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Review Article

FORMULATION AND EVALUATION OF AN ANTIOXIDANT CREAM FOR PROTECTION AGAINST FREE RADICAL–INDUCED SKIN DAMAGE

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Abstract:

Oxidative stress caused by free radicals plays a major role in premature skin aging, inflammation, and various dermatological disorders. Antioxidants are capable of neutralizing reactive oxygen species and protecting skin cells from oxidative damage. The present study was aimed at the formulation and evaluation of an antioxidant cream intended for topical application. An oil-in-water (O/W) cream base was selected due to its non-greasy nature and better patient acceptability. The antioxidant was incorporated into the cream using a conventional emulsification method, ensuring stability and uniform distribution. The formulated cream was evaluated for physicochemical parameters such as appearance, pH, viscosity, spreadability, and content uniformity. In-vitro antioxidant activity was assessed using standard free radical scavenging assays. The developed antioxidant cream showed satisfactory physical characteristics, skin-compatible pH, good spreadability, and significant antioxidant activity. The results suggest that the formulated antioxidant cream has potential for topical use in protecting the skin against oxidative stress and related damage.

Keywords: *Antioxidant cream; Oxidative stress; Free radicals; Topical formulation; Oil-in-water cream; Skin protection*

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1. INTRODUCTION:

Human skin acts as the primary protective barrier between the body and the external environment and is continuously exposed to physical, chemical, and biological stressors. Among these, oxidative stress is considered one of the most significant contributors to skin damage and premature aging. Oxidative stress arises due to an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms. Excessive ROS generation leads to cellular damage affecting lipids, proteins, and nucleic acids, ultimately impairing normal skin structure and function.

Reactive oxygen species such as superoxide anion, hydroxyl radicals, and hydrogen peroxide are generated in the skin through various endogenous and exogenous sources. Normal metabolic processes, mitochondrial respiration, and inflammatory responses are endogenous contributors, while ultraviolet (UV) radiation, pollution, cigarette smoke, and chemical exposure represent major external sources. Prolonged exposure to these factors accelerates oxidative damage, leading to skin aging, hyperpigmentation, inflammation, reduced elasticity, and increased susceptibility to dermatological disorders.[1]

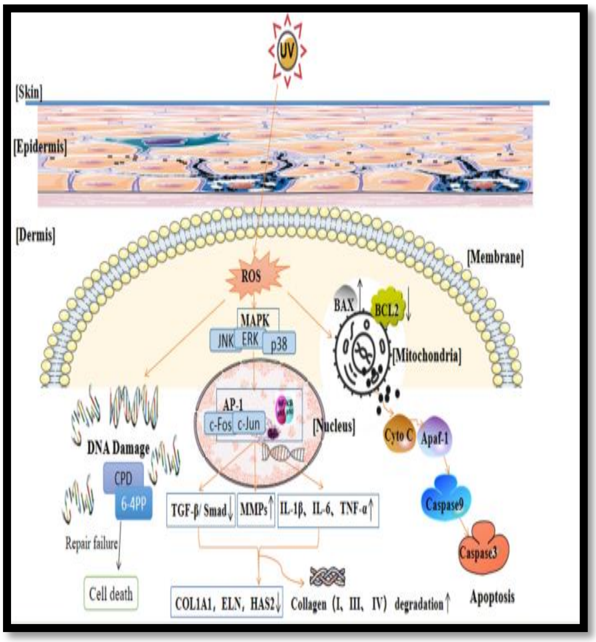

Figure 1: Generation of Reactive Oxygen Species and Oxidative Stress in Skin Cells

The human body possesses an intrinsic antioxidant defense system designed to counteract oxidative stress. This defense includes enzymatic antioxidants such as superoxide dismutase, catalase, and glutathione peroxidase, along with non-enzymatic antioxidants like vitamins, phenolic compounds, and flavonoids. However, under conditions of excessive oxidative burden, endogenous antioxidant systems become insufficient, making external supplementation necessary. Topical delivery of antioxidants has therefore gained considerable attention as an effective approach to reinforce the skin's protective mechanisms.[2]

