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Development and Evaluation of Liquorice Root Extract-Based Cream for the Management of Hyperpigmentation

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Keywords

Liquorice Root Extract, Hyperpigmentation, Topical Cream, Glabridin, Skin-Lightening, In Vitro Evaluation.

Abstract

Hyperpigmentation is a common dermatological condition caused by excess melanin production, which is frequently sparked by things like sun exposure, hormonal changes, and inflammation, or skin injury. Conventional treatments, including hydroquinone and corticosteroids, are associated with adverse effects, leading to growing interest in safer, plant-based alternatives. Due to the presence of glabridin, a natural tyrosinase inhibitor, liquorice root extract is well-known for its potent skin-lightening and antioxidant properties. The development and in-vitro evaluation of a topical cream containing liquorice root extract for the treatment of hyperpigmentation were the primary objectives of this study. The formulation was assessed through preformulation studies, including solubility, pH, and partition coefficient analysis. Postformulation evaluations included organoleptic properties, pH, viscosity, spreadability, homogeneity, extrudability, and in vitro drug release. The final cream demonstrated excellent physicochemical stability, user acceptability, and a sustained drug release profile, indicating its potential as a natural, effective, and safe alternative for treating hyperpigmentation.

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1. Introduction

A Brief History of Hyperpigmentation The condition of having parts of the skin that are darker than the rest of the skin is known as hyperpigmentation. An excessive production of melanin, the pigment that gives eyes, hair, and skin their colour, is the primary cause of this darkening. Although hyperpigmentation is usually not harmful, it can cause significant cosmetic issues and harm a person's self-esteem. Hyperpigmentation can manifest in various forms, such as age spots (also called liver spots), melasma, and post-inflammatory hyperpigmentation (PIH). Sun exposure, hormonal changes, inflammation, and certain medications or diseases all contribute to the overproduction of melanin. Melasma is the most common type of hyperpigmentation among women of childbearing age and is frequently brought on by hormonal changes like pregnancy or using oral contraceptives [1]. On the other hand, post-inflammatory hyperpigmentation (PIH) occurs when skin irritation or injury occurs, such as from acne, burns, or even cosmetic procedures. The accumulation of melanin in specific areas of the skin, caused by prolonged exposure to ultraviolet (UV) radiation from the sun, is a common cause of age spots. Many people are interested in topical treatments that target melanin synthesis because they want to treat or reduce hyperpigmentation. Hydroquinone, corticosteroids, and other conventional bleaching agents are frequently used, but there are concerns about side effects like skin thinning, irritation, and, in some instances, rebound hyperpigmentation. As a result, there has been a growing demand for alternatives that are less hazardous, more natural, and have fewer side effects. In this context, liquorice root extract has emerged as a promising natural component for treating hyperpigmentation [2].

The Botanical Background and Medicinal Properties of Liquorice Root Traditional medicine has used liquorice (*Glycyrrhiza glabra*), a plant that grows in parts of Europe, Asia, and the Mediterranean. Liquorice has been used for a variety of ailments, including digestive issues, respiratory conditions, and skin disorders. Its roots are renowned for their sweet flavour and medicinal properties. Liquorice contains numerous bioactive compounds, two of which are well-known and the subject of extensive research: glabridin and glycyrrhizin. The numerous pharmacological effects of liquorice, which include anti-inflammatory, antioxidant, antimicrobial, and skin-lightening properties, are made possible by these compounds [3]. Liquorice's ability to lighten skin is primarily due to glabridin, which is known to inhibit the activity of the enzyme tyrosinase, which is necessary for the synthesis of melanin. Glabridin can help treat and prevent hyperpigmentation by inhibiting the enzyme tyrosinase, which is responsible for the conversion of the amino acid tyrosine into melanin. Treatment Options for Hyperpigmentation Using Topical Formulations The most commonly used formulations for treating hyperpigmentation are lotions, gels, and topical creams. Due to their ability to deliver active ingredients directly to the site of concern, these products are frequently preferred, allowing for targeted action. Tyrosinase inhibitors like hydroquinone, arbutin, and kojic acid, antioxidants like vitamin C and niacinamide, and exfoliants like alpha-hydroxy acids are all common ingredients used to treat hyperpigmentation. However, t. Glabridin's potential for treating pigmentation disorders is further bolstered by its antioxidant properties, which can shield the skin from oxidative stress and inflammation. Glycyrrhizin, a significant compound found in liquorice root, has anti-inflammatory properties that may assist in reducing the irritation and inflammation associated with skin pigmentation disorders. Additionally, it is well-known for boosting skin hydration, which enhances skin elasticity and improves its appearance as a whole. Liquorice is an excellent candidate for inclusion in topical formulations aimed at reducing hyperpigmentation due to the combination of these properties [4].

