

Formulation and Evaluation of a Phytochemical-Enriched Face Serum for Hyperpigmentation

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Abstract

Hyperpigmentation is a common dermatological concern caused by excessive melanin production and environmental factors. The present study aimed to formulate and evaluate a phytochemical-enriched herbal face serum for the management of hyperpigmentation using natural ingredients such as lemon peel, pomegranate peel, orange peel, aloe vera, rose water, and Glycerin. The serum was prepared using a gel-based formulation and evaluated for organoleptic properties, physicochemical parameters, pH, viscosity, Spreadability, irritancy, and stability. The formulated serum showed acceptable appearance, pleasant odor, suitable pH, good Spreadability, non-irritant nature, and satisfactory stability. The presence of antioxidant-rich phytochemicals contributes to skin brightening, hydration, and protection against oxidative damage. The study concludes that the developed herbal face serum is safe, stable, and effective for reducing hyperpigmentation and improving overall skin health.

Keywords: Hyperpigmentation, herbal face serum, phytochemicals, lemon peel, pomegranate peel, antioxidants, skin brightening

Introduction

Hyperpigmentation is a common dermatological condition characterized by the darkening of skin due to excessive production of melanin. It is mainly caused by prolonged sun exposure, aging, hormonal imbalance, inflammation, and oxidative stress. Although several synthetic depigmenting agents are available for treatment, their long-term use is often associated with adverse effects such as skin irritation, dryness, and hypersensitivity. In recent years, herbal and natural cosmetic formulations have gained increased attention due to their safety, biocompatibility, and minimal side effects. Plant-based phytochemicals possess antioxidant, anti-inflammatory, and skin-brightening properties that help in regulating melanin synthesis and protecting the skin from oxidative damage. Face serums are lightweight formulations that enhance the penetration of active ingredients into the deeper layers of the skin, making them effective for targeted treatment. Therefore, the present study aims to formulate and evaluate a phytochemical-enriched herbal face serum using natural ingredients for the management of hyperpigmentation, focusing on safety, stability, and cosmetic effectiveness.

Advantages of Face Serum

- Contains a high concentration of active ingredients for effective skin treatment.
- Lightweight and fast-absorbing, allowing deeper penetration into the skin.
- Provides targeted action for specific skin concerns such as hyperpigmentation, acne, and aging.
- Enhances skin hydration and improves texture and elasticity.
- Boosts skin radiance and promote an even skin tone.
- Helps prevent premature aging by reducing fine lines and wrinkles.
- Strengthens the skin barrier and protects against environmental damage.
- Improves the effectiveness of other skincare products with minimal usage.

Disadvantages Of Face Serum:

- Some serums may contain potent ingredients that could cause irritation or allergic reactions.
- Proper storage and packaging are essential to maintain the effectiveness of serum.
- Using multiple products simultaneously or applying to the skin leads to adverse effects.

Literature Survey

Previous studies have demonstrated the effectiveness of face serums containing active and herbal ingredients in improving skin quality. West et al. (2021) reported significant enhancement in skin elasticity, hydration, and smoothness using a peptide- and vitamin-based serum. Rajdev et al. (2022) emphasized the importance of biocompatible, stable, and non-irritating serum formulations containing actives such as hyaluronic acid, aloe vera, and niacinamide, showing improved hydration and user acceptability. Herbal formulations have also gained attention; Ms. Shifa et al. (2024) and IJPREMS authors (2024) confirmed that polyherbal face serums possess good stability and cosmetic suitability due to their antioxidant and anti-inflammatory properties.