Antioxidants function by neutralizing free radicals, inhibiting chain reactions, and preventing oxidative damage to cellular components. They donate electrons to unstable free radicals, thereby stabilizing them and reducing their reactivity. In dermatological applications, antioxidants are particularly valuable because they can act directly at the site of ROS generation. Regular topical application of antioxidants has been reported to improve skin hydration, reduce inflammation, enhance collagen synthesis, and delay visible signs of aging.[3]

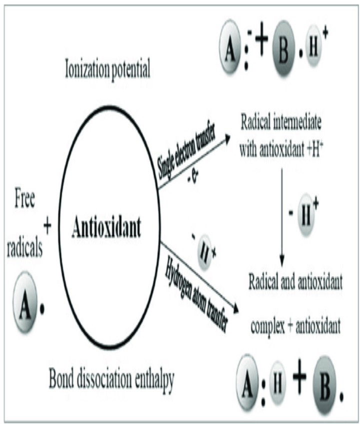

Figure 2: Mechanism of Antioxidant Action in Neutralization of Free Radicals

Among the various topical dosage forms, creams are widely preferred due to their ease of application, patient compliance, and cosmetic acceptability. Creams provide a suitable vehicle for delivering antioxidants to the skin surface while maintaining adequate contact time for absorption. Oil-in-water (O/W) creams are especially advantageous as they are non-greasy, easily washable, and suitable for all skin types. The emulsion-based structure of creams allows effective incorporation of both hydrophilic and lipophilic antioxidants, improving formulation versatility.[4]

Formulating antioxidants into topical creams presents certain challenges, including poor stability, sensitivity to light and oxygen, and limited skin penetration. Antioxidants such as vitamins and phenolic compounds are prone to degradation when exposed to environmental factors. Therefore, careful selection of formulation components and preparation methods is essential to preserve antioxidant activity and ensure product stability. The use of suitable emulsifiers, stabilizers, preservatives, and pH modifiers plays a crucial role in developing an effective antioxidant cream.[5]

Natural antioxidants derived from plant sources have gained increasing interest due to their safety, biocompatibility, and multifunctional therapeutic benefits. Herbal antioxidants such as flavonoids, polyphenols, and vitamins exhibit strong free radical scavenging activity along with anti-inflammatory and anti-aging properties. Incorporation of these antioxidants into topical creams offers a promising strategy for developing safer and more effective dermatological formulations.[6]

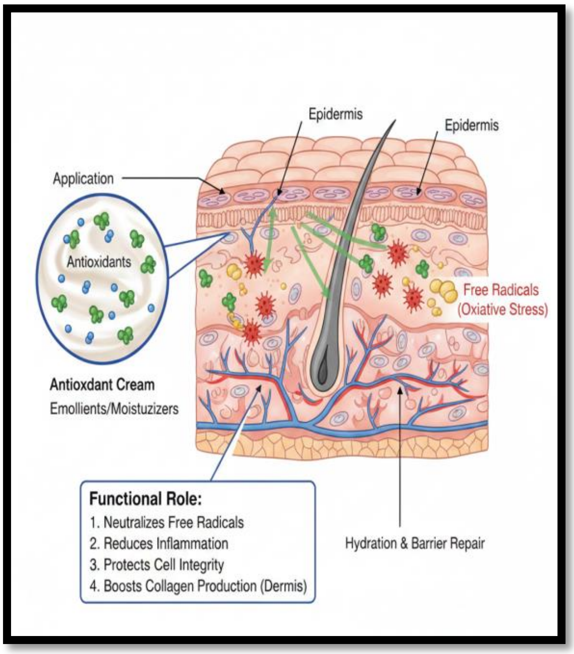

Figure 3: Structural Components and Functional Role of an Antioxidant Cream

Evaluation of antioxidant creams is essential to ensure their quality, safety, and therapeutic performance. Physicochemical parameters such as pH, viscosity, spreadability, and homogeneity determine user acceptability and stability. In addition, in-vitro antioxidant assays help in assessing the free radical scavenging potential of the formulated cream. These evaluations provide scientific evidence supporting the effectiveness of the formulation and guide further optimization.[7]

