



Formulation And Evaluation Of Photoprotective Face Serum

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Abstract: Face serums are lightweight, fast-absorbing formulations that deliver active ingredients deeper into the skin compared to traditional creams. This study focuses on the formulation and evaluation of a polyherbal face serum designed primarily for UV protection with additional benefits like hydration, anti-acne effects, and skin rejuvenation. The serum was formulated using natural ingredients including Butterfly pea, Calendula, Sea buckthorn, Aloe vera, Rose hydrosol, Niacinamide, and others. These herbs were selected for their antioxidant, photoprotective, and skin-enhancing properties. Four formulations with varying concentrations were developed, and one optimal formulation was selected based on physical and stability parameters. This formulation underwent evaluations for pH, viscosity, spreadability, stability, SPF value and other. The results demonstrated effective UV protection along with favourable cosmetic qualities. This polyherbal face serum offers a natural, multifunctional alternative to conventional UV-protective products, combining skincare and sun protection in a single formulation.

KEYWORDS: Photoprotection, Skin rejuvenation, Multifunctional skincare, Butterfly Pea, Calendula, Sea Buckthorn.

INTRODUCTION

The skin is the largest organ in the human body, serving as a protective barrier between the internal organs and the external environment. It plays a crucial role in regulating body temperature, protecting against pathogens, and providing sensory information. The skin is composed of several layers, each with its unique functions and characteristics. Understanding the types and layers of the skin can help us appreciate its complexity and significance in maintaining overall health.

There are three main types of skin: normal, dry, and oily. These types are determined by the amount of oil produced by the sebaceous glands, which are responsible for lubricating the skin. Normal skin has a balanced production of sebum, which helps maintain a healthy complexion. Dry skin lacks proper moisture and tends to feel tight and rough. Oily skin produces an excess amount of sebum, resulting in a shiny appearance, enlarged pores, and a tendency to develop acne or blemishes.

The skin is composed of three primary layers, each with distinct structures and functions. The epidermis is the outermost layer of the skin and acts as a protective barrier against the environment. The dermis lies beneath the epidermis and is composed of connective tissue, blood vessels, nerve endings, hair follicles, sweat glands, and sebaceous glands. The subcutaneous tissue, also known as the hypodermis or subcutis, is the deepest layer of the skin. It consists of fat cells (adipocytes) and connective tissue.

In today's world, healthy and radiant skin is not only a symbol of beauty but also a reflection of overall well-being. As environmental factors such as pollution, ultraviolet (UV) radiation, and changing lifestyles continue to impact skin health, proper and scientific skincare has become an essential part of daily life.

Among all environmental factors, UV radiation is a major contributor to skin aging, pigmentation, and increased risk of skin cancers. Educating individuals on the use of sunscreen and UV-protective products is crucial in modern skincare to minimize long-term damage and maintain skin youthfulness.

UV RADIATION

Sunlight is made up of a continuous spectrum of electromagnetic radiation, which includes ultraviolet (UV), visible, and infrared rays. Among these, UV radiation makes up about 45%, visible light around 5%, and infrared nearly 50% of the sunlight that reaches the Earth's surface.

Types of UV Radiation

According to the International Commission on Illumination, UV radiation is divided into three categories based on wavelength:

- 1) UVA (315–400 nm): Long-wave UV rays
- 2) UVB (280–315 nm): Medium-wave UV rays
- 3) UVC (100–280 nm): Short-wave UV rays

The ozone layer in the atmosphere absorbs all of UVC and most of UVB (around 95%), which means these rays do not reach the ground. However, UVA rays are not absorbed by the ozone layer at all, so they make up about 95% of the UV radiation that reaches our skin.

UV Rays Penetration and Impact on Skin

- UVA rays penetrate deep into the skin, reaching both the epidermis and dermis. These rays are about 1000 times more effective than UVB in producing immediate tanning, which is simply a darkening of existing melanin.
- Prolonged or intense exposure to UVA rays can lead to sunburn, skin aging (photoaging), and damage to deeper skin structures, including collagen and elastin, resulting in wrinkling, sagging, dryness, and patchy pigmentation.
- UVB rays, though mostly absorbed by the ozone layer, still reach the skin and are responsible for delayed tanning, sunburn, and can directly damage DNA, increasing the risk of skin cancers.

Mechanisms of UV-Induced Damage

1. Direct DNA damage: UV photons are absorbed by DNA and other cellular components, causing structural changes in the DNA.
2. Indirect damage through photosensitization: Certain natural (endogenous) or external (exogenous) molecules in the skin absorb UV rays and become excited. These excited molecules generate reactive oxygen species (ROS) and reactive nitrogen species (RNS), which then damage cellular structures.