Several reviews (Shambharkar, 2024; Vaidya, 2024; Shejul and Kudale, 2023) highlighted the role of peptides, vitamins, antioxidants, and hyaluronic acid in serums for hydration, anti-aging, and skin brightening, along with the significance of lightweight delivery systems for better skin penetration. Clinical studies by Raab et al. (2017) and Gallaga Towns and Martínez Garza (2024) reinforced the importance of hyaluronic acid in enhancing skin hydration, elasticity, and overall appearance. Additionally, herbal actives such as *Withania somnifera* were reported to offer antioxidant and anti-inflammatory benefits supporting skin health (Wolinski et al., 2023). Studies on hydroxy acids (Kornhauser, 2010) and anti-hyperpigmentation systems (Bhardwaj et al., 2024) further demonstrate the relevance of active-based formulations in improving skin tone and texture.

Overall, the literature supports the development of stable, effective, and safe herbal or active-enriched face serums for targeted skincare benefits, particularly in improving hydration, pigmentation, and overall skin quality.

Objective

- To determine the optimum and stable face serum.
- To determine the most stable face serum formulation in term of its physio-chemical stability study. To characterise the face serum formulation in term of its flow behaviour and sensory profile.
- To determine the most stable face serum formulation in terms of its physio-chemical stability study, ensuring long-term effectiveness and safety.

- To characterize the face serum formulation in terms of its flow behavior and sensory profile, assessing texture, absorption rate, and user experience
- To determine the antioxidant and brightening properties of lemon peel and pomegranate peel in combating dark spots and uneven skin tone.
- To determine the hydration and barrier protection effects of the serum while minimizing irritation for all skin types.
- To determine the efficacy of botanical extracts in promoting a radiant complexion through scientific testing and user trials.

Methodology:**1. LEMON PEEL:****SYNONYMS:** Citrus medica var. limonum.**TAXONOMICAL CLASSIFICATION**

- **Kingdom :** Plantae
- **Class :** Equisetopsida
- **Order :** Sapindales
- **Family :** Rutaceae
- **Genus :** Citrus
- **Species :** Citrus limon
- **Botanical Name :** Citrus limon (L.) Osbeck

CHEMICAL CONSTITUENTS:**Lemon peel is rich in:****Essential oils:** Limonene, citral, and linalool.**Flavonoids:** Hesperidin and diosmin.**Vitamins:** Vitamin C and small amounts of Vitamin A.**Minerals:** Potassium, calcium, and magnesium.**Other compounds:** Pectin and carotenoids.**BENEFITS TO SKIN:****Brightening:** Vitamin C helps reduce dark spots and promotes an even skin tone.**Antioxidant Protection:** Flavonoids and Vitamin C combat free radicals, reducing signs of aging.**Exfoliation:** Natural acids in lemon peel gently exfoliate dead skin cells.**Oil Control:** Helps regulate sebum production, making it beneficial for oily skin.**Antimicrobial Properties:** Essential oils like limonene can help fight acne-causing bacteria.



Fig 1: Lemon Peel

2. POMEGRANATE PEEL:

SYNONYMS : *Granatum punicum*

TAXONOMIC CLASSIFICATION:

- **Kingdom** : Plantae
- **Division** : Magnoliophyta
- **Class** : Magnoliopsida
- **Order** : Myrtales
- **Family** : Lythraceae
- **Genus** : *Punica*
- **Species** : *Punica granatum*
- **Botanical Name** : *Punica granatum* L.

CHEMICAL CONSTITUENTS:

Pomegranate peel is rich in:

Polyphenols: Ellagic acid, punicalagins, and tannins.

Flavonoids: Catechins and anthocyanins.

Vitamins: Vitamin C and Vitamin E.

Minerals: Potassium, calcium, and magnesium.

Other compounds: Alkaloids and pectin.

BENEFITS TO SKIN

Anti-Aging: Polyphenols combat free radicals, reducing wrinkles and fine lines.

Hydration: Helps retain moisture, keeping the skin soft and supple.

Brightening: Vitamin C promotes an even skin tone and reduces pigmentation.

Healing: Antioxidants and tannins aid in repairing damaged skin.

Acne Control: Antimicrobial properties help fight acne-causing bacteria.