In this context, the present study was undertaken to formulate and evaluate an antioxidant cream using a conventional oil-in-water emulsion technique. The formulation was designed to achieve skin-compatible properties, adequate stability, and effective antioxidant activity. The study aims to contribute to the development of a safe and efficient topical antioxidant preparation capable of protecting the skin from oxidative stress and related damage.[8]

2. MATERIALS AND METHODS:

2.1 Materials Used

The materials selected for the present study were chosen based on their pharmaceutical acceptability, safety for topical application, and compatibility with antioxidant cream formulation. The active antioxidant was selected from either a vitamin-based or natural antioxidant source known for strong free radical scavenging activity and skin-protective effects. Excipients required for cream formulation included oil phase components, emulsifying agents, humectants, preservatives, and purified water. All chemicals and reagents used were of analytical or pharmaceutical grade. The excipients were selected to ensure stability, ease of application, appropriate skin feel, and adequate drug release. Purified water was used throughout the formulation process. The selection of ingredients was guided by literature reports on topical antioxidant formulations and standard pharmacopeial guidelines to ensure reproducibility and formulation safety.[9]

Table 1: List of Materials Used in Antioxidant Cream Formulation[10,11,12,13]

Sr. No.	Material	Category	Role
1	Antioxidant (Vitamin / Herbal extract)	Active ingredient	Free radical scavenging
2	Stearic acid	Oil phase	Cream base, consistency
3	Cetyl alcohol	Oil phase	Emollient, thickening agent
4	Liquid paraffin	Oil phase	Moisturizer
5	Triethanolamine (TEA)	Emulsifier	Emulsion formation
6	Glycerin	Humectant	Skin hydration
7	Methyl paraben	Preservative	Microbial protection
8	Propyl paraben	Preservative	Stability enhancement
9	Purified water	Vehicle	Dispersion medium

2.2 Selection of Cream Base

An oil-in-water (O/W) cream base was selected for the formulation due to its superior cosmetic acceptability and patient compliance. O/W creams are non-greasy, easily washable, and suitable for prolonged topical application. The aqueous continuous phase allows better skin feel, while the dispersed oil phase provides emollient properties. Such creams are preferred for antioxidant delivery as they enable uniform distribution of the active ingredient on the skin surface. Additionally, O/W creams facilitate better release of hydrophilic antioxidants and are suitable for all skin types. The selected base also allows incorporation of stabilizers and preservatives to protect the antioxidant from degradation. The choice of base was therefore critical to ensure both stability and therapeutic effectiveness of the formulated cream[14,15].

2.3 Pre-formulation Considerations

Pre-formulation studies were conducted to ensure the compatibility of the antioxidant with selected excipients and to predict formulation stability. The antioxidant was evaluated for its solubility characteristics in aqueous and oil phases. Visual compatibility studies were carried out by mixing the antioxidant with individual excipients to observe any physical changes such as precipitation, color change, or phase separation. The stability of the antioxidant at different pH ranges was also considered, as skin-compatible formulations require a pH between 5.5 and 6.5. These preliminary assessments helped in selecting suitable formulation conditions and avoiding degradation of the antioxidant during processing and storage.[16,17]

2.4 Formulation Design of Antioxidant Cream

The formulation of antioxidant cream was designed using a conventional emulsification technique. The formulation involved separation of ingredients into oil and aqueous phases to ensure proper emulsification. The concentration of the antioxidant was optimized to achieve effective antioxidant activity without causing skin irritation. The ratio of oil to aqueous phase was carefully selected to obtain the desired consistency, spreadability, and stability. Preservatives were included to prevent microbial growth, while humectants were added to improve skin hydration. The formulation design was finalized after reviewing standard cream formulations reported in pharmaceutical literature.[18]

2.5 Method of Preparation of Antioxidant Cream

The antioxidant cream was prepared using the standard hot emulsification method. Initially, the oil phase consisting of stearic acid, cetyl alcohol, and liquid paraffin was accurately weighed and melted together on a water bath at a temperature of 70–75°C. Separately, the aqueous phase was prepared by dissolving glycerin, preservatives, and other water-soluble components in purified water and heating to the same temperature. The hot aqueous phase was slowly added to the oil phase with continuous stirring to form a stable emulsion. The mixture was stirred continuously until uniformity was achieved. The antioxidant was incorporated during the cooling phase (below 40°C) to prevent thermal degradation. The final product was homogenized to obtain a smooth, uniform cream and stored in suitable containers for evaluation.[19]