Role of Antioxidants and Oxidative Stress

Normally, the skin has natural antioxidant systems (like vitamins C and E, glutathione, and enzymes like catalase and superoxide dismutase) that neutralize ROS and keep the skin healthy.

However, when UV exposure is too frequent or intense, ROS production exceeds the skin's antioxidant capacity, leading to a condition called oxidative stress. This imbalance causes damage to DNA, proteins, and lipids, depletes cellular energy (NADH), and may initiate carcinogenesis (cancer development).

Photoaging and Skin Disorders

Photoaging refers to the premature aging of the skin due to chronic sun exposure. It affects various skin layers, especially the connective tissues in the dermis, leading to visible changes such as:

- Wrinkling
- Dryness
- Loss of skin elasticity (elastosis)
- Abnormal pigmentation
- Telangiectasia (spider veins)

Moreover, UV radiation may also cause:

- Inflammation
- Suppression of the immune system
- Cell cycle disturbances
- Skin cancers, including malignant melanoma, which has been linked to UVA exposure in around 67% of cases.

FACE SERUM

A serum is a potent skincare product, either water- or oil-based, similar to a cream. However, it contains nearly ten times the concentration of biologically active ingredients compared to regular creams, allowing it to address cosmetic concerns more rapidly and effectively.

- Serums have a light, thin consistency due to smaller molecular size.
- They typically contain minimal ingredients to enhance the delivery of active compounds.
- Active ingredients may include vitamins, growth factors, or herbal extracts.
- Serums can have up to 70% concentration of active ingredients, making them more potent than creams or moisturizers.
- Their low viscosity allows for rapid absorption and deeper skin penetration.
- They are ideal for layering in skincare routines and targeting specific concerns efficiently.

Types of Face Serums

1. Oil-Based Serum: This is the simplest type of serum to formulate, typically made from high-quality, fast-absorbing carrier oils, often referred to as “dry” oils.
2. Gel Serum: Gel serums offer a light, tightening feel on the skin, creating a temporary lifting effect.
3. Water-Based Serum: Similar to gel serums but usually thinner in texture, water-based serums contain minimal to no thickening agents like gums.
4. Emulsion Serum: Emulsion serums combine oil and water phases using an emulsifier, resulting in a lightweight moisturizer that not only hydrates but also enhances the delivery of active ingredients.
5. Pressed Balm Serum: This type blends a traditional balm base of oils, butters, and waxes with oil-soluble actives.

POLYHERBAL PHOTOPROTECTIVE FACE SERUM

Dermatologists often recommend herbal cosmetics for their skin-friendly properties. These products are compatible with all skin types, including sensitive and oily skin, and they seldom cause adverse reactions or allergies.

One of the key reasons behind the popularity of herbal cosmetics is their multifunctional benefits. Apart from enhancing appearance, these products often contain bioactive ingredients that contribute to skin nourishment, rejuvenation, and protection.

A polyherbal formulation is a blend of multiple plant extracts, designed to provide synergistic therapeutic effects by combining the photoprotective properties of various medicinal herbs. A polyherbal photoprotective face serum is an innovative cosmetic formulation aimed at offering broad-spectrum UV protection, along with antioxidant, anti-aging, skin-nourishing, and moisturizing benefits, through a natural and sustainable approach.

Unlike traditional sunscreen creams or lotions, which primarily act as a physical or chemical barrier to block or reflect UV rays, a face serum is a lightweight, fast-absorbing liquid formulation that delivers a concentrated dose of active phytoconstituents deep into the skin. Serums are designed for daily skincare routines to repair, hydrate, and protect the skin over time, rather than just providing temporary surface protection.

A photoprotective serum not only shields the skin from harmful UV-induced damage but also works to reverse early signs of photodamage, enhance skin tone, and improve overall skin health. Its low-viscosity nature ensures better penetration into the epidermis without leaving a greasy or white residue commonly associated with creams or lotions.

Synthetic sunscreens often contain compounds such as oxybenzone, octinoxate, and PABA derivatives, which can induce photoallergic reactions, generate reactive oxygen species (ROS), and exhibit cytotoxic or genotoxic effects. Studies have shown that titanium dioxide and zinc oxide nanoparticles can penetrate the skin, cause oxidative stress, and damage human neural cells and fibroblasts.

