide a homogenous, stable, and transparent formulation.

Phase 1: Preparation of Gel Base

10 mL of distilled water was taken in a clean beaker and heated gently to lukewarm temperature. Carbopol 934 and HPMC were slowly dispersed into the water with continuous stirring to avoid lump formation. The mixture was allowed to stand for one hour for complete hydration and swelling of the polymers. Intermittent stirring was carried out using a glass rod to obtain a smooth and homogeneous gel base.

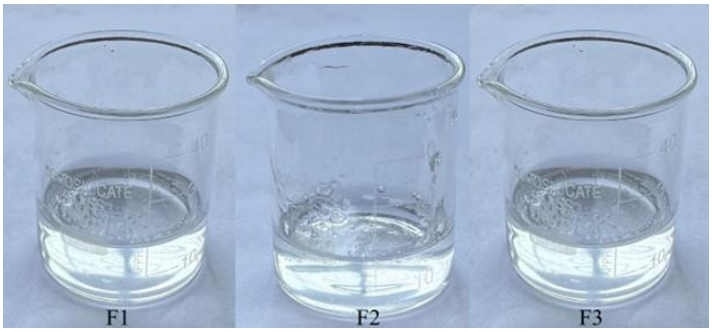

Figure 5: Gel Phase.

Phase 2: Incorporation of Herbal Extracts

In a separate beaker, measured quantities of cucumber extract, green tea extract, and licorice extract were mixed uniformly. Glycerin and propylene glycol were then added to the herbal blend with continuous stirring to ensure proper mixing and uniform distribution of the active constituents.

Phase 3: Preparation of Active Phase

Ascorbic acid and sodium benzoate were dissolved in 2 mL of distilled water. The prepared solution was then added to the herbal blend with gentle stirring to ensure uniform mixing. Disodium EDTA was incorporated as a chelating agent to enhance the stability of the herbal extracts and formulation.

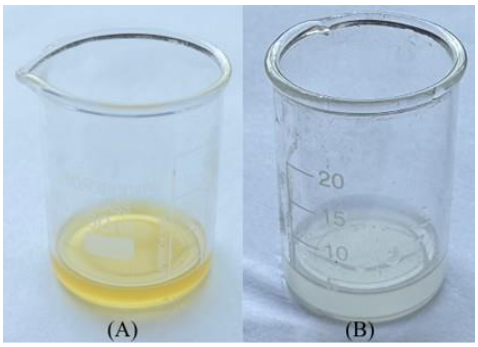

Figure 6: (A) Mixing of cucumber, green tea, and licorice extracts (B) Ascorbic acid & sodium benzoate in 2 mL distilled water.

Phase 4: Final Gel Preparation

The herbal active mixture was slowly incorporated into the hydrated polymer base with continuous gentle stirring. Slow stirring was maintained throughout the process to avoid the entrapment of air bubbles and to obtain a uniform gel consistency. The final volume of the formulation was adjusted to 20 mL using distilled water.

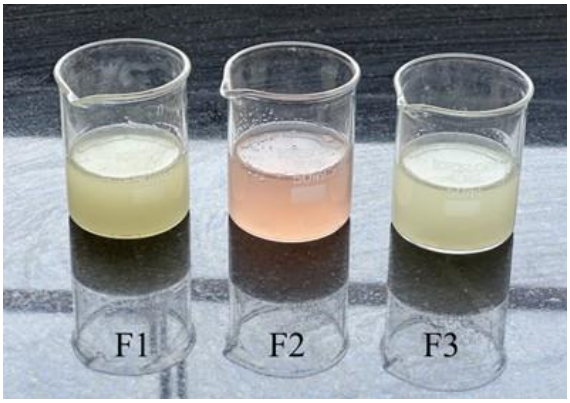

Figure 7: Final Formulation.

Evaluation

Organoleptic Evaluation

Color, odor, appearance, texture, consistency, cohesion, spreadability, and skin feel were among the organoleptic characteristics of the produced formulations that were assessed. Every batch had a non-greasy feel, a uniform look, a smooth texture, and adequate spreadability. F3 showed considerably higher skin adhesion and stiffness among the formulations.

Table 3: Organoleptic Evaluation of Under-Eye Gel Formulations.