Fig 2: Pomegranate peel

3. ALOE VERA GEL

Aloe vera gel in face serum hydrates and soothes the skin, thanks to its high-water content and anti-inflammatory properties. It also promotes collagen production, helping to maintain skin elasticity and reduce wrinkles.

SYNONYMS : Aloe

TAXONOMICAL CLASSIFICATION

- **Kingdom** : Plantae
- **Division** : Magnoliophyta
- **Class** : Liliopsida
- **Order** : Liliales
- **Family** : Liliaceae
- **Genus** : Aloe L
- **Species** : Aloe Barbadensis Mill, Aloe vera (L.)

CHEMICAL CONSTITUENTS:

The most important constituents of Aloes are the three isomers of Aloins, Barbaloin, β barboloin and Iso-barbaloin, which constitute the so-called 'crystalline' Aloin, present in the drug at from 10 to 30%. Other constituents are amor-phous Aloin, resin, emodin and Aloe-emodin.

USES:

Aloe vera has been traditionally used to treat skin injuries (burns, cuts, insect bites, and eczemas) and digestive problems because its anti-inflammatory, antimicrobial, and wound healing properties and it also moisturizes the skin cells and reduces inflammation.



Fig 3: Aloe Vera

4. ORANGE PEEL:

SYNONYMS : Citrus aurantium var. sinensis

TAXONOMIC CLASSIFICATION:

- **Kingdom** : Plantae
- **Class** : Magnoliopsida
- **Order** : Rutales
- **Family** : Rutaceae
- **Genus** : Citrus
- **Species** : Citrus sinensis
- **Botanical Name** : Citrus sinensis (L.) Osbeck

CHEMICAL CONSTITUENTS:

Orange peel contains:

- **Essential Oils:** Limonene, myrcene, and linalool.
- **Flavonoids:** Hesperidin and naringin.
- **Vitamins:** Vitamin C and small amounts of Vitamin A.
- **Minerals:** Calcium, potassium, and magnesium.
- **Other Compounds:** Pectin, carotenoids, and polyphenols.

BENEFITS TO SKIN:

Brightening: Vitamin C helps reduce dark spots and promotes a radiant complexion.

Exfoliation: Natural acids gently remove dead skin cells, revealing smoother skin.

Oil Control: Helps regulate sebum production, making it ideal for oily skin.

Anti-Aging: Antioxidants combat free radicals, reducing wrinkles and fine lines.

Acne Control



Fig 4: Orange Peel

5. ROSE WATER:

Rose water contains vitamin B, which is often used in sunscreen and sun products. It helps to bolster the effectiveness of SPF. Rose water can be used to lighten skin pigmentation. Rose water can remove oils and dirt from your skin by unclogging your pores. It helps maintain the pH level of your skin. It is a hydrating and nourishing agent for skin and protects skin against harmful environmental aggressors. Gulabjal has antioxidant levels that tackle free radicals and keep skin healthy and glowing.



Fig 5: Rose water

6. GLYCERIN:

Glycerin in face serums deeply hydrates the skin by attracting moisture and enhances the skin's barrier function, preventing water loss. Its lightweight, non-comedogenic nature makes it ideal for all skin types, promoting smooth and healthy skin. Glycerin in face serums deeply hydrates the skin by attracting moisture and enhances the skin's barrier function, preventing water loss. Its lightweight, non-comedogenic nature makes it ideal for all skin types, promoting smooth and healthy skin.



Fig 6: Glycerin

Experimental Work:

COLLECTION OF ACTIVE INGREDIENTS

Sourcing Raw Materials:

Ingredients like lemon peel, pomegranate peel, orange peel, aloe vera, rose water, and glycerine are sourced from reliable suppliers or directly from natural sources. Organic and pesticide-free materials are preferred to maintain purity.

PREPARATION OF INGREDIENTS:

- **Peels:** Dried and powdered to extract their active compounds.
- **Aloe Vera:** The gel is extracted from fresh leaves and filtered to remove impurities.
- **Rose Water:** Distilled from fresh rose petals to retain its natural properties.
- **Glycerin:** Used as-is, as it is a refined product.