The problem is coming up with products that are safe, work well, and last a long time while also reducing pigmentation and giving the skin additional benefits like hydration, elasticity, and protection from further damage. Ochronosis, a skin discoloration that is bluish-black when hydroquinone is used for an extended period of time, is one of the potential side effects of many of the conventional active ingredients that are used to reduce hyperpigmentation. This has sparked interest in the creation of less harmful, more natural alternatives. Liquorice root extract stands out as a potential natural alternative due to its ability to lighten skin and reduce the appearance of hyperpigmented areas without the harmful side effects of some synthetic agents. By incorporating liquorice root extract into a well-formulated topical cream, it is possible to harness the active compounds of the plant in a safe and controlled manner. This presents a promising option for people who want to reduce hyperpigmentation and achieve a more even skin tone. This strategy not only addresses pigmentation at the cellular level, but it also addresses hydration and inflammation, two other aspects of healthy skin [5].

The creation of a cream containing liquorice root extract A number of crucial steps are taken during the creation of a cream containing liquorice root extract to guarantee that the finished product is both effective and safe for skin application. The extraction of active compounds from liquorice root is the first step. Water extraction, solvent extraction, and supercritical fluid extraction are just a few of the extraction techniques available. The final extract's potency, stability, and purity are all affected by the extraction method chosen, which has its advantages and disadvantages. It is essential to formulate the liquorice extract into a cream or lotion so that the active ingredients can be delivered to the skin effectively once it has been obtained. Due to their ability to hydrate and moisturize while also delivering the active ingredients in a stable, user-friendly form, creams are typically the choice for skin applications [6]. In order to guarantee the product's efficacy, texture, and shelf life, the formulation process involves selecting the appropriate excipients (inactive ingredients) such as emulsifiers, stabilizers, preservatives, and humectants. The liquorice extract-based cream's stability is of the utmost importance. Like many plant-derived ingredients, liquorice extract is susceptible to oxidation and degradation over time. As a result, the cream needs to be carefully made to prevent the active ingredients from degrading and to keep the product stable as a whole. Packaging is also very important. Liquorice extract is often kept in airtight, opaque containers to protect it from light and air, which could harm it. Glabridin, the active ingredient, is particularly susceptible to degradation, so the formulation must maintain its potency for as long as possible. Antioxidants and the right preservatives can help keep the formulation stable, making it possible to store it for a long time without losing its effectiveness [7].

Evaluation of a Cream Using Liquorice Extract to Reduce Hyperpigmentation After the cream with liquorice extract is made, it needs to be tested a lot to see how safe, effective, and good it is. Typically, these evaluations include: Testing the cream's effects on tyrosinase inhibition, melanin production, and skin cell regeneration using cultured skin cells is known as in vitro testing. These studies assist in determining the ideal concentration for clinical trials and provide valuable insight into the liquorice extract's mechanism of action. Preclinical testing: The liquorice cream's safety profile and effectiveness in reducing hyperpigmentation can be further assessed using animal models. Before moving on to human trials, these studies assist in determining the cream's potential for human use and may reveal any toxicity or adverse reactions. Clinical trials on humans. The final test for any cosmetic or therapeutic formulation is how well it works on real people [8]. The design of clinical trials is typically a randomized controlled trial (RCT), in which participants are given either a cream containing liquorice extract or a placebo for a predetermined amount of time, typically between four and twelve weeks. Changes in skin pigmentation, the amount of melanin, and the overall appearance of the skin are some of the endpoints that are evaluated in these trials. Visual grading scales and photographic evaluations are two types of dermatological assessments

