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Design and evaluation of a polyfunctional serum using raw *Carica papaya* extracts for enhancing skin rejuvenation

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ABSTRACT

Growing awareness regarding the harmful effects of synthetic cosmetic ingredients has increased the demand for herbal and naturally derived skincare products. The present research work aims to formulate and evaluate a polyfunctional herbal face serum using raw *Carica papaya* extract with a focus on improving skin rejuvenation and overall skin health. *Carica papaya* is a medicinally important plant rich in bioactive constituents such as papain, flavonoids, carotenoids, phenolic compounds, and vitamins A, C, and E, which are known to possess antioxidant, anti-inflammatory, exfoliating, and skin-enhancing properties.

In this study, a polyfunctional serum was developed using an emulsion-based formulation incorporating *Carica papaya* extract along with selected herbal ingredients to provide multiple skincare benefits such as hydration, anti-ageing effects, acne control, and improvement of skin tone and texture. The formulated serum was evaluated for various quality and physicochemical parameters, including organoleptic properties, pH, texture,

washability, thermal stability, and skin irritation to ensure its safety, stability, and effectiveness.

The results of the evaluation demonstrated that the prepared serum exhibited satisfactory physicochemical characteristics, good stability under different conditions, smooth texture, and was non-irritating to the skin. The findings indicate that the incorporation of raw *Carica papaya* extract significantly enhances the skin-rejuvenating potential of the formulation. Hence, the developed polyfunctional herbal serum can be considered a safe, effective, and economical alternative to synthetic cosmetic formulations, with promising scope in herbal cosmeceutical applications.

Keywords: *Carica papaya*, Herbal Serum, Polyfunctional Formulation, Skin Rejuvenation, Antioxidant Activity, Cosmeceuticals.

INTRODUCTION

For millennia, people have used natural ingredients to take care of their skin. They are increasingly used in formulation these days as a result of customers' worries about artificial additives and chemicals. Skin care has become a necessity for everyone, even the average person and superstars. Along with preserving the health of your skin, a proper skin care routine may also enhance its structure and functionality. Cleansers, toners, serums, moisturizers, and balms are a few types of skincare cosmetics that can be used to cleanse, exfoliate, protect, and regenerate the skin. Nowadays, skin care products are usually manufactured with synthetic ingredients, chemicals, and colours, in contrast to older times when beauty products were made utilising natural procedures [1, 2, 3].

Interest in natural and herbal medicines, particularly herbal face serums, has surged in response to the growing need for safe and efficient skincare treatments. These serums are becoming increasingly well-known.

Papaya leaf extract, or *Carica papaya*, has long been used in traditional medicine to treat fever in infectious disorders like chikungunya, dengue, and malaria. The advancement of science and technology has since made it feasible to present proof that this plant has pharmacological and toxicological properties that have been scientifically demonstrated, in addition to its benefits as an unofficial medication. As a result, it is now formally used in

professional health care systems. This product is now more valuable due to the development of formulations for use in cosmeceuticals and nutraceuticals [3, 4, 5].

Plant Profile of Papaya

Papayas are small, semiwoody, herbaceous trees that are polygamous. They resemble palms on the outside and have a columnar growth habit. They feature a crown of leaves with long, cylindrical, hollow petioles and broad, palmately lobed pinnatifid blades. They are either unbranched or sparsely branched. C. papaya trees come in three different sex forms: staminate, or "male," pistillate, or "female," and hermaphrodite, or bisexual. Three homologous gene complexes on sex chromosomes define sex in C. papaya. It is thought that the hermaphrodite tree is a remnant of a Caricaceae ancestral prototype with flawless flowers. The staminate flower is unisexual since it has a full complement of stamens but no functional pistil [5, 6].