Given the drawbacks associated with synthetic agents, the pharmaceutical and cosmetic industries are increasingly shifting towards natural formulations that are sustainable, skin-friendly, and environmentally safe. Extracts and oils from medicinal plants have demonstrated significant photoprotective potential, owing to their bioactive phytoconstituents such as flavonoids, polyphenols, carotenoids, tocotrienols, and mycosporins.

These natural compounds offer multiple benefits:

- Absorption of UV radiation across both UVA and UVB spectrums.
- Antioxidant activity to neutralize ROS.
- Anti-inflammatory and anti-carcinogenic properties.
- Compatibility with all skin types and lower risk of allergic reactions.

INGREDIENTS USED TO FORMULATE POLYHERBAL PHOTOPROTECTIVE SERUM

1. Butterfly Pea



Clitoria ternatea, widely recognized by names such as butterfly pea, blue pea, Asian pigeonwings, bluebellvine, cordofan pea, and Darwin pea, is a flowering plant from the Fabaceae family. It is native to the Indonesian island of Ternate and is traditionally known as *Aparajita* in Indian Ayurvedic medicine.

Taxonomy

Kingdom: Plantae

Order: Fabales

Family: Fabaceae

Genus: *Clitoria*

Species: *C. ternatea*

Medicinal Properties

Aparajita (*Clitoria ternatea*) is known for its medicinal properties, including anti-inflammatory, antioxidant, and neuroprotective effects. It aids in improving cognitive function, reducing stress, and promoting relaxation. The plant's flower extract is beneficial for the skin, offering soothing and brightening effects while helping to combat signs of aging. It also promotes wound healing and reduces skin irritation.

2. Sea Buckthorn



Hippophae rhamnoides, commonly referred to as sea buckthorn, sandthorn, sallowthorn, or seaberry, is a flowering plant species in the *Elaeagnaceae* family, native to the cold-temperate areas of Eurasia (combined mass of Europe and Asia). It is a spiny, deciduous shrub.

Taxonomy:

Kingdom: Plantae
Order: Rosales
Family: *Elaeagnaceae*
Genus: *Hippophae*
Species: *H. rhamnoides*

Medicinal Properties:

Hippophae rhamnoides, or sea buckthorn, is a versatile plant known for its medicinal benefits, including promoting cardiovascular health, supporting digestion, and boosting immunity. Its rich content of vitamins and antioxidants also aids in liver health and wound healing. In skincare, sea buckthorn is widely used for its hydrating, anti-aging, and soothing properties, making it an effective ingredient for improving skin texture and combating signs of aging.

3. Calendula

Calendula officinalis, commonly known as pot marigold, ruddles, Mary's gold, or Scotch marigold, is a flowering plant belonging to the *Asteraceae* (daisy) family. Though likely native to southern Europe, its extensive cultivation over time has made its exact origin uncertain, and it is now widely naturalized in various regions.

Taxonomy:

Kingdom: Plantae
Order: Asterales
Family: *Asteraceae*
Genus: *Calendula*
Species: *C. officinalis*

Medicinal Properties:

Calendula officinalis possesses strong anti-inflammatory, antimicrobial, and wound-healing properties. It is widely used in skincare for soothing irritated skin, promoting healing of cuts, burns, and acne, and enhancing skin hydration. Beyond skin benefits, calendula is also used to relieve menstrual cramps, support oral health, and aid in digestive issues due to its antispasmodic and healing effects on mucous membranes.

4. Aloe Vera



Aloe vera provides two main components: a soothing clear gel for topical use and a yellow latex for laxative purposes. The gel is commonly used in treating burns, wounds, rashes, dry skin, acne, and psoriasis, though results vary and allergic reactions may occur in some users. Aloe latex is used for constipation relief but can be toxic if ingested in large or prolonged doses. Aloe is also found in food and cosmetic products, with small amounts of topical use generally considered safe.

5. Rose



Roses, especially *Rosa* species, possess medicinal properties beneficial for both skin and general health. Rose extracts and rose water are widely used in cosmetics for their soothing, anti-inflammatory, and hydrating effects on the skin. Beyond skincare, rose petals and hips are used in herbal remedies for digestive issues, menstrual discomfort, and mild respiratory ailments due to their antioxidant and mild laxative properties.

6. Niacinamide

Niacinamide (nicotinamide) is an extensively utilized ingredient in cosmetics recognized for its anti-aging, brightening, and photoprotective properties. It enhances skin texture, elasticity, and barrier function by stimulating ceramides, sphingolipids, and cholesterol. Niacinamide is a robust antioxidant and anti-inflammatory agent that decreases production of ROS and cytokines. Additionally, niacinamide protects skin from UV damage, promotes collagen synthesis, and inhibits MMPs and elastase. In clinical studies, niacinamide did not indicate any toxicity, irritation, sensitization, photosensitization or comedogenicity and is considered safe for use in cosmetic products.