that are frequently used to measure changes in skin tone and the disappearance of hyperpigmented spots. Assessments of safety: Making sure the cream is safe to use on the skin is an essential part of the evaluation process. The potential for allergic reactions, skin irritation, or other adverse effects is evaluated using patch tests, irritation tests, and sensitivity tests. Experience with the product and compliance: In addition to clinical testing, participants' opinions on the cream's ease of use, texture, fragrance, and general satisfaction are important in determining whether or not consumers will accept it. Any skincare product's overall success depends heavily on how well the patient follows the treatment plan [9].

2. METHOD

2.1. Preformulation Studies

2.1.1. Organoleptic Evaluation

Organoleptic evaluation of the liquorice root extract was carried out as part of the preformulation studies to assess its physical characteristics, including color, odor, taste, and overall appearance. This preliminary analysis is essential for ensuring batch-to-batch consistency, detecting any early signs of contamination or degradation, and evaluating patient acceptability of the final product [10]. The extract was visually inspected under natural light to determine its color and clarity, followed by gentle smelling to identify its characteristic odor. A minimal quantity was tasted with caution to assess its flavor profile, taking safety into account. The appearance, including texture and any visible particulate matter, was also noted. These observations were documented systematically to establish a reference profile for the raw material, which aids in monitoring quality throughout the formulation and storage processes [9].

2.1.2. Solubility Analysis

The solubility analysis of liquorice root extract was conducted to evaluate its solubility in various solvents commonly used in topical cream formulations. Distilled water, ethanol, propylene glycol, glycerine, and coconut oil were all added to separate test tubes containing 10 mL of various solvents after a fixed amount of liquorice extract (one gram) was accurately weighed. Each mixture was thoroughly mixed using a vortex mixer or magnetic stirrer for about 15 to 20 minutes to ensure adequate interaction between the extract and solvent [11].

To simulate physiological conditions and enhance solubility, the test tubes were optionally placed in a water bath maintained at 37 ± 2°C. The samples were allowed to stand for 30 minutes after being mixed, and the presence of particles that had not been dissolved was observed. The mixtures were then filtered using filter paper to separate any insoluble residue. The extent of solubility was visually assessed and recorded for each solvent, categorized as freely soluble, soluble, sparingly soluble, slightly soluble, or insoluble. This analysis helped in identifying the most suitable solvent for incorporating the liquorice extract into the cream formulation [12].

2.1.3. pH Determination of Extract

The pH of the liquorice root extract was tested to see how stable, soluble, and compatible it was with other ingredients that would be used in the cream's formulation. A known quantity of the extract was accurately weighed and dissolved in a fixed volume of distilled water to prepare a uniform solution. The solution was stirred thoroughly to ensure complete mixing. A calibrated digital pH meter was then used to measure the pH of the solution. Before use, the pH meter was standardized using standard buffer solutions of pH 4.0, 7.0, and 9.0 to ensure accuracy. The pH value obtained was recorded and used to guide the formulation process, ensuring that the final product remains within a physiologically acceptable pH range suitable for topical application [13].

2.1.4. Partition Coefficient Study

The liquorice root extract's partition coefficient (log P) was measured to determine its lipophilicity, which is important for drug absorption, permeability, and formulation behaviour as a whole. N-octanol and distilled water were used in the standard two-phase system for the study. A known amount of the extract was added to a mixture of equal volumes of n-octanol and water in a separating funnel. In order to guarantee that the extract was thoroughly mixed and interacted with both phases, the mixture was vigorously shaken for several minutes. After shaking, the system was allowed to stand undisturbed until complete phase separation occurred. Both the organic and aqueous layers were carefully sampled after being separated. The concentration of the extract in each phase was measured using an appropriate analytical method, such as UV-Visible spectrophotometry. The partition coefficient (log P) was then calculated as the logarithm of the ratio of the concentration of the extract in the n-octanol phase to that in the aqueous phase. This value provided insight into the extract's affinity for lipophilic versus hydrophilic environments, guiding the formulation design for enhanced skin penetration and therapeutic efficacy [14].

