FORMULATION AND EVALUATION OF ANTI-AGEING CREAM BY USING AMLA

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***Abstract*—Skin ageing is a universal, inevitable, and multidimensional biological process that significantly impacts the physical appearance, psychological wellbeing, and quality of life of individuals worldwide. The global anti-ageing skincare market, valued at over USD 60 billion and growing at a compound annual growth rate of approximately 5–7%, reflects the enormous personal and commercial significance of skin ageing as a cosmetic concern and public health issue. The visible signs of skin ageing — wrinkles, fine lines, hyperpigmentation, skin laxity, dullness, and uneven texture — are driven by two interconnected processes: intrinsic chronological ageing, which is determined by genetic programming and inevitable cellular senescence, and extrinsic photoageing, which is caused primarily by chronic ultraviolet radiation exposure and results in up to 80% of visible facial ageing changes.**

The growing consumer demand for natural, plant-derived, and scientifically validated anti-ageing cosmeceutical products has led to intense scientific interest in identifying and formulating effective botanical anti-ageing actives as alternatives or complements to synthetic retinoids, alpha-hydroxy acids, and UV-filtering chemicals. Amla — the fruit of Emblica officinalis Gaertn. (Family: Phyllanthaceae), commonly known as the Indian Gooseberry — stands as one of the most scientifically compelling and pharmacologically comprehensive natural anti-ageing ingredients available in the Indian botanical pharmacopoeia, having been used in Ayurvedic medicine as a rasayana (rejuvenating tonic) for skin vitality and longevity for more than 5,000 years.

***Index Terms*—Amla, Emblica officinalis, Anti-ageing Cream, Vitamin C, Collagen Synthesis, MMP Inhibition, Antioxidant, Photoprotection, Emblicanin, Gallic Acid, Skin Brightening, Topical Formulation, Cosmeceutical, Indian Pharmacopoeia**

I. Introduction

1.1 Skin Ageing — A Global Perspective

The word 'ageing' is derived from the Old French word aagier meaning 'to grow old,' and in the context of skin biology, it describes the progressive, multidimensional, and ultimately inevitable changes in the structure, composition, function, and appearance of human skin that occur as a consequence of advancing chronological age and cumulative environmental exposures. Skin ageing is not a single event or process but rather the complex, superimposed result of multiple interacting biological mechanisms — genomic instability, telomere attrition, mitochondrial dysfunction, cellular senescence, stem cell exhaustion, chronic low-grade inflammation (now termed 'inflammageing'), and progressive tissue macromolecular damage — unfolding simultaneously across the epidermis, dermis, and hypodermis over the course of an individual's lifetime.The skin is the largest organ of the human body by surface area (approximately 1.7–2.0 m² in adults) and weight (approximately 4–5 kg), performing a remarkable array of essential physiological

functions that include primary barrier protection against physical, chemical, and microbial threats, thermoregulation through vasodilation, vasoconstriction, and sweating, sensory perception of touch, pressure, temperature, and pain, neuroendocrine and immune functions, vitamin D photosynthesis, and communication of emotional states through facial expression and blushing. As the most externally visible and socially significant organ, the skin is also the primary anatomical site where the visible signs of biological ageing manifest — making skin ageing a topic of profound personal relevance to individuals across all cultures and demographic groups.

Fig.No.1

The global significance of skin ageing as both a health and cosmetic concern is reflected in the extraordinary scale of the anti-ageing skincare industry. The global anti-ageing market was valued at approximately USD 58.5 billion in 2020 and is projected to reach USD 88.3 billion by 2026, growing at a CAGR of approximately 7.5%. This growth is driven by multiple converging trends — the rapid ageing of the global population, with the number of people over 65 years expected to double from 703 million in 2019 to 1.5 billion by 2050; rising disposable incomes and consumer sophistication in rapidly developing economies; increasing scientific literacy among consumers about skin health and the availability of evidence-based cosmeceutical products; and a growing global trend toward natural, plant-derived, and 'clean beauty' formulations that align with sustainability values and minimize exposure to synthetic chemicals of uncertain safety.In India, the anti-ageing skincare market occupies a particularly significant position, driven by a population of 1.4 billion individuals, rapid economic growth expanding the middle class, a deeply rooted cultural tradition of herbal and Ayurvedic skin care that predisposes consumers toward botanical anti-ageing formulations, and the availability of a uniquely rich native botanical pharmacopoeia containing numerous plants with scientifically validated anti-ageing skin-care properties. India's tropical climate — characterized by intense UV radiation exposure, high humidity, air pollution in urban centers, and extreme temperatures — creates a uniquely challenging environmental skin ageing context that compounds the