7. Xanthum Gum

Xanthum gum was used in this formulation as a thickening agent. The Cosmetic Ingredient Review (CIR) Expert Panel has deemed xanthan gum a safe and multifunctional component in personal care products. There are approximately 3,470 cosmetic products that contain xanthan gum for functions such as emulsion stabilization, film formation, binding, thickening, and skin conditioning.

8. Glycerin

Glycerin is a flexible and safe substance frequently used in cosmetic formulations as a humectant, skin conditioning agent, solvent, and viscosity suppressant. It is used in more than 15,000 products, including skincare, hair care, oral hygiene products, and products designed for babies. Studies have demonstrated that glycerin is non-irritating and safe for human use in cosmetics, with no negative effects indicated.

9. Soy Lecithin

Derived mainly from soybeans, soy lecithin is a low toxicity emulsifier with a considerable nutritional value, as a result is widely used in cosmetic formulations due to its effectiveness and safety. Soy lecithin includes several form of lipids such as triglycerides, fatty acids, sterols, glycolipids and, phospholipids, which can work synergistically to stabilize oil-in-water emulsions and promote the formation of liposomes. Natural phospholipids, a type of lipid found in soy lecithin, not only provide stability to formulations, but also improves skin hydration and facilitates dermal penetration, allowing soy lecithin to be a multifaceted component in natural cosmetic formulations.

10. Geogard Ect

Geogard ECT is a broad spectrum preservative that is low-color and low-odor as well as water soluble, and it can provide broad spectrum protection in many types of personal care products. It is a combination of salicylic acid, benzyl alcohol, and sorbic acid. The CIR Expert Panel determined that benzyl alcohol is safe for use in cosmetics at concentrations up to 5%. Sorbic acid is either biologically-derived or synthetically identical, and marketed as potassium sorbate, and it is allowed in organic cosmetics at a concentration of 0.6% or less without needing a warning label. salicylic acid acts as an active ingredient and preservative, demonstrating bactericidal and fungicidal properties. Salicylic acid is classified as a safe ingredient, with required maximum concentration limits in place being verified.

11. Japanese Cherry Blossom water soluble fragrance.

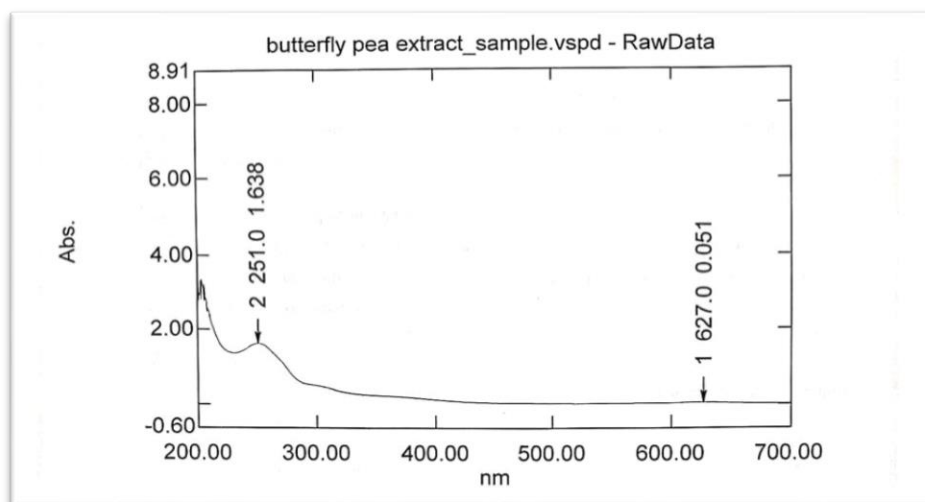
It was bought from an online website. The website stated that this fragrance is safe to be used in cosmetics. The Japanese Cherry Blossom water soluble fragrance adds a soft refreshing scent to the face serum, creating a pleasant and calming skincare experience.