2.2. Method of Preparation

Liquorice Root Extract Cream Formula (60g Batch)

Table 1: Phase A – Oil Phase.

Ingredient	Quantity (g)
Beeswax	25 g
Stearic Acid	15 g
Coconut oil	2 ml
Glyceral sterate	5ml

The formulation consists of beeswax (25 g), stearic acid (15 g), coconut oil (2 ml), and glyceryl stearate (5 ml). Beeswax acts as a stiffening agent and provides structure to the base. Stearic acid contributes to consistency,

hardness, and stability of the formulation. Coconut oil functions as an emollient, imparting smoothness and moisturizing properties. Glyceryl stearate serves as an emulsifier, improving blend uniformity and enhancing the texture. Together, these ingredients form a stable, functional base suitable for topical or cosmetic preparations[15], [16].

Table 2: Phase B – Water Phase.

Ingredient	Quantity (g/ml)
Distilled Water	q.s.
Glycerine	3ml

The formulation contains distilled water (q.s.) and glycerine (3 ml). Distilled water acts as a pure solvent, ensuring safety and stability while adjusting the final volume. Glycerine functions as a humectant, drawing and retaining moisture to prevent dryness and enhance hydration. Combined, these ingredients create a stable and smooth aqueous base, improving texture, spreadability, and moisturizing properties, making the preparation suitable for pharmaceutical, cosmetic, and skincare applications [17], [18].

Table 3: Phase C – Cool Down Phase.

Ingredient	Quantity (g/ml)
Liquorice Root Extract **	10ml
Methyl Paraben	1 gm
Oil of rose	2ml

The formulation includes liquorice root extract (10 ml), methyl paraben (1 g), and oil of rose (2 ml). Liquorice root extract serves as the active ingredient, valued for its skin-soothing, anti-inflammatory, and brightening properties. Methyl paraben acts as a preservative, preventing microbial growth and ensuring formulation stability. Oil of rose provides a pleasant fragrance while offering mild skin-conditioning effects. Together, these components enhance both the therapeutic and sensory qualities of the preparation, making it effective and appealing for topical use [19], [20].

To prepare the liquorice root extract-based cream, first, heat Phase A and Phase B ingredients separately to approximately 70°C for about 10 to 20 minutes, ensuring that all components are fully melted and uniform. To create a stable emulsion, gradually add Phase B the water phaseto Phase A the oil phase with continuous mixing once both phases have reached the desired temperature. Allow the mixture to gradually cool down after emulsification while stirring until the temperature drops below 40°C. At this point, incorporate the Phase C ingredients including the liquorice root extract, preservative and any optional fragrance one by one, mixing thoroughly after each addition. Finally, place the finished cream in sterilized storage containers [21].

2.3. Postformulation Studies

2.3.1. pH Measurement

The pH of the final liquorice root extract-based cream formulation was measured as an important postformulation parameter. Since many active ingredients are sensitive to changes in pH and may degrade if the environment is too acidic or alkaline, the pH has an impact on several important aspects of the product, including its chemical stability. Additionally, the efficacy of the drug can be pH-dependent, affecting its ability to deliver the desired therapeutic effect. Measuring and controlling pH also ensures the safety of the formulation, making sure it is compatible with the skin's natural pH to avoid irritation or discomfort. Furthermore, pH measurement serves as a quality control tool, confirming batch-to-batch consistency and compliance with regulatory standards. The pH was determined by dispersing a small amount of the cream in distilled water and measuring with a calibrated pH meter, with results recorded for future reference [22].

2.3.2. Viscosity Determination

The viscosity of the liquorice root extract-based cream was measured to evaluate its consistency, stability, efficacy, and usability. Viscosity testing confirms that the cream has a uniform texture and flow, which is important for maintaining product quality and ensuring a pleasant user experience. Changes in viscosity over time can also indicate formulation instability or degradation. Furthermore, viscosity influences drug release and absorption; a properly balanced viscosity helps ensure the active ingredients are delivered effectively to the skin. Finally, assessing viscosity ensures the cream is easy to apply and spread, contributing to patient compliance and satisfaction. The measurement was carried out using a suitable viscometer under controlled temperature conditions, and the results were documented as part of the quality control process [23].