effects of intrinsic ageing and underscores the importance of effective photoprotection and antioxidant skin care. Despite the enormous size and dynamism of the anti-ageing skincare market, consumer and regulatory scrutiny of conventional synthetic anti-ageing actives has intensified significantly in recent years. Retinoids — despite their well-documented efficacy — cause photosensitivity, skin irritation, dryness, and are contraindicated in pregnancy. Hydroquinone — the standard depigmenting agent — carries carcinogenicity concerns and is banned in the European Union and restricted in multiple other jurisdictions. Many chemical UV filters — including oxybenzone and octinoxate — have raised concerns about endocrine disruption, marine ecosystem toxicity, and skin sensitization. This regulatory and consumer environment creates a compelling commercial and scientific opportunity for the development of effective, natural, and well-tolerated anti-ageing cosmeceutical products based on botanical actives with established safety records and multi-mechanistic anti-ageing efficacy.

1.2 The Skin — Structure, Function, and Age-Related Changes

A thorough understanding of the structure and function of healthy skin is prerequisite to understanding how and why it ages, and how anti-ageing cosmeceutical formulations can intervene in these processes. The skin is organized into three primary tissue layers — the epidermis, the dermis, and the hypodermis (subcutaneous tissue) — each with distinct cellular populations, structural components, and functional contributions to skin health and appearance.

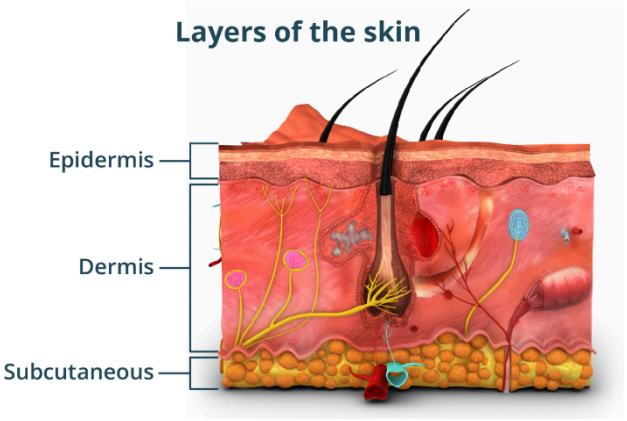


Fig.No.2

1.2.1 The Epidermis

The epidermis is the outermost layer of the skin, approximately 0.1–0.3 mm in thickness over most of the body and up to 1.5 mm on the palms and soles, composed almost entirely (90–95%) of keratinocytes at various stages of terminal differentiation. The epidermis is organized into five histologically distinct layers from basal to superficial: the stratum basale (germinative layer), stratum spinosum (prickle cell layer), stratum granulosum (granular layer), stratum lucidum (present only in palmoplantar skin), and stratum corneum (horny layer). The stratum basale contains mitotically active keratinocyte stem cells that

continuously proliferate and differentiate, progressively ascending through the epidermal layers over a period of approximately 28 days before reaching the stratum corneum as fully keratinized, anucleate, dead cells that are eventually shed through desquamation.