UV ABSORPTION SPECTRUM OF BUTTERFLY PEA, CALENDULA, AND SEA BUCKTHORN EXTRACTS

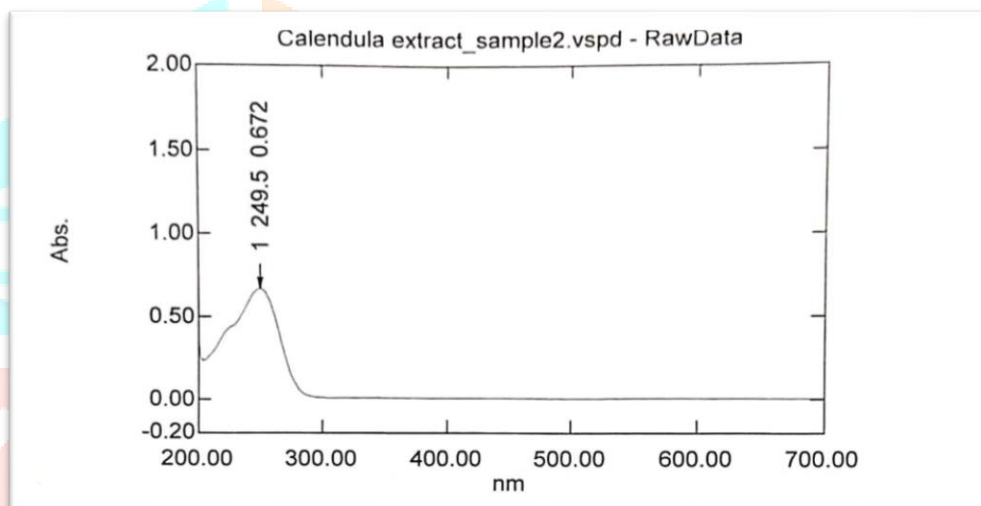
To evaluate the UV absorption capabilities of natural plant extracts, UV-Visible spectroscopy was performed on butterfly pea flower extract (*Clitoria ternatea*) diluted to 1% v/v in distilled water, calendula flower extract (*Calendula officinalis*) diluted to 0.1% v/v in ethanol, and sea buckthorn extract (*Hippophae rhamnoides*) diluted to 0.1% v/v in chloroform. The UV absorption spectra were then recorded to confirm the presence of UV-absorbing phytoconstituents, supporting their potential application in photoprotective or cosmetic formulations.

The results demonstrated that all three extracts exhibited significant UV absorption in specific wavelength regions. This indicates their potential as natural UV filters, suggesting their usefulness in the development of herbal sunscreens or skincare products with protective properties against harmful ultraviolet radiation.

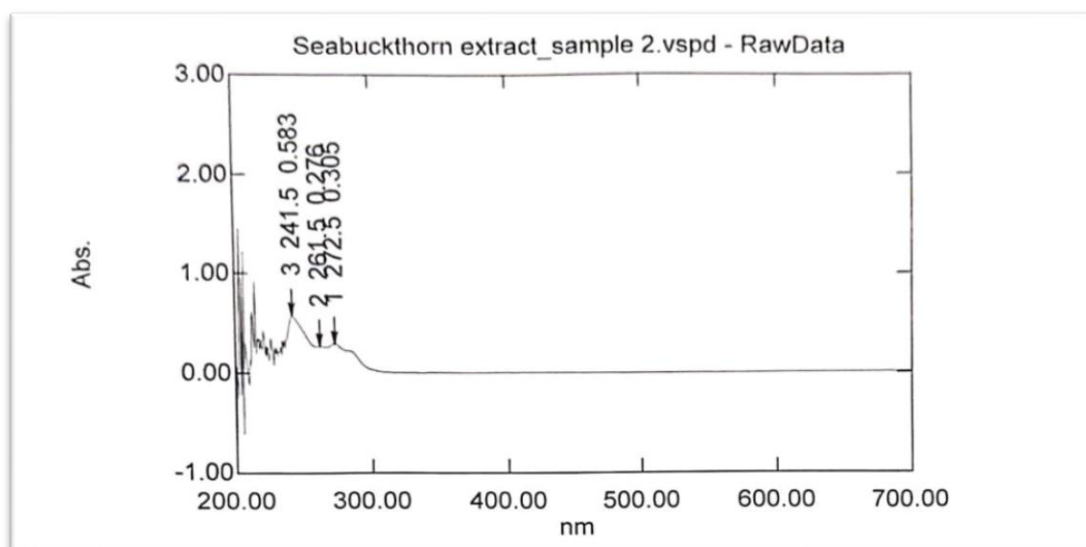
1. Absorption spectrum of Butterfly Pea extract



2. Absorption spectrum of Calendula extract



3. Absorption spectrum of Sea buckthorn extract



FORMULATION

In creating a face serum, the physical traits and stability of a serum are principal considerations when evaluating overall product quality. A face serum is typically thought of as an emulsion, or the combination of two immiscible liquids. To mitigate instability in an emulsion, a thickener and/or emulsifier is incorporated. An emulsifier minimizes the interfacial differences between the oil and water phases in a formulation so that the formulation will remain stable for the duration of its shelf life, especially when dispersing the oil phase in the water phase, to again minimize the interfacial differences. The mixing of the oil and water phases will ensure the overall stability and shelf life of the product. Thus, since oil and water are historically thermodynamically unstable when mixed, the emulsifier plays a working role to change the interfacial differences to provide a more stable and uniform mixture.