Sr No.	Parameter	F1	F2	F3
1.	Color	Yellowish green	Peach	Light green
2.	Odor	Pleasant	Pleasant	Pleasant
3.	Texture	Soft	Smooth & soft	Smooth & slightly firm
4.	Appearance	Homogeneous	Glossy & homogeneous	Homogeneous
5.	Consistency	Semi-solid	Semi-solid	Semi-solid with better firmness
6.	Feel on application	Cooling & smooth	Cooling & smooth	Smooth with better adherence
7.	Greasiness	Non-greasy	Non-greasy	Non-greasy
8.	Ease of washability	Easily washable	Easily washable	Moderately washable

Physicochemical evaluation

To determine the generated polyherbal under-eye gel compositions quality, stability, and topical applicability, a number of physicochemical parameters were assessed. Standard methods were used to assess parameters such as pH, homogeneity, viscosity, spreadability, washability, and irritancy. The assessments were conducted at room temperature, and each formulation's observations were meticulously documented (F1–F3).

pH Determination

A pH meter was used to measure the produced gel compositions pH at room temperature. The pH was measured after dispersing around 1 g of gel in 10 mL of distilled water. All formulations were found to have pH values between 5.7 and 6.5, which is thought to be appropriate for topical application and compatible with the pH of normal skin. The acquired pH values show that the formulations are well suited for application on the sensitive area under the eyes and that there is a decreased risk of skin irritation.[6]

Homogeneity

The prepared formulations were visually inspected for homogeneity, appearance, and consistency after complete gel formation. Phase separation, lumps, aggregates, and grittiness were all looked for in the gels. The smooth texture, consistent appearance, and acceptable homogeneity of all formulations suggested that the polymers and herbal extracts were properly dispersed throughout the gel basis.

Viscosity

A viscometer was used to measure the compositions' viscosity at room temperature. It was discovered that the viscosity increased as the concentration of HPMC and Carbopol 934 increased, which enhanced the stability and consistency of the gel. Because of its increased polymer concentration, F3 had the highest viscosity of all the formulations, which improved hardness and retention on the skin's surface.[7]

Spreadability

In order to assess spreadability, a defined amount of gel was placed between two glass slides, and the ease of spreading under the influence of a given weight was measured. For topical formulations, good spreadability is crucial since it guarantees even application across the skin's surface. Every formulation displayed adequate spreadability. Spreadability dropped from F1 to F3 as the concentration of polymer increased. Because of its reduced viscosity and softer consistency, formulation F1 had the best spreadability, while formulation F3 had the

worst spreadability due to its increased viscosity from higher concentrations of Carbopol 934 and HPMC. However, the gel was better retained and adhered to the skin's surface due to F3's decreased spreadability.[84]

Washability

A tiny amount of gel was applied to the skin, and then the skin was washed under running water to assess washability. The formulations were evaluated based on how easy they were to remove and how much residue remained after washing. All formulations demonstrated acceptable cosmetic qualities for topical application, with low residue and good washability.

Irritancy Test

The irritancy test was carried out by applying a small quantity of gel on the dorsal surface of the skin and observing for any signs of redness, itching, irritation, or edema over a period of 24 hours. None of the created formulations showed any obvious evidence of sensitivity or irritation, indicating that the gels were safe and appropriate for topical administration on the area beneath the eyes.[9]

Stability Studies

The prepared polyherbal under-eye gel formulations (F1–F3) were subjected to stability studies in order to evaluate their physical stability under different storage conditions. The formulations were stored at room temperature (25 ± 2°C) and accelerated temperature conditions (40 ± 2°C) for a period of 30 days. [10] The study was carried out to determine the stability and suitability of the prepared formulations for topical application during storage.

Table 4: Room Temperature Stability Study of Under-Eye Gel Formulations (25 ± 2°C) after 30 days.

Parameter	F1	F2	F3
Colour	Yellowish green	Pinkish brown	Light green
Odour	Pleasant	Pleasant	Pleasant
pH	5.7	5.9	6.0
Homogeneity	Maintained	Maintained	Maintained
Consistency	Slightly reduced	Stable	Stable
Texture	Smooth	Smooth and glossy	Smooth with better firmness
Phase separation	Absent	Absent	Absent

Table 5: Accelerated Stability Study of Under-Eye Gel Formulations (40 ± 2°C) after 30

days.

Parameter	F1	F2	F3
Colour	Slightly faded	No significant change	No significant change
Odour	Slightly reduced	Stable	Stable
pH	5.5	5.8	6.0
Homogeneity	Slightly reduced	Maintained	Maintained
Consistency	Reduced	Slightly reduced	Stable
Texture	Slightly thin	Smooth	Smooth with better firmness
Phase separation	Absent	Absent	Absent

According to the stability analysis, all of the produced formulations maintained their physical stability throughout the investigation. There were no signs of phase separation, microbiological contamination, or noticeable color or homogeneity changes. In F1 and F2, slight alterations in pH, consistency, and texture were noted when the temperature was raised. Over the course of the investigation, formulation F3 demonstrated superior stability with no change in physicochemical properties. The higher concentration of Carbopol 934 and HPMC may have contributed to the enhanced stability of F3 by improving the gel's strength and consistency throughout storage.

RESULT AND DISCUSSION

Table 6 shows the comparative evaluation of formulations F1, F2, and F3 based on various physicochemical parameters.

Table 6: Comparison of F1, F2 & F3.