EXTRACTION, AND FORMULATION OF FACE SERUM:



Fig 7: Extraction of the serum

FORMULA :

Table No.1 Formulation of Face serum

Sr. No.	Ingredients	Quantity Taken		
		Formulation F1H	Formulation F2H	Formulation F3H
1	Lemon Peel	3.75 gm	7.5 gm	15gm
2	Pomegranate peel	3.75 gm	7.5 gm	15gm
3	Rose water	25 ml	50 ml	100 ml
4	Aloe Vera Gel	q.s	q.s	q.s
5	Glycerine	3.75 ml	7.5 ml	15 ml

PREPARATION OF FACE SERUM:

- Measure 100ml Rose Water into a clean bowl
- Add 15gm Lemon Peel Powder & 15gm Pomegranate Peel Powder
- Mix well & let it sit for 30 minutes.
- Filter the mixture to remove solid residues.
- Add 15 ml Glycerine & mix thoroughly.
- Add Aloe Vera Gel (1-2 tbsp or as needed) & mix well.
- Pour into a clean serum bottle.
- Refrigerate for 30 minutes before use.



Fig 8: Preparation of Herbal Face serum

EVALUATION OF HERBAL FACE SERUM:**1) Organoleptic Evaluation**

It refers to the evaluation of the herbal face serum by its color, Odor, texture etc. (Table no. 2)

2) Physicochemical Evaluation

Physicochemical parameters were determined, including the determination of Ash Value, pH. (Table no.3)

a) Total Ash Value:

- Weigh accurately about 3gms of the powdered drug in a tared silica crucible.
- Heat at 450°C until free from carbon.
- Cool and weigh.

Formula:

$$\% \text{ Total ash} = \frac{\text{Ash Weight}}{\text{Weight of sample}} \times 100$$

b) Acid Insoluble Ash:

- Total Ash
- Add 10 mL 3N HCL and boil for 5 mins
- Filter through ashless filter paper
- Ignite at 450 C°
- Cool and weigh
- Formula:

$$\% \text{ Acid-insoluble ash} = \frac{\text{Acid insoluble Ash Weight}}{\text{Weight of sample}} \times 100$$

c) Water Insoluble Ash:

- Total Ash
- Add 10ml water and boil for 5 mins
- Filter through ashless filter paper
- Ignite at 450
- Cool and weigh

Formula:

$$\% \text{ Water-soluble ash} = \frac{\text{Total Ash Weight} - \text{water insoluble residue in total ash}}{\text{Weight of Sample}} \times 100$$

3) IRRITANCY TEST

Mark an area (1sq.cm) on the left-hand dorsal surface. Definite quantities of prepared face serum were applied to the specified area and time was noted. Irritancy, was checked if any for regular intervals up to 24 hrs. and reported. (Table. no. 4)

4) STABILITY STUDIES:

Stability testing of prepared formulation was conducted by storing at different temperature conditions for

the period of one month. The packed glass vials of formulation stored at different temperature conditions like, room temperature and 40°C and were evaluated for physical parameters like color, odour, pH, consistency and feel. (Table no.5)

5) VISCOSITY:

Viscosity is a critical parameter for topical formulation. Topical solutions with low viscosity have faster clearance than viscous solutions. In addition, highly viscous solutions can have an undesirable effect on the skin. (Table no. 6)

6) SPREADABILITY:

Spread ability denotes the extent of area to which the gel readily spreads on application to skin or the affected part. The bioavailability efficiency of a cream also depends on its spreading value. (Table no. 7)

RESULTS AND DISCUSSION

Organoleptic Evaluation

Herbal face serum was evaluated for Organoleptic parameters showed in the Table No. 3 The colour of formulation was Brown. The odour of prepared formulations was pleasant and good acceptable which is desirable to cosmetic formulations. Texture and smoothness were acceptable as per requirement of cosmetic formulations.