METHOD OF PREPARATION

1.Preparation of Aloe Vera Extract

Fresh Aloe vera leaves were washed, dried, and cut using a clean knife to collect the inner gel. The collected gel was crushed using a mixer grinder and subjected to heat treatment at 70°C for 30 minutes in a water bath. The resulting juice was filtered by adding 0.1% activated charcoal, followed by sequential filtration through G3 and G4 sintered glass filters to obtain a clear Aloe vera extract, which was used in the serum formulation.

2.Preparation of Polyherbal Serum Base

In Beaker B1, the clear Aloe vera extract was mixed with rose hydrosol. Niacinamide was then added to this mixture and stirred until it completely dissolved. In a separate Beaker B2, Xanthan gum was dispersed in glycerine and allowed to hydrate. The mixture was stirred until a smooth gel-like consistency was formed. The contents of Beaker B1 and B2 were then combined and stirred thoroughly to form a uniform base.

3.Addition of Herbal Extracts and Final Ingredients

To the above base, the following extracts were added drop by drop with continuous stirring:

- Butterfly pea extract
- Calendula extract
- Sea buckthorn extract
- Soy lecithin

The mixture was stirred continuously until a homogeneous serum was formed. Finally, Geogard ECT (a natural preservative) and a perfuming agent were added dropwise with continuous stirring to complete the formulation.



COLLECTION OF INGREDIENT, ITS ROLE, AND QUANTITY IN 20ML FACE SERUM

Ingredients	Place
Butterfly Pea Flower	Bought from online shopping site
Calendula flower extract	Bought from online shopping site
Sea buckthorn berry extract	Bought from online shopping site
Niacinamide	Bought from online shopping site
Aloe vera	Collected from Peripheral area of Rampura village
Rose Hydrosol	Bought from online shopping site
Glycerin	Used from college laboratory
Xanthum gum	Used from college laboratory
Geogard ect	Bought from online shopping site
Soy lecithin	Bought from online shopping site
Japanese Cherry Blossom Fragrance oil	Bought from online shopping site

Sr. no.	Ingredients	Roles	Quantity
1	Butterfly pea flower extract	Antioxidant and Photoprotection	3ml
2	Sea buckthorn berry extract	Whitening agent, Skin rejuvenation, and Photoprotection	3ml
3	Calendula flower extract	Anti acne and Photoprotection	2.4ml
4	Niacinamide	Smoothen skin texture, Brighten skin, and Photoprotection	1.2 gm
5	Aloe vera Gel	Hydration and Moisturization	6.7ml
6	Rose hydrosol	Toner and gives refreshing cooling effect	6.7ml
7	Glycerin	Humectant	1.8ml
8	Xanthum gum	Thickening agent	0.10gm
9	Soy lecithin	Emulsifier	0.9ml
10	Geogard ect	Preservative	0.3ml
11	Japanese Cherry Blossom Fragrance oil	Perfuming agent	0.3ml

EVALUATION OF SERUM

1. Physical Evaluation



The Colour and appearance of the formulation was observed visually. This test was confirmed by visual appearance and by touch.

2. pH value



A pH meter was calibrated using a standard buffer solution. Nearly 1 ml of the face serum was properly weighed and dissolve in 50 ml of distilled water and finally its pH was calculated. The skin has an acidic range and the pH of the skin serum should be in the range of 4.1-6.7.

3. Skin Irritancy

The serum was applied to the dorsal side of the hand of three individuals, and the application area was observed for 24 hours to check for any signs of irritation or adverse skin reactions.



4.Determination of Viscosity



Viscosity of the formulation was determined by Brookfield Viscometer at 100rpm, using spindle type model S64. 5 ml of the serum was taken in a beaker and the spindle was dipped in it for about 5 minutes and then the readings were taken.

5.Stability Studies:

Formulation and development of a pharmaceutical product is not complete without proper stability analysis carried out on it to determine physical and chemical stability and thus safety of the product. The stability studies were carried out as per ICH guidelines. Short term accelerated stability study was carried out for the period of 15 days for the prepared formulation.

The samples were stored at different storage conditions of temperatures ranging from 2°C to 40°C.