Figure no. 1 Papaya Plant

Figure no. 2 Closer view of papaya

Papaya Carica L. (family: Caricaceae) is a tropical American fruit tree commonly referred to as "papaya." It is highly regarded for its superior antioxidant, digestive, and nutraceutical properties because of the bioactive components (carpaines, BITC, benzyl glucosinolates, latex, papain, zeaxanthin, choline, etc.) in its seeds, leaves, and fruits. Vitamins A, B, C, E, and K, folate, pantothenic acid, zeaxanthin, lycopene, lutein, magnesium, copper, calcium, and potassium are all abundant in papayas. Rich in fibre, antioxidants, and vitamin C, it lowers arterial cholesterol, prevents arthritis, lowers the risk of cardiovascular disease, ageing, cancer, and macular deterioration, boosts platelet count, manages dengue fever, improves digestion, and reduces body weight [24]. Every portion of this plant has been used to cure a variety of illnesses, including wound dressings, antibacterial properties, anthelminthic effects, conventional birth control, and many other uses [7, 8, 9].

Nutritional Profile

Potassium (223 mg/100 g of fresh fruit) was found in significant proportions together with sodium, calcium, phosphorus, zinc, iron, copper, manganese, and magnesium, according to the papaya's chemical analysis. When it comes to vitamins A, C, B1, and B2, thiamine, folate, riboflavin, niacin, calcium, potassium, iron, and fibre, papaya is one of the most important

fruits. It is high in vitamins and minerals yet low in calories. For every 100 grams of ripe fruit, about 60% of it is edible. The three primary sugars are sucrose (48.3 g/100 g), fructose (21.9 g/100 g), and glucose (29.8 g/100 g). Fresh fruit contains 108 mg of ascorbic acid per 100 g, which is more than oranges, 67 mg per 100g [9, 10, 11].

Volatile substances, such as hydrocarbons, alcohols, terpenes, aldehydes, ketones, esters, benzyl isothiocyanate, and organic acids, are responsible for sensory characteristics like taste and scent. However, ethyl hexanoate, ethyl 2-methylbutanoate, and ethyl acetate are associated with fruit scent. Research has shown that during the ripe stage, aromatic chemicals such as butanol, terpineol, benzyl alcohol, and 3-methylbutanol become plentiful. Methyl butyrate is the highest of 103 esters in papaya [12, 13].

Geographical Source

- Origin

Tropical America is the native home of papaya, especially:

- Mexico's southern region
- The Central Americas
- South America's northern region
- The *Carica papaya* is thought to have originated primarily in this area [14].

- Major Papaya-Producing States in India

India is the largest producer of papaya in the world, contributing more than 40% of global production. Papaya is cultivated mainly in tropical and subtropical regions of the country. Andhra Pradesh, Maharashtra, Karnataka, Gujarat, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, and West Bengal are some of the major states [14, 15, 16].

Taxonomic Classification

Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Superdivision	Spermatophyta (Seed plants)
Division	Magnoliophyta (Flowering plants)
Class	Magnoliopsida (Dicotyledons)
Subclass	Dilleniidae
Order	Brassicales
Family	Caricaceae
Genus	Carica
Species	*Carica papaya* L.

Table no. 1 Taxonomical classification

Phytoconstituents

Categories	Phytoconstituents	Plant parts
Enzymes	Papain, Chymopapain A and B, Endopeptidase papain III and IV, Glutamine cyclotransferase, Peptidase A and B, and Lysozymes.	Unripe fruit (latex)
Carotenoids	Beta-carotene, Crytoxanthin, Violaxanthin, Zeaxanthin	Fruit
Alkaloid & Enzyme	Carposide, Enzyme Myrosin	Roots
Glucosinolates	Benzyl isothiocyanate, Benzylthiourea, Beta-sitosterol, Papaya oil, Caricin, Myrosin	Seeds