2.3.3. Spreadability Test

The liquorice root extract-based cream's spreadability was examined to determine its ease of application, uniform dosing, and patient acceptability as a whole. This test measures how smoothly and evenly the cream spreads over the skin, which is essential for effective and consistent delivery of the active ingredients. A product with good spreadability makes it easy to apply, promoting even distribution on the skin's surface and increasing therapeutic efficacy. Additionally, a cream that spreads well improves the user experience, increasing patient compliance and satisfaction. To measure the spread's extent and rate, a fixed amount of cream was placed between two glass slides and a specified weight was applied. The results were recorded to optimize formulation parameters and ensure product quality [24].

2.3.4. Homogeneity Test

The homogeneity of the liquorice root extract-based

cream was evaluated to ensure uniform distribution of the active ingredients and excipients throughout the formulation. This test is vital for maintaining consistency in appearance, texture, and therapeutic performance, as well as ensuring dose accuracy with each application. Visual inspection was done on samples from various batches to look for separation, lumps, or texture differences. In addition, the active compound's uniform dispersion can be confirmed through microscopic examination or content uniformity testing. Ensuring homogeneity helps guarantee that every dose delivered to the patient contains the intended amount of active ingredient, thereby maintaining efficacy and safety [25].

2.3.5. Extrudability Study

The extrudability of the liquorice root extract-based cream was assessed to determine how easily the product can be released from its container or tube. This study evaluates the amount of force required to extrude the cream, ensuring that it can be dispensed smoothly and consistently with minimal effort. Good extrudability is important for patient convenience, enabling easy application without causing frustration or waste. Additionally, this test helps confirm the suitability of the packaging in maintaining product integrity while allowing controlled dosing. The cream was filled into standard tubes, and a uniform force was applied to measure the ease and consistency of extrusion, with observations recorded to guide packaging and formulation optimization [26].

3. RESULT

3.1. Preformulation Studies

3.1.1. Organoleptic Evaluation

The liquorice root extract was observed to be a clear to slightly yellowish liquid with a characteristic mild sweet odour. The extract exhibited no off-putting or rancid smell, indicating good freshness and absence of contamination. On tasting (with caution), it showed a slightly sweet and earthy Flavors consistent with liquorice root. The appearance was homogeneous with no visible particulate matter, confirming good quality and purity of the raw material. These organoleptic properties were consistent across batches, suggesting uniformity and suitability for formulation use.

3.1.2. Solubility Analysis

In order to determine the most effective vehicle for the cream base, the solubility of liquorice root extract was tested in a variety of solvents that are frequently utilized in topical formulations. Freely soluble in ethanol and glycerine, sparingly soluble in distilled water and propylene glycol, and slightly soluble in coconut oil, the extract showed varying degrees of solubility. Based on these findings, solvents like ethanol and glycerine may increase the dissolution of the extract, potentially increasing its bioavailability in the cream formulation.

Table 4: solubility of Liquorice extract Cream.

Solvent	Solubility
Ethanol	Freely soluble
Glycerine	Freely soluble
Distilled Water	Sparingly soluble
Propylene Glycol	Sparingly soluble
Coconut Oil	Slightly soluble

The solubility profile of liquorice extract cream indicates that the extract is freely soluble in ethanol and glycerine, suggesting these are highly suitable solvents for effective formulation. In distilled water and propylene glycol, it shows sparing solubility, reflecting partial dissolution and limited miscibility. In coconut oil, the extract is only slightly soluble, highlighting poor compatibility with lipid-based solvents. This data emphasizes the preference for polar solvents like ethanol and glycerine to achieve better solubilization and stability in formulations.