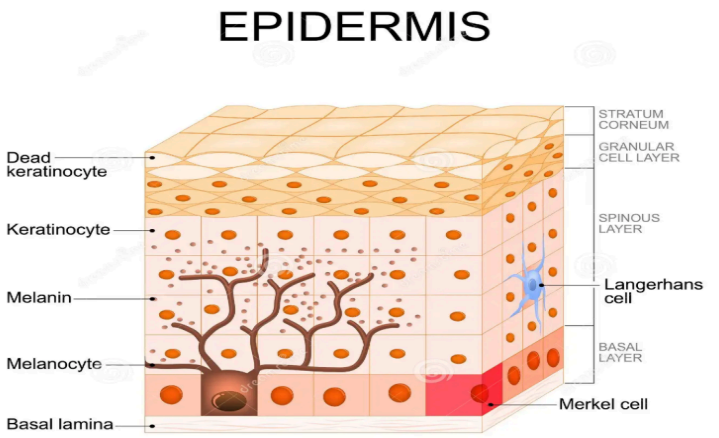


Fig.No.3

The stratum corneum — composed of 15–20 layers of flattened, interlocked corneocytes embedded in a lipid-rich extracellular matrix of ceramides, fatty acids, and cholesterol — constitutes the primary physical barrier of the skin, restricting transepidermal water loss, preventing penetration of xenobiotics and microorganisms, and determining the cosmetic attributes of skin hydration and surface texture. The epidermal barrier function deteriorates progressively with age due to reduced lipid synthesis, altered lipid composition, and declining desquamation efficiency — contributing to the characteristic dryness, roughness, and increased permeability of aged skin.The epidermis also contains three additional specialized cell populations: melanocytes (approximately 5–10% of basal layer cells) that produce and transfer melanin pigment to surrounding keratinocytes through dendritic processes, providing photoprotection and skin colour; Langerhans cells (professional antigen-presenting dendritic cells of the immune system, approximately 2–4% of epidermal cells) that provide immune surveillance against epidermal pathogens and contact allergens; and Merkel cells associated with sensory nerve endings that function as slowly adapting mechanoreceptors for fine touch discrimination.

1.2.2 The Dermis

The dermis is the thick, fibrous connective tissue layer situated immediately below the epidermis, separated from it by the dermo-epidermal junction (DEJ) — a complex, undulating basement membrane structure that mechanically interlocks the two layers and facilitates nutrient exchange between the avascular epidermis and the vascularized dermis. The dermis is subdivided into two regions: the papillary dermis (thin, loose, irregular connective tissue immediately subjacent to the DEJ, rich in collagen type III, elastic fibers, and capillaries) and the reticular dermis (thicker, denser, more regularly organized layer composing the bulk of dermal thickness, rich in collagen type I bundles and mature elastic fibers).

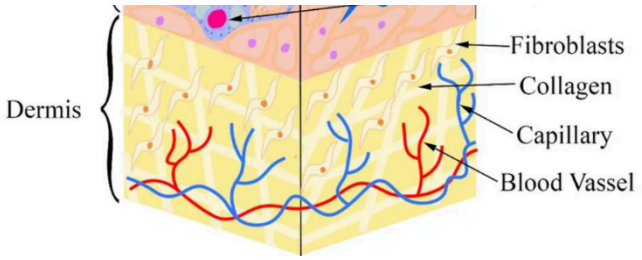


Fig.No.4

The dermis is the seat of the skin's structural and biomechanical properties — its firmness, elasticity, and resilience — and contains the dermal extracellular matrix (ECM), which is primarily composed of collagen (predominantly type I collagen at approximately 70–80% of skin dry weight), elastic fibers (elastin, fibrillin, and associated microfibrils at approximately 2–4% of dry weight), and a hydrated glycosaminoglycan (GAG) gel consisting principally of hyaluronic acid, chondroitin sulfate, dermatan sulfate, and heparan sulfate. The dermal ECM is synthesized and maintained by dermal fibroblasts — the resident mesenchymal cells of the dermis — whose synthetic and proliferative capacity is progressively diminished by the ageing process.The dermis also contains the skin's vascular and lymphatic networks, sensory and autonomic nerve endings, eccrine and apocrine sweat glands, sebaceous glands, hair follicles, and arrector pili muscles — all of which undergo age-related structural and functional changes that contribute to the overall ageing phenotype of the skin.