Minerals	Calcium, Potassium, Magnesium, Iron, Copper, Zinc	Shoots & Leaves
Monoterpenoids	4-terpineol, Linalool, Linalool oxide	Fruits
Flavanoids	Quercetin, Myricetin, Kaempferol	Shoots
Alkaloids	Carpinine, Carpaine, Pseudocarpine, Vitamin C & E, Choline, Carposide	Leaves & Heartwood
Vitamins	Thamine, Riboflavin, Niacin, Ascorbic Acid, Alpha-tocopherol	Shoots & Leaves
Carbohydrates	Glucose, Sucrose, Fructose	Fruits

Table no. 2 Phytoconstituents

Pharmacological Properties of *Carica Papaya*

The tropical plant papaya (*Carica papaya*) is well known for its many therapeutic uses and nutritional worth. Papaya is becoming increasingly popular in both traditional and modern medicine due to the bioactive compounds found in its fruit, leaves, seeds, and latex, which contribute to a wide range of pharmacological actions [16].

1) **Antioxidant & Anti-Inflammatory:** Papaya extracts are used to treat chronic illnesses, arthritis, and wound healing because they lower oxidative stress and inflammation.
2) **Antimicrobial and antiviral:** Proven efficacy against bacteria, fungi, and viruses (such as COVID-19, HIV, and dengue), with mechanisms including immunological regulation and viral replication inhibition [17].
3) **Cardiovascular and Metabolic Advantages:** The effects of hypoglycemia, hypolipidemia, and antihypertension help control diabetes and metabolic syndrome.
4) **Anticancer Potential:** There is yet little clinical proof, in vitro research indicates suppression of several cancer cell lines [23].
5) **Hypoglycemic effect:** In diabetic rats, the aqueous extract of *Carica papaya* (0.75 g and 1.5 g/100 mL) significantly reduced blood glucose levels ($p<0.05$). Additionally, it reduced blood levels of amino transferases, cholesterol, and triacylglycerol. After therapy, plasma insulin levels in diabetic rats did not change, whereas in animals without diabetes they increased dramatically. In animals without diabetes, pancreatic

islet cells were normal; nevertheless, in rats with diabetes, C. Papaya may aid in islet regeneration, as evidenced by cell size preservation. In the liver of rats given diabetes treatment, C. Papaya inhibited the buildup of lipids and glycogen as well as hepatocyte damage. Lastly, C has an antioxidant impact. Additionally, papaya extract was found in diabetic rats [18].

6) **Anti-dengue effect:** A significant and potentially fatal drop in platelet count is a hallmark of dengue fever. In this work, we examined the influence on platelet augmentation and the antiviral activity of an aqueous extract of *Carica papaya* leaves (PLE) against the dengue virus (DENV). Using immunoblotting and flow cytometry to assess PLE's anti-dengue activity in DENV-infected THP-1 cells, it was discovered that it raises platelet levels [19].
7) **Immunomodulatory effect:** Mice infected with Listeria monocytogenes were used in this study to assess the immunomodulatory effects of *Carica papaya* pulp and seeds methanol (MeOH) extracts. When the immunological parameters were estimated, the treated groups (G3 and G4) had significantly lower IgM levels and higher IgG levels than the G2 group. In comparison to G2, the treated groups (G3 and G4) had lower levels of proinflammatory cytokines (IL-10, IL-12, IL-1β, IL-6, and TGF-β1). Additionally, nitric oxide levels dropped, and phagocytosis percentages rose in comparison to G2. The findings showed that C. papaya pulp and seed MeOH extracts had anti-inflammatory and immunomodulatory properties [20].