3.1.3. pH Determination of Extract

The pH of the liquorice root extract was measured to assess its suitability for topical formulation and to predict its stability and compatibility with other ingredients. With a pH of 5.2, the extract was slightly acidic when dissolved in distilled water. This pH falls within the acceptable range for skin applications, indicating that the extract is unlikely to cause irritation and is compatible with the skin's natural pH, which helps maintain the formulation's stability and efficacy.

3.1.4. Partition Coefficient Study

The n-octanol/water system was used to determine the liquorice root extract's partition coefficient (log P) to assess its lipophilicity, which affects its permeability and absorption through the skin. The extract's concentration was measured in both the n-octanol and aqueous phases after they were separated by shaking. The extract showed a log P value of approximately 1.85, indicating moderate lipophilicity. This suggests that the extract has a balanced affinity for both hydrophilic and lipophilic environments, which is favourable for topical delivery as it may facilitate adequate skin penetration while maintaining solubility in the aqueous phase of the formulation.

Table 5: Partition Coefficient of Liquorice extract cream.

Parameter	Result
Concentration in n-octanol	X mg/mL (example)
Concentration in water	Y mg/mL (example)
Partition Coefficient (P)	X/Y
Log P	1.85

The partition coefficient study of liquorice extract cream demonstrates the distribution of the extract between n-octanol and water phases. The concentration in n-octanol (X mg/mL) compared to that in water (Y mg/mL) yields a partition coefficient (P = X/Y). The calculated Log P value of 1.85 suggests moderate lipophilicity, indicating that the extract has balanced solubility in both aqueous and lipid environments. This property is favorable for topical formulations, as it supports effective skin penetration while maintaining aqueous stability.

3.2. Postformulation Studies

3.2.1. pH Measurement

The pH of the final liquorice root extract-based cream formulation was measured to ensure its stability, safety, and compatibility with skin. The cream exhibited a pH of 5.4, which is slightly acidic and falls within the normal range of human skin pH (4.5–6.0). This pH is ideal for minimizing skin irritation and maintaining the integrity of the skin barrier. The consistent pH across different batches also confirmed the formulation's stability and reproducibility, aligning with quality control and regulatory requirements.

3.2.2. Viscosity Determination

The viscosity of the liquorice root extract-based cream was measured to assess its consistency, stability, and ease of application. The formulation exhibited a smooth, uniform texture with viscosity values appropriate for topical creams, ensuring good spreadability and retention on the skin. The viscosity measurements were performed at different spindle speeds using a rotational viscometer, and the results indicated stable rheological behaviour, which is essential for maintaining product performance during storage and use.

Table 6: Viscosity of Liquorice extract cream.

Spindle Speed (rpm)	Viscosity (cP)
10	3200
20	2800
30	2500
50	2100

The viscosity profile of liquorice extract cream shows a gradual decrease in viscosity with increasing spindle speed. At 10 rpm, the viscosity is highest at 3200 cP, which decreases to 2800 cP at 20 rpm, 2500 cP at 30 rpm, and 2100 cP at 50 rpm. This shear-thinning behaviour is characteristic of non-Newtonian pseudoplastic fluids, typical of topical creams. Such rheological properties are desirable, as they allow the cream to spread easily under shear while retaining consistency at rest.

3.2.3. Spreadability Test

The spreadability of the liquorice root extract-based cream was evaluated to determine how easily the formulation spreads on the skin, which affects user comfort and uniform application. A fixed quantity of cream was placed between two glass slides, and a standard weight was applied to measure the diameter of the spread after a specific time. The cream was easy to apply and well-received by patients because it was easy to spread and spread evenly with little effort. Consistent spreadability also ensures uniform dosing and better therapeutic outcomes.

Table 7: Spreadability of Liquorice extract cream

Weight Applied (g)	Time (seconds)	Diameter of Spread (cm)
50	30	4.2
100	30	5.8
150	30	6.5

The spreadability test of liquorice extract cream indicates that the diameter of spread increases with higher applied weight. At 50 g, the cream spreads to 4.2 cm, while at 100 g, the spread increases to 5.8 cm, and at 150 g, it reaches 6.5 cm within 30 seconds. This direct relationship between applied weight and spread diameter reflects good spreadability, ensuring ease of application. Such behaviour is desirable for topical formulations, enhancing uniform distribution, patient compliance, and overall effectiveness.