II. LITERATURE SURVEY

1. Textbook of Pharmacognosy — C.K. Kokate, A.P. Purohit, S.B. Gokhale — Nirali Prakashan, 2020 — Supports phytochemical profile, biological source, chemical constituents, and anti-ageing properties of Emblica officinalis.

2. Essentials of Medical Pharmacology — K.D. Tripathi — Jaypee Brothers, 2021 — Explains the mechanisms of skin ageing, UV radiation biology, and pharmacology of antioxidant and anti-inflammatory agents.

3. Theory and Practice of Industrial Pharmacy — Lachman L., Lieberman H.A., Kanig J.L. — CBS Publishers, 2009 — Covers cream formulation technology, emulsification methods, excipient selection, and evaluation of semi-solid preparations.

4. Indian Pharmacopoeia — Government of India — IPC Ghaziabad, 2022 — Standard reference for all IP grade excipients, specifications, and quality control methods for topical preparations.

5. Biopharmaceutics and Pharmacokinetics — D.M. Brahmankar, S.B. Jaiswal — Vallabh Prakashan, 2015 — Guides percutaneous absorption, skin penetration mechanisms, and topical bioavailability of cream formulations.

6. Cosmetic Formulation, Manufacturing and Quality Control — Sharma P.P. — Vandana Publications, 2018 — Covers cream formulation principles, SPF testing methodology, and stability evaluation of topical cosmeceuticals.

7. Herbal Drug Technology — A.K. Gupta, S.S. Tandon — CBS Publishers, 2020 — Covers standardization, extraction, and formulation of herbal drugs including Amla for cosmeceutical preparations.

8. Pharmaceutical Analysis — Kasture A.V., Mahadik K.R. — Nirali Prakashan, 2016 — Supports UV spectrophotometric SPF determination, DPPH antioxidant assay, and Vitamin C content analysis.

9. Handbook of Medicinal Plants — S.S. Handa, M.K. Kaul — CBS Publishers, 2021 — Provides detailed ethnobotanical and pharmacological data on Emblica officinalis for cosmeceutical applications.

10. Pharmacognosy and Phytochemistry — Vinod D. Rangari — Career Publications, 2022 — Details chemical constituents, standardization methods, and anti-ageing pharmacological activities of Amla.

III. MATERIAL

Active Ingredient: Amla Powder (Emblica officinalis Gaertn.) — self-prepared and standardized for Vitamin C content.

Excipients: Stearic Acid IP, Cetyl Alcohol IP, Liquid Paraffin IP, Glycerin IP, Propylene Glycol IP, Triethanolamine (TEA) IP, Methyl Paraben IP, Propyl Paraben IP, Perfume/Essential Oil (pharmaceutical grade, optional), Distilled Water (freshly prepared).

Equipment: Mortar and Pestle, Water Bath (with temperature control), Mechanical Stirrer, Beaker (500 mL and 250 mL), Glass Rod, Spatula, Weighing Pan, Petri Dishes, Desiccator, Cream Tubes / Opaque Plastic Containers.

Instruments: Analytical Weighing Balance, pH Meter (calibrated), Brookfield Viscometer (with appropriate spindle), UV-Visible Spectrophotometer, Penetrometer (for spreadability), Stability Chamber, Microscope (for homogeneity), Centrifuge, Hot Air Oven.

IV. METHOD

Step 1: Preparation of Amla Powder

1. Collect fresh, fully ripe Amla fruits (Indian Gooseberry) from a reliable, authenticated botanical source. Confirm botanical identity as Emblica officinalis by macroscopic characters — small, globular, greenish-yellow fruit with 6 vertical furrows and translucent flesh.

2. Wash the fruits thoroughly under running water and then rinse with distilled water to remove surface contamination, pesticide residues, and microbial flora.