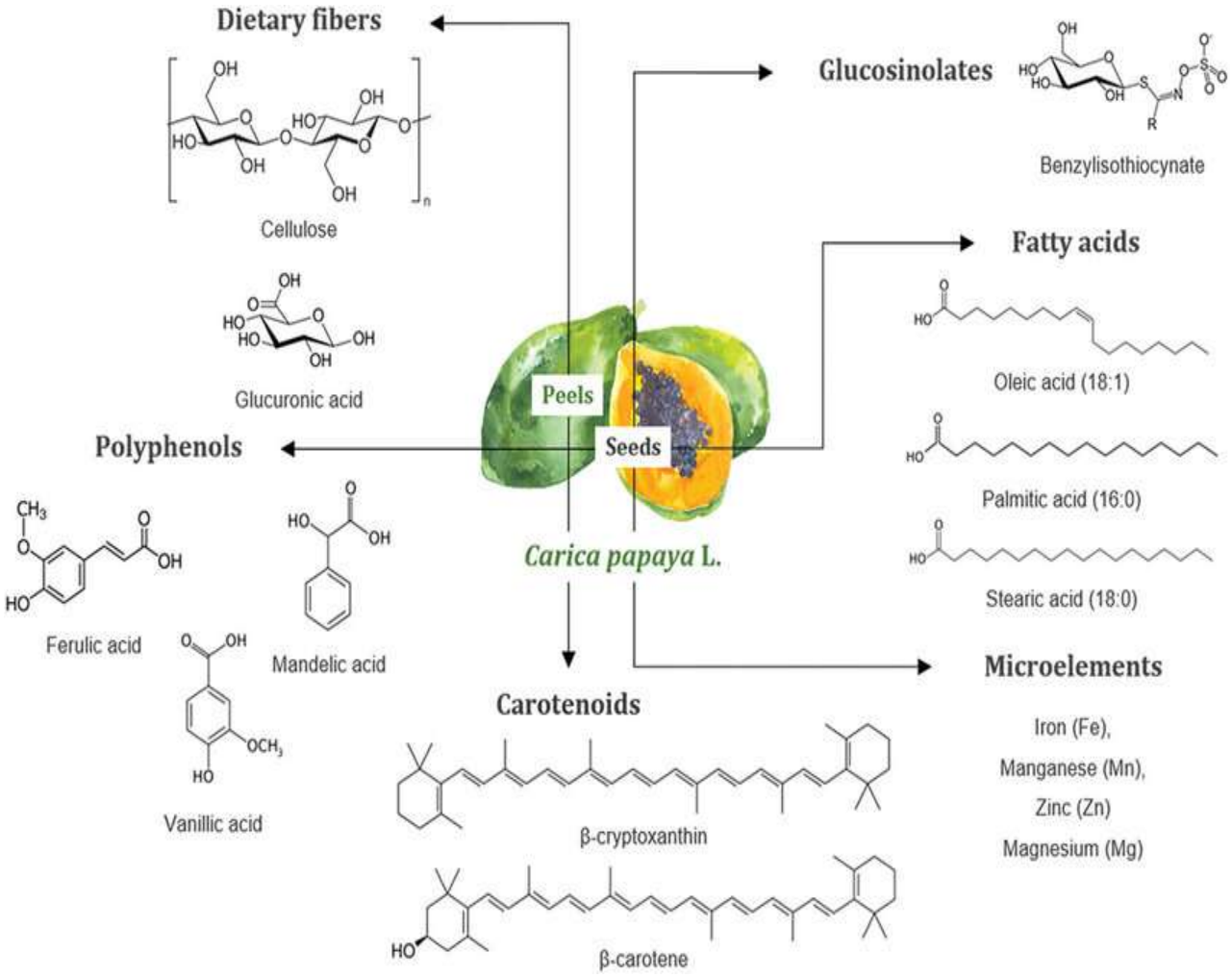

Figure no. 3 Chemicals in seeds and peel of Papaya [25]

PROCEDURE / METHODOLOGY

Extraction of papaya pulp

Carica papaya dry powder pulp weighing 200 g was macerated in different solvents (500ml) for two days, including water and ethanol.

Extraction of papaya pulp with water

STEP 1 - Clean and peel the fresh papaya fruit.

STEP 2 - Remove the seeds.

STEP 3 - Slice the papaya into uniform thin slices [ideally ¼ or ½ inch thick] to ensure even drying.

STEP 4 - Keep the slices in a hot air oven at 50-60°C, then dry until it becomes brittle.