3.2.4. Homogeneity Test

The homogeneity of the liquorice root extract-based cream was evaluated to ensure uniform distribution of the active ingredient and excipients throughout the formulation. Visual inspection of samples taken from different portions of the batch revealed a consistent appearance with no signs of lumps, phase separation, or gritty particles. The cream had a consistent texture and colour throughout, indicating that the formulation was well mixed and stable. This uniformity ensures accurate dosing and consistent therapeutic efficacy with each application.

Table 8: Homogeneity of Liquorice extract cream

Sample Location	Appearance	Texture	Remarks
Top portion	Smooth, uniform	Consistent	Homogeneous
Middle portion	Smooth, uniform	Consistent	Homogeneous
Bottom portion	Smooth, uniform	Consistent	Homogeneous

The homogeneity evaluation of liquorice extract cream shows uniformity across all examined portions. The top, middle, and bottom samples exhibited smooth and uniform appearance with consistent texture, indicating no signs of phase separation, grittiness, or irregularity. The remarks for all sections confirm the cream as homogeneous. This result highlights the stability and proper mixing of the formulation, ensuring even distribution of active ingredients, which is essential for reproducible efficacy, patient acceptability, and quality assurance in topical applications.

3.2.5. Extrudability Study

The extrudability of the liquorice root extract-based cream was tested to assess the ease with which the formulation can be dispensed from its packaging, ensuring patient convenience and consistent dosing. The cream was filled into standard aluminum tubes, and a uniform force was applied to extrude the product. The cream extruded smoothly without requiring excessive force, indicating good packaging compatibility and ease of application. This property ensures minimal product wastage and enhances user experience.

Table 9: Extrudability of Liquorice extract cream

Applied Force (N)	Extruded Cream Length (cm)	Remarks
5	4.5	Smooth extrusion
10	9.2	Consistent flow
15	13.8	No clogging or resistance

The extrudability study of liquorice extract cream demonstrates smooth and consistent extrusion under varying applied forces. At 5 N, the cream extrudes to 4.5 cm with smooth flow, while at 10 N, it reaches 9.2 cm, showing consistent output. At 15 N, the cream extrudes up to 13.8 cm without clogging or resistance. These findings indicate excellent extrudability, ensuring ease of removal from containers and convenient application. Such characteristics enhance patient compliance and confirm good formulation handling properties.

3.2.6. *In Vitro* Drug Release Study

The purpose of the in vitro drug release study was to assess the liquorice root extract's release profile from the cream formulation. A Franz diffusion cell apparatus equipped with a dialysis membrane was used to simulate drug release through a semi-permeable barrier. A fixed amount of the cream was applied uniformly onto the membrane, which was then mounted between the donor and receptor compartments. The receptor compartment was filled with phosphate buffer saline (pH 5.5) maintained at 37 ± 0.5°C with continuous stirring to mimic skin conditions. Samples (5 mL) were withdrawn from the receptor compartment at predetermined time intervals (0.5, 1, 2, 4, 6, 8 hours), replaced with equal volumes of fresh buffer to maintain sink conditions, and analysed using UV-Visible spectrophotometry at a specific wavelength to quantify the released active compound. Plotting the cumulative percentage of drug release against time revealed a pattern of sustained release, which favours a prolonged therapeutic effect.