3. Remove seeds manually and cut the fleshy pericarp into thin slices (1–2 mm thickness) to maximize drying efficiency.

4. Shade-dry at room temperature away from direct sunlight for 7–10 days, or alternatively dry in a hot air oven at 45–50°C for 48 hours. Do NOT exceed 60°C — higher temperatures cause significant Vitamin C degradation.

5. Grind the completely dried Amla pieces in a mechanical grinder to obtain a fine powder.

6. Pass through an 80-mesh sieve to ensure fine, uniform particle size appropriate for cream incorporation — coarser particles would compromise the smooth texture of the cream.

7. Determine moisture content (LOD) — should be not more than 8% w/w.

8. Standardize the batch for Vitamin C content by iodometric titration and for total phenolics by Folin-Ciocalteu method.

9. Store in an airtight, amber-colored glass container in a cool (4°C), dark environment away from moisture and oxygen to minimize Vitamin C oxidation during storage.

V. PLANT PROFILE

Amla — Emblica officinalis Gaertn.

Drug Name: Amla / Indian Gooseberry (Emblica officinalis)

Fig.No. 5

Biological Source: The drug consists of the fresh or dried fruits (pericarp) of Emblica officinalis Gaertn. (synonyms: Phyllanthus emblica Linn., Cicca emblica Kurz).

Family: Phyllanthaceae (formerly Euphorbiaceae)

Common Names: Amla / Indian Gooseberry (English), Amalaki / Dhatri (Sanskrit), Amla / Aanvala (Hindi/Marathi), Nelli / Nellikkai (Tamil/Malayalam), Usirikaya (Telugu), Nellikai (Kannada)

Chemical Constituents of Amla (Relevant to Anti-Ageing Activity):

• Vitamin C (Ascorbic Acid) — 600–900 mg per 100 g fresh fruit — richest natural source; essential for collagen synthesis and antioxidant defense

• Emblicanin A ($C_{38}H_{28}O_{28}$, MW 956.62) — unique tannoid complex; extraordinary antioxidant potency; protects Vitamin C from oxidation

• Emblicanin B ($C_{44}H_{32}O_{32}$, MW 1108.64) — higher MW tannoid; synergistic antioxidant with Emblicanin A

• Punigluconin — hydrolysable tannin; potent antioxidant and anti-glycation activity

• Pedunculagin — ellagitannin with antioxidant and anti-inflammatory properties

• Gallic Acid — phenolic acid; tyrosinase inhibitor, MMP inhibitor, antioxidant, UV absorber

• Ellagic Acid — dilactone of hexahydroxydiphenic acid; tyrosinase inhibitor, antioxidant, anti-UV

• Chebulinic Acid and Chebulagic Acid — tannins with antioxidant and anti-inflammatory properties

• Quercetin — flavonol; anti-inflammatory, antioxidant, UV filter

• Rutin — quercetin-3-rutinoside; anti-inflammatory, strengthens capillaries

• Phyllemblin — coumarin derivative; antimicrobial, antioxidant

• Mucic Acid (Galactaric Acid) — unique organic acid of Amla

• Minerals: Calcium, Phosphorus, Iron, Chromium (Chromium enhances insulin sensitivity)

Morphological Characteristics of Amla Fruit and Powder:

• Fruit Shape: Globular, 1–3 cm diameter, with 6 characteristic vertical furrows.

• Fruit Colour: Greenish-yellow when fresh; translucent pale green flesh.

• Powder Colour: Light greenish-yellow to brownish-yellow.

• Powder Odour: Characteristic, slightly acidic, faintly astringent.

• Powder Taste: Sour, astringent, then slightly sweet aftertaste — characteristic panchaswada (five tastes) of Ayurveda.