STEP 5 - Then grind the dried slices of papaya to a fine powder using a blender so that it can be used further for maceration.

STEP 6 - Soak a known amount of papaya powder (200 mg) in the chosen solvent (500ml of distilled water) in a closed container.

STEP 7 - Stir the mixture using an orbital shaker at a controlled speed of 200 rpm for 24 to 72 hours, to enhance the extraction of bioactive compounds.

STEP 8 - Filter the liquid extract to separate it from the solid residue.

Extraction of papaya pulp with 70% ethanol

STEP 1 - Clean and peel the fresh papaya fruit.

STEP 2 - Remove the seeds.

STEP 3 - Slice the papaya into uniform thin slices [ideally ¼ or ½ inch thick] to ensure even drying.

STEP 4 - Keep the slices in a hot air oven at 50-60°C, then dry until it becomes brittle.

STEP 5 - Then grind the dried slices of papaya to a fine powder using a blender so that it can be used further for maceration.

STEP 6 - Soak a known amount of papaya powder (200 mg) in the chosen solvent (500ml of distilled water) in a closed container.

STEP 7 - Stir the mixture using an orbital shaker at a controlled speed of 200 rpm for 24 to 72 hours, to enhance the extraction of bioactive compounds.

STEP 8 - Filter the liquid extract to separate it from the solid residue.

Extraction of papaya seeds

Carica papaya dry powder seeds weighing 200gm were macerated in different solvents (500ml) for two days, including water and ethanol.

Extraction of papaya seeds with water

STEP 1 - Clean and peel the fresh papaya fruit.

STEP 2 - Remove the seeds.

STEP 3 - Wash the seeds properly and pat them dry to ensure even drying.

STEP 4 - Keep the slices in a hot air oven at 50-60°C, then dry until it becomes brittle.

STEP 5 - Then grind the dried seeds of papaya to a fine powder using a blender so that it can be used further for maceration.

STEP 6 - Soak a known amount of papaya seed powder (200 mg) in the chosen solvent (500ml of distilled water) in a closed container.

STEP 7 - Stir the mixture using an orbital shaker at a controlled speed of 200 rpm for 24 to 72 hours, to enhance the extraction of bioactive compounds.

STEP 8 - Filter the liquid extract to separate it from the solid residue.

Extraction of papaya seeds with 70% of ethanol

STEP 1 - Clean and peel the fresh papaya fruit.

STEP 2 - Remove the seeds.

STEP 3 - Wash the seeds properly and pat them dry to ensure even drying.

STEP 4 - Keep the slices in a hot air oven at 50-60°C, then dry until it becomes brittle.

STEP 5 - Then grind the dried seeds of papaya to a fine powder using a blender so that it can be used further for maceration.

STEP 6 - Soak a known amount of papaya seed powder (200 mg) in the chosen solvent (500ml of distilled water) in a closed container.

STEP 7 - Stir the mixture using an orbital shaker at a controlled speed of 200 rpm for 24 to 72 hours, to enhance the extraction of bioactive compounds.

STEP 8 - Filter the liquid extract to separate it from the solid residue.

Post-extraction processing

1. The solvent-rich extract will be collected in the maceration jar, which is then filtered to remove any plant residues.
2. The dark coloured solvent extract will be collected and then filtered to remove any residue.

3. The filtrate will be concentrated using a rotatory evaporator under reduced pressure at 40-50°C [85].
4. The extract will be stored at 4°C in a refrigerator until further use.
5. The resulting semi-solid crude extract will be scraped, weighed, and transferred to an amber-coloured glass container.

PHYTOCHEMICAL SCREENING

1. Mayer's Reagent – Test for Alkaloids

Procedure

1. Take 2 ml of extract in a test tube.

2. Add a few drops of dilute HCl, warm gently, and filter if needed to get a clear solution.

3. To 1–2 ml of this acidified solution, add 2–3 drops of Mayer's reagent.

Result: The formation of a cream or white precipitate indicates the presence of alkaloids.