6.Spreadability test:

Spreadability test was performed using the parallel-plate method. In this method, 1 g of the serum sample, prepared 48 hours prior, was placed between two glass plates measuring 20 x 20 cm. A weight of 100 g was gently placed on the top plate for 1 minute, after which the spread diameter of the sample was measured.

In these cases, spreadability is determined by the formula:

$S_i = d^2 \times \pi / 4$; S_i —spreading area (mm²), d —spreading area diameter (mm)

7.SPF determination :

In the present study, the in vitro sun protection factor (SPF) of the polyherbal face serum was determined using a spectrophotometric method based on the procedure developed by Mansur et al.. For this analysis, Formulation 3 was diluted to 1% v/v with distilled water, and its absorbance was measured in the UV range of 290–320 nm at 5 nm intervals using a UV-visible spectrophotometer. The SPF value was then calculated using the Mansur equation.

Mansur equation: $SPF = CF \times \sum (EE(\lambda) \times I(\lambda) \times Abs(\lambda))$

CF = Correction factor (usually 10)

$EE(\lambda)$ = Erythral effect spectrum at wavelength λ

$I(\lambda)$ = Solar intensity spectrum at wavelength λ

$Abs(\lambda)$ = Absorbance of the sample at wavelength λ

λ = Wavelength from 290 to 320 nm (measured at 5 nm intervals)

8.Microbial test

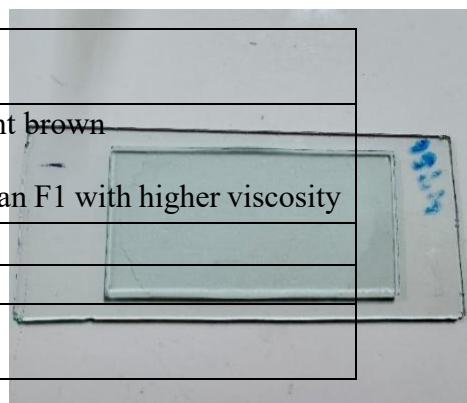
Cosmetics are not required to be sterile, but they must be properly preserved to prevent microbial contamination. Microbial growth can occur in products like serums, creams, lotions, and gels, which are intended for skin care use. Therefore, it is crucial that the serum remains free from microbial contamination to ensure its safety. In this context, microbial activity and antimicrobial testing were performed specifically for *Staphylococcus aureus* and *Escherichia coli* to assess the serum's effectiveness against these pathogens.

9. Absorbance time :

Serum was applied on skin, with the help of a stopwatch time was recorded to see how quickly it absorbs.

RESULT

Sr no.	Test	Result
1.	Physical evaluation	Colour: Translucent light brown Odour: Aromatic Consistency: Thicker than F1 with higher viscosity
2.	pH value	5.52
3.	Skin irritancy	No
4.	Viscosity determination	1752 mPas.



Stability studies:

The serum was stored at various temperatures, ranging from 2°C to 40°C, to simulate real-world conditions. At all three storage conditions, low temperature (2-4°C), room temperature (20-25°C), and elevated temperature (40-45°C) the serum exhibited no phase separation or colour change, maintaining its homogeneity and consistency. The appearance of the serum remained stable throughout the study period, demonstrating that it is resilient to temperature fluctuations and can retain its quality under various environmental conditions.



Spreadability test:

The measured diameter of the spread area was 5.8 mm.

Formula:

$$Si = d^2 \times \pi / 4$$

Values:

$$d = 5.8 \text{ mm}$$

$$\pi = 3.1416$$

calculation:

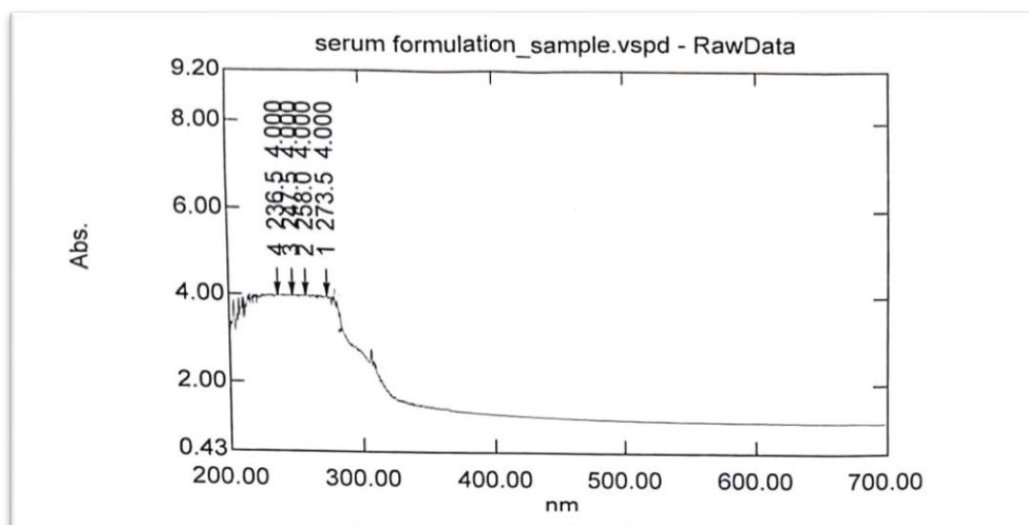
$$d^2 = 5.8 \times 5.8 = 33.64$$

$$d^2 \times \pi = 33.64 \times 3.1416 = 105.66$$

$$Si = 105.66 / 4 = 26.415 \text{ mm}$$

SPF determination

SPF of polyherbal face serum was calculated by Mansur equation. To measure absorbance of Ultraviolet radiation, UV spectroscopy of Serum Formulation was performed and the Spectrum is given below.



Observation and calculation

Wavelength (λ)	Absorbance	EE(λ) × I(λ)	EE(λ) × I(λ) × Abs(λ)
290nm	2.912	0.015	0.04368
295nm	2.833	0.081	0.229473
300nm	2.669	0.287	0.766003
305nm	2.466	0.327	0.806382
310nm	2.236	0.186	0.415896
315nm	1.950	0.083	0.16185
320nm	1.724	0.018	0.031032

Mansur equation:

$$\begin{aligned}
 \text{SPF} &= \text{CF} \times \sum (\text{EE}(\lambda) \times \text{I}(\lambda) \times \text{Abs}(\lambda)) \\
 &= 10 \times (0.04368 + 0.229473 + 0.766003 + 0.806382 + 0.415896 + 0.16185 + 0.031032) \\
 &= 24.54316
 \end{aligned}$$

SPF: Sun Protection Factor (SPF) is a measure that indicates how effectively a sunscreen protects the skin from UVB rays, which cause sunburn. It represents how much longer a person can stay in the sun without developing redness compared to unprotected skin. For example, using an SPF 30 product correctly means it would take 30 times longer for the skin to show signs of sunburn. SPF is widely accepted as a key indicator of sunscreen performance.

Absorbance:

The serum starts to absorb as soon as it is applied to the skin and is fully absorbed in 1-2 minutes.

Microbial test:

Microbial testing for *Staphylococcus aureus* and *Escherichia coli* showed the absence of microbial contamination, suggesting the product is microbiologically safe. Furthermore, the serum exhibited antimicrobial activity against both organisms.

APPLICATION

Wash your face, it is best to start the process with a clean face, which will help the serum absorb better. Apply toner (optional), Toners can enhance your skin's freshness and prep for the product's application. Put 2-3 drops of serum, dispense a small amount of the photoprotective serum onto your fingertips. Apply to entire area, gently pat the serum over your face and neck, with more focus on sun-exposed areas. Give it a moment to fully absorb for maximum protection.

CONCLUSION

Conventional sunscreens and photoprotective serums typically include synthetic ingredients such as oxybenzone, octinoxate, PABA derivatives, titanium dioxide, and zinc oxide. While effective, these agents may induce adverse effects such as photoallergic reactions, oxidative stress, and cytotoxicity. Moreover, nanoparticles of titanium dioxide and zinc oxide have been associated with skin penetration and potential damage to neural cells and fibroblasts. To overcome these limitations, the present study focused on formulating a polyherbal photoprotective face serum using natural and safe ingredients.

The formulation underwent various evaluation tests including pH, viscosity, spreadability, UV absorbance, skin irritancy, and stability studies. All parameters fell within ideal or standard ranges. The serum remained homogenous with no phase separation or color change during storage at varying temperatures (2–40°C), indicating excellent physical stability. A skin irritancy test performed on three individuals showed no signs of irritation, confirming its skin compatibility.

Microbial testing for *Staphylococcus aureus* and *Escherichia coli* showed the absence of microbial contamination, suggesting the product is microbiologically safe. Furthermore, the serum exhibited antimicrobial activity against both organisms. UV spectrophotometric analysis revealed an SPF value of 24.5, indicating effective photoprotective properties.

Overall, the polyherbal serum, composed of natural ingredients, offers maximum skin benefits with minimal or no side effects. Based on the above evaluation parameters, it can be concluded that the formulated herbal serum is safe, stable, and an effective alternative to conventional synthetic products.

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