Anti-Ageing Mechanisms — Summary:

Anti-Ageing Mechanism	Active Compound	Target
Collagen synthesis stimulation	Vitamin C	Prolyl/lysyl hydroxylase cofactor → procollagen maturation
MMP collagenase inhibition	Gallic acid, Ellagic acid	MMP-1, MMP-3 enzyme inhibition → collagen preservation
Antioxidant / Free radical scavenging	Emblicanin A&B, Vitamin C, Quercetin	ROS neutralization → prevents oxidative skin damage
Tyrosinase inhibition / Brightening	Vitamin C, Gallic acid, Ellagic acid	Melanin synthesis reduction → even skin tone
Hyaluronic acid production	Vitamin C	Hyaluronan synthase stimulation → skin hydration
Anti-inflammatory / Anti-inflammageing	Quercetin, Rutin, Emblicanins	NF-κB, COX-2 inhibition → reduces inflammageing
UV absorption (Photoprotection)	Tannins, Gallic acid, Ellagic acid	UVB chromophore absorption → skin photoprotection

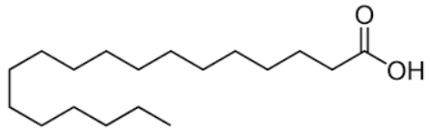
Anti-glycation	Polyphenols, Vitamin C	AGE formation inhibition → prevents collagen cross-linking

EXCIPIENTS:

1. Stearic Acid IP

Official Name: Stearic Acid (IP, USP, BP)

Chemical Name: Octadecanoic acid



Molecular Formula: $C_{18}H_{36}O_2$

Molecular Weight: 284.48 g/mol

Melting Point: 69–70°C

Category: Emulsifying agent, Cream base component, Stiffening agent, Self-emulsifying agent (when neutralized with TEA)

Description:

• Colour: White or almost white, waxy solid or powder.
• Odour: Faint, characteristic fatty odour.
• Solubility: Practically insoluble in water; soluble in alcohol, chloroform, and fixed oils.
• HLB: Low (hydrophobic) in native form; forms soap emulsifier of HLB ~18 when neutralized with TEA.

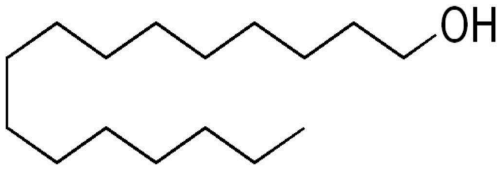
Uses:

• Primary emulsifying agent — Stearic Acid reacts with TEA (triethanolamine) during emulsification to form in-situ triethanolamine stearate soap, which is an excellent o/w emulsifier with HLB ~18.
• Cream base component — provides the characteristic smooth, pearlescent cream texture and appropriate consistency.
• Stiffening agent — contributes to the semi-solid consistency of the cream at room temperature.
• Emollient — smooths skin surface by filling microscopic surface defects.
• Used at 2.5 g per 50 g batch (5% w/w) — consistent across all three formulations.

2. Cetyl Alcohol IP

Official Name: Cetyl Alcohol (IP, USP, BP) — also known as Hexadecan-1-ol

Chemical Name: 1-Hexadecanol (n-cetyl alcohol)



Molecular Formula: $C_{16}H_{34}O$

Molecular Weight: 242.44 g/mol

Melting Point: 49–51°C

Category: Emulsion stabilizer, Emollient, Thickener, Co-emulsifier, Stiffening agent

Description:

• Colour: White, waxy, crystalline flakes or solid.

• Odour: Faint, characteristic fatty odour.

• Solubility: Practically insoluble in water; soluble in alcohol, chloroform, and fixed oils.

Uses:

• Emulsion stabilizer — Cetyl Alcohol incorporates into the interfacial film formed by stearate soap emulsifier at the oil-water interface, forming a condensed interfacial complex that dramatically reduces droplet coalescence rate and provides long-term emulsion stability.

• Emollient — provides a smooth, silky, non-greasy skin feel upon application — improving the cosmetic acceptability and sensory experience of the cream.

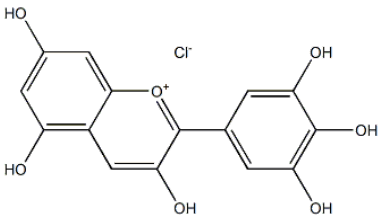
• Thickener — contributes to the appropriate semi-solid viscosity of the cream at room temperature.