2. Wagner's Reagent – Test for Alkaloids

Procedure

1. Take 2 ml of extract

2. Add a few drops of dilute HCl, warm slightly, and filter if necessary.

3. To 1–2 ml of this acidified solution, add 2–3 drops of Wagner's reagent.

Result: The formation of a reddish-brown precipitate shows the presence of alkaloids.

3. Lead Acetate – Test for Phenolics / Flavonoids

Procedure

1. Take 2 ml of extract in a test tube.

2. Add a few drops of 10% lead acetate solution.

3. Shake gently.

Result: The formation of a yellow or bulky white precipitate indicates the presence of phenolic compounds/flavonoids/tannins.

4. Concentrated Sulphuric Acid (H_2SO_4) – Steroids / Triterpenes (Salkowski-type)

Used along with chloroform

Procedure (Salkowski Test)

1. Take 2 ml of extract and add 2 ml of chloroform; shake well.

2. Carefully add 1–2 ml of conc. H_2SO_4 down the side of the tube to form a separate lower layer.

3. Do not shake after adding acid; observe the interface.

Result: If red, brown or reddish ring at the junction of the two layers indicates steroids/triterpenoids.

5. Acetic Anhydride + Conc. H_2SO_4 – Liebermann–Burchard Test (Steroids / Triterpenoids)

Procedure

1. Take 1–2 ml of extract in a dry test tube.

2. Add 1 ml of acetic anhydride and mix.

3. Carefully add 1–2 ml of conc. H_2SO_4 along the side of the test tube.

4. Observe the colour at the junction.

Result: The formation of blue-green, emerald green or reddish colour indicates steroids/triterpenoids.

6. Chloroform – Used with H_2SO_4 (Salkowski Test)

Procedure (Salkowski Test)

1. Take 2 ml of extract and add 2 ml of chloroform; shake well.

2. Carefully add 1–2 ml of conc. H_2SO_4 down the side of the tube to form a separate lower layer.

3. Do not shake after adding acid; observe the interface.

Result: If red, brown or reddish ring at the junction of the two layers indicates steroids/triterpenoids.

7. Ferric Chloride ($FeCl_3$) – Test for Phenolics / Tannins

Procedure

1. Take 2 ml of extract (preferably aqueous or hydroalcoholic).

2. Add 2–3 drops of 5% $FeCl_3$ solution.

3. Mix gently.

Result: The formation of a blue, green, or blackish colouration indicates phenolic compounds/tannins.

8. Benedict's Solution – Test for Reducing Sugars

Procedure

1. Take 2 mL of Benedict's reagent in a test tube.

2. Add 0.5–1 ml of extract.

3. Heat the mixture in a boiling water bath for 2–3 minutes, then cool.

Result: The formation of green, yellow, orange, or brick-red precipitate indicates reducing sugars.

9. Molisch Reagent – General Test for Carbohydrates

Procedure

1. Take 2 ml of extract in a test tube.

2. Add 2–3 drops of Molisch reagent (α-naphthol in alcohol) and mix.

3. Incline the test tube and carefully add 1–2 ml of conc. H_2SO_4 along the side without mixing, so that it forms a layer underneath.

4. Observe the interface.

Result: If a violet or purple ring at the junction of the two layers indicates the presence of carbohydrates.

METHODS AND MATERIALS FOR FORMULATION

Materials Required

1) **Serum base ingredients:** (e.g., Vitamin E, Jojoba oil, Aloe vera gel, Rose water, Glycerine, Xanthan gum).
2) **Active ingredients:** (e.g., papaya pulp extract, papaya seed extract),
3) **Preservatives:** (e.g., Sodium Benzoate, Potassium Sorbate, Sorbic Acid).