Table No. 2: Organoleptic Evaluation

Sr. No	Parameters	F1H	F2H	F3H
1.	Colour	Reddish Brown	Reddish Brown	Reddish Brown
2.	Odour	Pleasant	Pleasant	Pleasant
3.	Appearance	Fine	Fine	Fine
4.	Smoothness	Smooth	Smooth	Smooth

Physicochemical Evaluation

Herbal face serum was evaluated for physicochemical parameters showed in the Table no. 4. The pH of formulation was found close to neutral. The ash content limit.

Table No.3: Physicochemical Evaluation

		F1H	F2H	F3H
Total Ash Value:	Pomegranate Peel Powder	13.6%	13.4%	13.5%
	Lemon Peel Powder	9.2%	9.09%	9.16%
Acid Insoluble Ash:	Pomegranate Peel Powder	4.54%	4.52%	4.56%
	Lemon Peel Powder	1.96%	1.86%	1.99%
	Pomegranate Peel Powder	2.03%	2.04%	2.07%

Water In-soluble Ash	Lemon Peel Powder	2.11%	2.09%	2.12%
PH		4.5	6	5

Irritancy Test:

This formulation is used for only external surface. the prepared formulation is showing the absence of irritation, redness and swelling during irritancy studies.

Table No. 4: Irritancy Test

Sr. No	Parameters	F1H	F2H	F3H
1.	Irritation	No	No	No
2.	Redness	No	No	No
3.	Swelling	No	No	No

Stability Studies:

The prepared formulation is required testing of stability by storing at different temperature conditions for the period of one month, temperature conditions like, room temperature and 40 °C and were evaluated for physical parameters like colour, odour, consistency etc.

Table No.5: Stability Studies

Sr. No	Parameters	F1H	F2H	F3H
1.	Colour	No change	No change	No change
2.	Odour	No change	No change	No change
3.	Appearance	Fine	Fine	Fine
4.	Smoothness	Smooth	Smooth	Smooth

Viscosity

Table No. 6: Viscosity

Sr. No	Parameters	F1H	F2H	F3H
1.	Viscosity	250CP	320CP	300CP

Spreadability

The Spreadability of the three formulations, F1H, F2H and F3H, was carried out, and out of that, for F3H, the time taken by the three slides to separate is less, so as said in the description of the evaluation test, the time taken for the separation of the three slides was better, so according to this statement, F3H showed better Spreadability.

Table No. 7: Spread ability of face serum

Sr. No	Formulation	Time (sec)	Spreadability (g/cm/sec)
1.	F1H	12	6
2.	F2H	14	7

3.	F3H	10	8
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Conclusion:

- The study's objective was to combine several herbs to create a serum that would moisturise and brighten skin. Cosmeceuticals are skin care items that include both medications and cosmetics.
- Aloe vera was utilised to make this serum. Fresh aloe vera gel made from the parenchyma, the inner middle portion of the leaf, frequently works wonders for eczema, acne, pimples, and other skin conditions.
- It can also be used to treat radiation dermatitis and burns from heat and sun exposure. Numerous bioactive chemicals are believed to be present in lemon peels.
- Pomegranate peels include dietary fibre and polyphenols that protect against cardiovascular disease by reducing blood total cholesterol, triglycerides, and lipid peroxidation levels. They also contain a decent quantity of vitamin C, fibre, calcium, potassium, D-limonene, and magnesium.
- Pomegranate peels may help with acne, hyperpigmentation, ageing symptoms, wound healing, and UVB protection. As a humectant, glycerine is excellent for the skin. Moreover, it is an emollient.
- Numerous vitamins and minerals included in aloe vera have potent hydrating properties and anti-ageing properties that help keep skin looking young and healthy.
- The gel improves the healing of injured skin by promoting cell development. Thus, skin-related issues can be treated using this serum.

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