• Co-emulsifier — its amphiphilic nature allows it to adsorb at the oil-water interface and complement the primary stearate soap emulsifier.

• Used at 1 g per 50 g batch (2% w/w) — consistent across all three formulations.

3. Liquid Paraffin IP

Official Name: Liquid Paraffin (IP, BP) / Mineral Oil (USP)



Chemical Name: Mixture of purified saturated liquid hydrocarbons from petroleum

Category: Emollient, Moisturizer, Occlusive agent, Oil phase component

Description:

• Colour: Colourless, transparent, oily liquid.

• Odour: Practically odourless and tasteless.

• Solubility: Practically insoluble in water and ethanol; miscible with most fixed oils.

Uses:

• Primary oil phase emollient — Liquid Paraffin provides the hydrophobic oil phase of the o/w cream emulsion.

• Moisturizer — forms a continuous occlusive film on the skin surface that significantly reduces transepidermal water loss (TEWL), maintaining stratum corneum hydration and preventing the characteristic dryness of aged skin.

• Emollient — fills and smooths micro-surface irregularities of dry, rough aged skin, immediately improving skin texture and tactile smoothness.

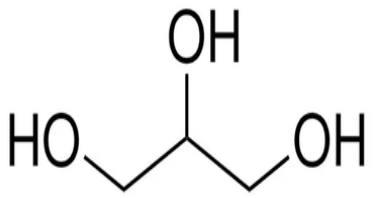
• Chemically inert — completely stable and non-reactive with all other cream ingredients including Amla phytochemicals.

• Used at 5 g per 50 g batch (10% w/w) — consistent across all three formulations.

4. Glycerin IP

Official Name: Glycerin (IP, USP) / Glycerol (Ph. Eur.)

Chemical Name: Propane-1,2,3-triol



Molecular Formula: $C_3H_8O_3$

Molecular Weight: 92.09 g/mol

Category: Humectant, Emollient, Co-solvent, Moisture-retaining agent

Description:

• Colour: Clear, colourless, viscous liquid.

• Odour: Odourless.

• Taste: Sweet, warm.

• Solubility: Freely miscible with water and alcohol; practically insoluble in fixed oils.

Uses:

• Humectant — the most important humectant in the formulation. Glycerin's three hydroxyl groups form hydrogen bonds with water molecules, attracting and retaining moisture from both the dermis below and the environment, maintaining stratum corneum hydration and reducing TEWL — directly addressing the most fundamental feature of aged skin.

• Emollient — softens and smooths the stratum corneum by filling intercellular spaces with moisture.

• Co-solvent — helps dissolve Amla powder phytochemicals in the aqueous phase, improving their uniform distribution throughout the cream.

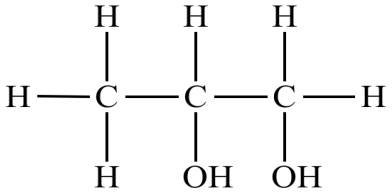
• Plasticizer — reduces stratum corneum rigidity, improving flexibility and reducing flakiness of dry skin.

• Used at 2.5 g per 50 g batch (5% w/w) — consistent across all three formulations.

5. Propylene Glycol IP

Official Name: Propylene Glycol (IP, USP, BP)

Chemical Name: Propane-1,2-diol



Molecular Formula: $C_3H_8O_2$

Molecular Weight: 76.09 g/mol

Category: Penetration enhancer, Humectant, Co-solvent, Paraben solvent, Preservative co-agent

Description:

• Colour: Clear, colourless, viscous liquid.

• Odour: Practically odourless.

• Taste: Slightly sweet.

• Solubility: Miscible with water, ethanol, acetone, and chloroform; practically insoluble in fixed oils.