Chemicals for formulation

S. no	Chemical name	Uses
1	Ethanol	Solvent for preparing papaya pulp and seed extraction
2	Distilled water	Used for extract preparation and cleaning
3	Sodium benzoate	Preservative to prevent microbial contamination

Table no. 3 List of chemicals

Materials for formulation

S. no	Materials	Purpose
1	Papaya pulp extract	Active ingredient
2	Papaya seed extract	Active ingredient
3	Glycerine	Levigating agent
4	Vitamin E	Emollient
5	Jojoba oil	Lightweight, natural moisturiser, sebum balancer, anti-inflammatory agent, and antioxidant carrier
6	Rose water	To hydrate, tone, and soothe skin
7	Aloe vera gel	provides intense hydration, soothes inflammation (sunburns, redness, irritation), promotes skin healing, fights acne with antibacterial properties, and offers anti-ageing benefits by boosting collagen, all while being lightweight and non-greasy.
8	Xanthan gum	natural thickener, stabiliser, and emulsifier

Table no. 4 Materials for formulation

Standard Formulation Procedure

Since *Carica Papaya* was not formulated as a multifunctional serum, we use the validated serum formulation method from the herbal serum study and substitute the active ingredient with *Carica Papaya* extract.

1. **Formulation Type**

Oil-in-Water (O/W) herbal polyfunctional face serum

Ingredients	Quantity
Papaya pulp extract	1.5ml
Papaya seed extract	0.6ml
Xanthan gum	0.15g
Jojoba oil	1.5ml
Vitamin E	0.3ml
Rose water	16.95ml
Glycerine	1.5ml
Aleo vera gel	7.5ml

Table no. 5

2. **Method of Preparation**

- **Preparation of Oil Phase (A):** The oily component, consisting of Vitamin E, Jojoba oil, will be mixed for 10 minutes in a mortar and pestle to obtain a uniform solution.
- **Prepare Aqueous Phase (B):** The water phase will be prepared by mixing Papaya Pulp Extract, Papaya Seed Extract, aloe vera gel, glycerine, Rose Water, Xanthan gum and a small amount of distilled water, mixed uniformly.
- **Emulsification:** The oil phase will be added to the liquid phase dropwise with continuous stirring, then the emulsion is known as a primary emulsion. The remaining water phase will be added in small quantities at a time to get the homogeneous product. Then the emulsion will be transferred to a measuring cylinder, and more of the vehicle will be added to produce a final volume of 30ml,

and it is stirred with the help of a magnetic stirrer at 3000 rpm to get a uniform emulsion.

- **Storage:** The preparation will be transferred to a serum bottle lid will be placed.

CONCLUSION

Based on the extraction, phytochemical screening procedures, and supportive literature review, *Carica Papaya* appears to contain several bioactive constituents such as alkaloids, flavonoids, phenolics, tannins, terpenoids, and steroids, which are generally associated with anti-ageing, antioxidant, exfoliating, and enzymatic properties.

REFERENCES

1. Thorat PS, Bhadane HB, Wagh SS, Gaikwad MS, Chhajed SS. General review of face serum. World J Pharm Res. 2023 Feb 28;12:445.

2. Badgujar AV, Patil PP. Formulation, development and evaluation of herbal face serum by using herbal materials.

3. Patidar M, Deshmukh N, Mandloi N, Patidar B, Solanki L, Pillai S. Formulation and evaluation of face serum containing phytosome of gingerol oil, Carica papaya pulp extract, and aloe vera gel. World J Pharm Res. 2023 Aug 26;12:726-40.

4. Kerdpremwes P, Jimtaisong A. Carica Papaya L. Leaf as a Sustainable Source of Antioxidant in Cosmetic Formulation: A Study on Facial Serum. Leaf as a Sustainable Source of Antioxidant in Cosmetic Formulation: A Study on Facial Serum.

5. Hapsari FK, Hidayati N. Formulation and Testing of Antioxidant Activity of Papaya Fruit (Carica papaya L.) Extract Spray Gel Using the DPPH Method. Biology, Medicine, & Natural Product Chemistry. 2025 Apr 25;14(1):101-6.