Table 10: *In-Vitro* Drug Release of Liquorice extract cream

Time (hours)	Cumulative Drug Release (%)
0.5	15.4
1	28.7
2	43.1
4	61.5
6	78.2
8	90.6

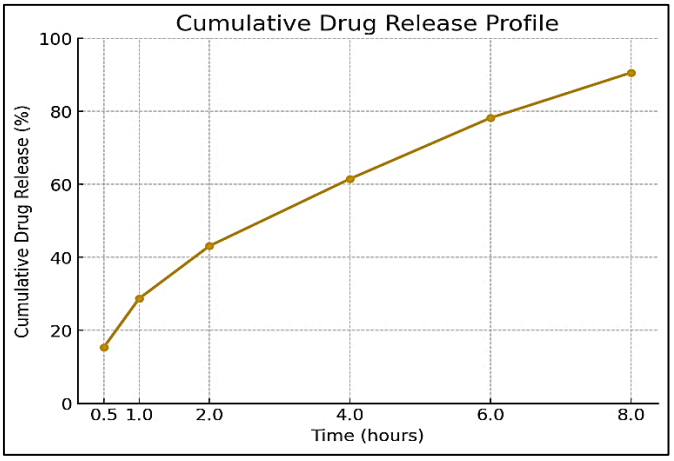

Figure 1: *In-Vitro* Drug Release of Liquorice extract cream

The *in-vitro* drug release study of liquorice extract cream shows a progressive increase in cumulative drug release over time. At 0.5 hours, 15.4% of the drug was released, rising to 28.7% at 1 hour and 43.1% at 2 hours. By 8 hours, the release reached 90.6%, indicating sustained and controlled drug release from the cream formulation.

4. Discussion

The present study focused on the formulation and in-vitro evaluation of a topical cream incorporating Liquorice root extract for the management of hyperpigmentation. The formulation was designed using pharmaceutically acceptable excipients to ensure stability, efficacy, and patient compliance. The Preformulation studies demonstrated that the Liquorice extract had acceptable organoleptic properties and showed good solubility in ethanol and glycerine solvents commonly used in topical preparations. The slightly acidic pH (5.2) of the extract falls within the skin-compatible range, minimizing the risk of irritation. The partition coefficient (log P ~1.85) indicated balanced lipophilic and hydrophilic properties, supporting effective skin permeation. Upon formulation, the cream exhibited favourable organoleptic characteristics, including uniform texture, mild aroma, and good spreadability. The pH of the final cream (5.4) was well within the physiologically acceptable range for topical application, supporting skin compatibility and product stability. Post formulation studies confirmed the formulation's uniformity and stability. The viscosity profile showed suitable rheological behaviour for ease of application without compromising retention. Spreadability and extrudability values further validated the cream's practicality for regular topical use. The study supports that Liquorice extract, rich in glabridin, effectively inhibits melanin synthesis and offers antioxidant benefits, making it a promising natural alternative to synthetic agents like hydroquinone, which are associated with safety concerns. The formulated Liquorice root extract-based cream is effective, safe, and cosmetically acceptable for the management of hyperpigmentation, warranting further clinical investigations to establish its in vivo efficacy.

Conclusion

A cream containing liquorice root extract for the treatment of hyperpigmentation was developed and evaluated successfully in this study. The formulation process was guided by thorough Preformulation studies, which confirmed the extract's suitable physicochemical properties, including optimal solubility, acceptable pH, and balanced lipophilicity. Post formulation evaluation of the cream demonstrated favourable organoleptic characteristics, stability, homogeneity, and user-friendly properties such as good spreadability and extrudability. The in vitro drug release profile revealed a sustained and effective release of the active ingredient, indicating its potential for prolonged therapeutic action. Given the skin-lightening, anti-inflammatory, and antioxidant properties of Liquorice extract, the developed cream offers a promising, natural, and safer alternative to conventional synthetic agents used in hyperpigmentation treatment. The results support further exploration through in vivo studies and clinical trials to validate its effectiveness and safety in human subjects.

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Author Contribution

SR; Performed experiments and prepared the manuscript, **BP;** Supervised the study and revised the manuscript, **PSJ;** Assisted in methodology, validation, and final editing.

Conflict of Interest

The authors declare no conflict of interest.

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Abbreviation

BW = Beeswax
SA = Stearic Acid
CO = Coconut Oil
DW = Distilled Water
GLY = Glycerin
LRE = Liquorice Root Extract
MP = Methyl Paraben
RO = Rose Oil
% = Percentage
°C = Degrees Celsius
NM = Nanometer
MG = Milligram
LOG P = Partition Coefficient
> = Greater Than
± = Plus or Minus

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