2.6 Formulation Composition

The optimized formulation composition of the antioxidant cream is presented to ensure reproducibility. The concentrations of ingredients were selected based on standard topical formulation practices and literature support.[20,21]

Table 2: Composition of Optimized Antioxidant Cream

Ingredient	Quantity (% w/w)
Antioxidant	0.5–1.0
Stearic acid	10.0
Cetyl alcohol	2.0
Liquid paraffin	5.0
Glycerin	5.0
Triethanolamine	q.s
Methyl paraben	0.15
Propyl paraben	0.05
Purified water	q.s to 100

2.7 Evaluation of Antioxidant Cream

The formulated antioxidant cream was subjected to various evaluation parameters to assess its quality, stability, and suitability for topical application.

2.7.1 Physical Appearance and Homogeneity

The cream was visually examined for color, odor, texture, and homogeneity. A small quantity of cream was pressed between the thumb and index finger to detect the presence of any grittiness or coarse particles. Homogeneous appearance without phase separation indicated uniform dispersion of ingredients. This evaluation ensured cosmetic acceptability and patient compliance.[22]

2.7.2 Determination of pH

The pH of the cream was determined using a calibrated digital pH meter. One gram of cream was dispersed in distilled water and the pH was measured at room temperature. Maintaining a skin-friendly pH is essential to avoid irritation and ensure compatibility with normal skin physiology.

2.7.3 Spreadability

Spreadability of the cream was determined to assess ease of application. A measured amount of cream was placed between two glass slides and compressed. The diameter of the spread was measured after a fixed time. Good spreadability indicates easy application and better patient acceptability.[23]

2.7.4 Viscosity Measurement

Viscosity was measured using a Brookfield viscometer to determine the flow behavior of the cream. Appropriate viscosity ensures ease of application, stability, and retention on the skin surface.

2.7.5 Drug Content Uniformity

The antioxidant content in the cream was determined to ensure uniform distribution of the active ingredient. A known quantity of cream was dissolved in a suitable solvent, filtered, and analyzed using a UV-visible spectrophotometer.[24]

2.7.6 In-Vitro Antioxidant Activity

The antioxidant activity of the formulated cream was evaluated using standard in-vitro free radical scavenging assays such as the DPPH method. The ability of the formulation to neutralize free radicals confirmed the functional effectiveness of the antioxidant after formulation.[25,26]

2.8 Stability Studies

Stability studies were conducted to evaluate the physical stability of the cream under different storage conditions. The formulation was stored at room temperature and accelerated conditions and observed for changes in appearance, pH, and phase separation. Stability assessment ensures shelf-life prediction and formulation reliability.[27]

6. Results and Discussion

The antioxidant cream formulated using an oil-in-water emulsion technique was evaluated for its physicochemical characteristics, stability, and antioxidant performance. The results obtained from various evaluation parameters indicate that the developed formulation possesses desirable properties for topical application. The discussion below interprets the observed results with respect to formulation quality, skin compatibility, and functional antioxidant efficacy.

6.1 Physical Appearance and Homogeneity

The formulated antioxidant cream exhibited a smooth, uniform, and glossy appearance with a pleasant odor. No signs of phase separation, grittiness, or aggregation were observed during visual inspection. Homogeneity testing confirmed uniform dispersion of the antioxidant throughout the cream base. The absence of coarse particles indicates effective emulsification and proper incorporation of formulation ingredients. These findings suggest that the selected excipients and emulsification method were appropriate for producing a stable and cosmetically acceptable cream. Good physical appearance is an essential parameter for topical formulations, as it directly influences patient compliance and acceptability during regular use.