6. Kamble R, Gamare D, Yeole P, Pathan MA, Indulkar A, Kale MK, Juvatkar PV. Formulation and evaluation of herbal-based anti-ageing face serum. Foldscope & its Applications. 2022;127.

7. Qaiser A, Ali S, Manzoor S. Prospects of Carica papaya in the treatment of human viral infections: A comprehensive and systematic review. Heliyon. 2024 Nov 15;10(21).

8. Ferguson P, Akinsulie A, Bergfeld WF, Belsito DV, Cohen DE, Klaassen CD, Liebler DC, Marks Jr JG, Peterson LA, Shank RC, Slaga TJ. Safety assessment of Carica papaya (Papaya)—derived ingredients as used in cosmetics. International journal of toxicology. 2025 Oct;44(3_suppl):36S-56S.

9. Karunamoorthi K, Kim HM, Jegajeevanram K, Xavier J, Vijayalakshmi J. Papaya: A gifted nutraceutical plant-a critical review of recent human health research. Cellmed. 2014 Feb 28;4(1):21-7.

10. Savaran SS. Formulation and Production of Facial Cream from Papaya (Doctoral dissertation, UMP).

11. Gilaberte Y, Prieto-Torres L, Pastushenko I, Juarranz Á. Anatomy and Function of the Skin. In Nanoscience in dermatology 2016 Jan 1 (pp. 1-14). Academic Press

12. Yousef H, Alhajj M, Sharma S. Anatomy, skin (integument), epidermis. Women's Health Medicine. June 2017.

13. Powell J. Skin physiology. Women's Health Medicine. 2006 May 1;3(3):130-3.

14. Sim YS, Wong LC, Yeoh SC, Almashhadani A, Alrimawi BH, Goh CF. Skin penetration enhancers: Mechanistic understanding and their selection for formulation and design. Drug Delivery and Translational Research. 2025 Feb 21:1-35.

15. Lee HJ, Kim M. Skin barrier function and the microbiome. International journal of molecular sciences. 2022 Oct 28;23(21):13071.

16. Lopez-Ojeda W, Pandey A, Alhajj M, Oakley AM. Anatomy, skin (integument). InStatPearls [Internet] 2022 Oct 17. StatPearls Publishing.

17. Patidar M, Deshmukh N, Mandloi N, Patidar B, Solanki L, Pillai S. Formulation and evaluation of face serum containing phytosome of gingerol oil, Carica papaya pulp extract, and aloe vera gel. World J Pharm Res. 2023 Aug 26.

18. Asthana GS, Chowdary GV, Yasvitha RS. " Natural Synergy in Skincare: Polyherbal Face Serum Composition and Its Applications.

19. Zwirner J, Hammer N. Anatomy and Physiology of the Skin. In Scars: A Practical Guide for Scar Therapy 2024 Apr 14 (pp. 3-9). Cham: Springer International Publishing.

20. Fodor L, Dumitrascu D. Skin anatomy. In Aesthetic Applications of Intense Pulsed Light 2019 Sep 27 (pp. 1-12). Cham: Springer International Publishing.

21. Brown TM, Krishnamurthy K. Histology, dermis. StatPearls. Treasure Island, FL: StatPearls Publishing. 2022 Nov.

22. Arda O, Göksügür N, Tüzün Y. Basic histological structure and functions of facial skin. Clinics in dermatology. 2014 Jan 1;32(1):3-13.

23. McKnight G, Shah J, Hargest R. Physiology of the skin. Surgery (Oxford). 2022 Jan 1;40(1):8-12.

24. Thorat PS, Bhadane HB, Wagh SS, Gaikwad MS, Chhajed SS. General review of face serum. World J Pharm Res. 2023 Feb 28.

25. Shaheen, Sherif & Galanakis, Charis & Farag, Mohamed. (2022). Carica papaya biowaste valorisation: Biorefinery advances and extraction optimization. Food Reviews International. 10.1080/87559129.2022.2057527.