Evaluation Test	Batch F1	Batch F2	Batch F3
Homogeneity	Smooth and uniform	Smooth and uniform	Uniform with slight air bubbles
pH Value	5.92	6.28	6.22
Viscosity	3,850 cP	6,950 cP	9,810 cP
Spreadability	15.42 g·cm/s	11.5 g·cm/s	6.12 g·cm/s
Washability	Easily washable	Easily washable	Moderately washable
Irritancy Test	No irritation observed	No irritation observed	No irritation observed

Batch F3 is the most successful formulation created in this research, according to the evaluation results. The higher concentration of Carbopol 934 and HPMC, which enhanced the formulation's consistency, retention, and skin adhesion, may be the cause of F3's increased viscosity and decreased spreadability. Its texture is smooth and lump-free, and its appearance is elegant and transparent. Its pH of 6.2 is exactly within the range of natural skin, so it won't

irritate or redden the eyes.

pH Study Under Room Temperature Conditions

The pH values of the formulations stored under room temperature conditions showed minimal variation throughout the study period. The observed pH range was found to be suitable for topical application and indicated good stability of the prepared formulations.

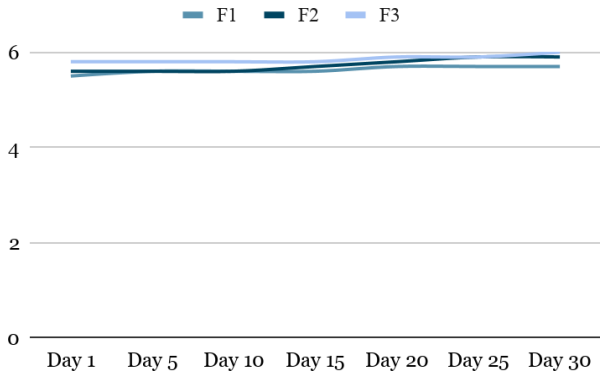

Figure 8: pH values of samples stored under room temperature conditions.

Comparative Viscosity of Polyherbal Under-Eye Gel Formulations

The viscosity of the formulations was found to increase from F1 to F3 with increasing polymer concentration. Variation in viscosity among the formulations may be attributed to differences in the concentration of Carbopol 934 and HPMC used in the gel base.

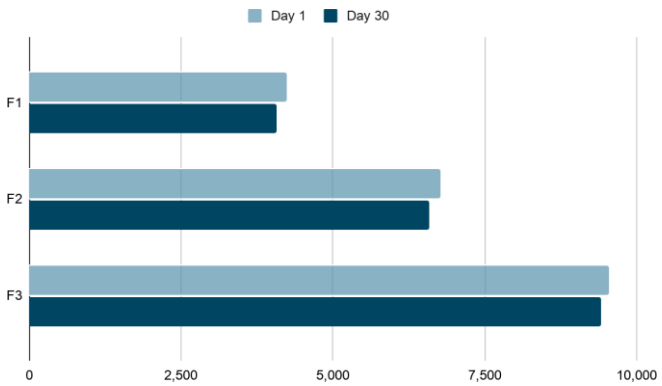

Figure 9: Comparative viscosity of polyherbal under-eye gel formulations.

Spreadability of Polyherbal Under-Eye Gel Formulations

Spreadability of the prepared formulations was determined using the slip and drag method and calculated using the following equation:

Where,

S = Spreadability (g·cm/s)

M = Weight tied to the upper slide (g)

L = Length moved by the glass slide (cm) T = Time taken to separate the slides (s)

Spreadability Values F1 = 15.42 g·cm/s F2 = 11.50 g·cm/s F3 = 6.12 g·cm/s

Packaging

The prepared polyherbal under-eye gel was packed in a 20 mL transparent roll-on container. The container consisted of a stainless-steel roller ball fitted with a leak-proof closure to ensure convenient application and minimize contamination. The airtight cap helped protect the formulation from moisture loss and external environmental exposure during storage.

Storage Condition

The prepared polyherbal under-eye gel was stored in a cool and dry place away from direct sunlight and excessive heat. The formulation was kept in a tightly closed container to maintain its stability, consistency, and effectiveness during storage.

Directions for use

Apply a small amount of the polyherbal under-eye gel gently over the under-eye area using the roll-on applicator. Massage lightly in circular motion until completely absorbed. For best results, use twice daily on clean and dry skin.

Figure 10: Final Prepared Under-Eye Gel Formulation (F3).

CONCLUSION

The present study successfully formulated and evaluated a polyherbal under-eye gel containing extracts of licorice, cucumber, green tea, and beetroot using Carbopol 934 and HPMC as gelling agents. The prepared formulations exhibited satisfactory physicochemical properties, stability, and suitability for topical application. Among all batches, formulation F3 demonstrated superior viscosity, consistency, texture, and stability. The herbal extracts incorporated into the formulation showed potential antioxidant, soothing, and depigmenting effects, indicating the suitability of the polyherbal gel for under-eye care applications. However, further pharmacological and clinical studies are required to confirm its long-term safety and efficacy.

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