6.2 pH Evaluation

The pH of the formulated antioxidant cream was found to be within the range of **5.8–6.2**, which is considered ideal for topical application. This pH range closely matches the natural pH of human skin and helps prevent irritation, dryness, or disruption of the skin barrier. Maintaining a skin-compatible pH is particularly important for antioxidant formulations, as extreme pH conditions may reduce antioxidant stability and efficacy. The observed pH values indicate that the formulation is safe for prolonged topical use and suitable for different skin types.

6.3 Spreadability and Viscosity

Spreadability studies revealed that the antioxidant cream spreads easily under minimal applied force, indicating good ease of application. Adequate spreadability ensures uniform distribution of the cream over the skin surface, enhancing therapeutic effectiveness. Viscosity measurements showed that the formulation possesses moderate viscosity, which allows easy application while maintaining sufficient retention on the skin. A balance between viscosity and spreadability is crucial in cream formulations to avoid excessive run-off or difficulty during application. The optimized formulation achieved this balance effectively, contributing to improved user convenience and formulation performance.

6.4 Drug Content Uniformity

Drug content analysis demonstrated uniform distribution of the antioxidant within the cream matrix. The percentage drug content was found to be within acceptable limits, indicating minimal loss of active ingredient during formulation. Uniform drug distribution ensures consistent antioxidant delivery at the site of application and reflects the efficiency of the mixing and homogenization process. These results confirm that the formulation method employed is suitable for incorporating antioxidants into topical cream bases without compromising content uniformity.

Table 1: Physicochemical Evaluation Results of Antioxidant Cream

Parameter	Observed Result	Interpretation
Appearance	Smooth, uniform	Acceptable
Homogeneity	No grittiness	Good
pH	5.8–6.2	Skin compatible
Spreadability	Good	Easy application
Viscosity	Moderate	Stable and applicable
Drug content	98–101%	Uniform distribution

6.5 In-Vitro Antioxidant Activity

The antioxidant activity of the formulated cream was evaluated using standard free radical scavenging assays. The results indicated significant antioxidant activity, demonstrating that the antioxidant retained its functional efficacy after incorporation into the cream base. The formulation showed concentration-dependent free radical scavenging activity, confirming effective interaction between the antioxidant and free radicals. The results suggest that the cream base did not interfere with antioxidant performance, but rather provided a suitable medium for antioxidant delivery to the skin surface.

The graphical representation shows an increase in percentage scavenging activity with increasing concentration of the cream, indicating dose-dependent antioxidant action. This confirms the effectiveness of the formulation in neutralizing free radicals responsible for oxidative skin damage.

6.6 Stability Studies

Stability studies were conducted to assess the physical stability of the antioxidant cream under different storage conditions. The formulation remained stable with no significant changes in appearance, pH, or homogeneity during the study period. No phase separation or color change was observed, indicating good formulation stability. Stability is a critical parameter for antioxidant creams, as antioxidants are often sensitive to environmental conditions. The observed stability suggests that the selected excipients and formulation method effectively protected the antioxidant from degradation.

Table 2: Stability Study Results of Antioxidant Cream

Storage Condition	Appearance	pH	Phase Separation
Initial	Normal	6.0	Absent
Room temperature	Normal	5.9	Absent
Accelerated condition	Normal	5.8	Absent

SUMMARY AND CONCLUSION:

In the present investigation, an antioxidant cream was formulated and evaluated with the objective of developing an effective topical preparation for protection against oxidative skin damage. An oil-in-water emulsion system was selected to enhance cosmetic acceptability and ease of application. The prepared cream demonstrated desirable physical characteristics, including uniform texture, smooth appearance, suitable viscosity, and a skin-friendly pH range. Evaluation studies confirmed consistent distribution of the antioxidant throughout the formulation and revealed appreciable in-vitro free radical scavenging activity, indicating preservation of antioxidant functionality within the cream base. Stability assessment showed no noticeable changes in physical properties under tested conditions, suggesting good formulation stability. The findings of this study indicate that the developed antioxidant cream is safe, stable, and effective for topical use. Such a formulation may serve as a promising approach for protecting the skin from oxidative stress and associated damage. Further experimental and clinical studies are recommended to explore its long-term efficacy and therapeutic benefits.

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