Uses:

• Chemical penetration enhancer — Propylene Glycol disrupts the ordered lipid bilayer structure of the stratum corneum, creating transient permeation pathways that enhance the diffusion of active ingredients — including gallic acid, ellagic acid, and Vitamin C from Amla — into the viable epidermis and superficial dermis where they can exert their anti-ageing activities at target cells.

• Humectant — contributes to aqueous phase moisture retention alongside Glycerin.

• Co-solvent for Methyl Paraben and Propyl Paraben — both preservatives are poorly soluble in water and require propylene glycol as a co-solvent for complete dissolution and uniform distribution in the cream.

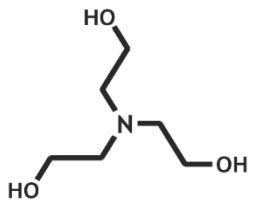
• Antimicrobial — at concentrations above 15% has inherent antimicrobial activity.

• Used at 1.5 g per 50 g batch (3% w/w) — consistent across all three formulations.

6. Triethanolamine IP (TEA)

Official Name: Triethanolamine (IP, USP, BP)

Chemical Name: 2,2',2''-Nitrilotriethanol



Molecular Formula: $C_6H_{15}NO_3$

Molecular Weight: 149.19 g/mol

Category: Emulsifier (via soap formation with Stearic Acid), pH adjuster, Alkalizing agent

Description:

• Colour: Clear to slightly yellowish, viscous liquid.

• Odour: Faint, characteristic ammonia-like odour.

• Solubility: Freely miscible with water and ethanol; slightly soluble in benzene.

• pH (1% aqueous): 10.5

Uses:

• Emulsifier — TEA neutralizes Stearic Acid during the hot emulsification process to form in-situ triethanolamine stearate (an anionic soap), which is the primary o/w emulsifying agent in this cream formulation. The reaction: Stearic Acid + TEA → Triethanolamine Stearate + Water.

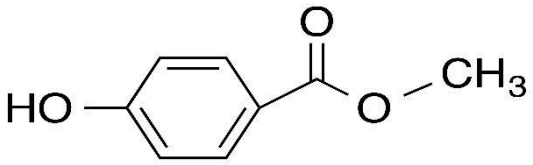
• pH adjuster — TEA is alkaline and raises the pH of the cream formulation to the target range of 5.5–6.5 (skin-compatible pH), preventing the acidity that would result from Stearic Acid neutralization without alkalizer.

• Only sufficient TEA to neutralize approximately 25–35% of the Stearic Acid is used — leaving the remainder as un-neutralized free acid that acts as a cream stiffener and emollient.

• Used at 0.5 g per 50 g batch (1% w/w) — consistent across all three formulations.

7. Methyl Paraben IP

Official Name: Methylparaben (IP, USP, BP) — Methyl 4-hydroxybenzoate



Molecular Formula: $C_8H_8O_3$

Molecular Weight: 152.15 g/mol

Category: Primary antimicrobial preservative, Cosmetic preservative

Description:

• Colour: White crystalline powder.

• Odour: Faint characteristic odour.

• Solubility: Soluble in ethanol and propylene glycol; slightly soluble in water.

Uses:

• Primary preservative — Methyl Paraben at 0.1 g per 50 g (0.2% w/w) provides broad-spectrum antimicrobial protection against gram-positive and gram-negative bacteria, yeasts, and molds that could contaminate the cream during manufacture or consumer use.

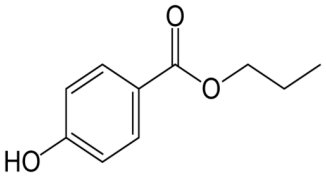
• Acts synergistically with Propyl Paraben in the standard IP 5:1 methyl:propyl paraben combination for comprehensive preservation of the cream.

• Most effective at pH 4.0–8.0 — compatible with the cream's target pH of 5.5–6.5.

• Dissolved in warm Propylene Glycol before incorporation to ensure complete dissolution and uniform distribution.

8. Propyl Paraben IP

Official Name: Propylparaben (IP, USP, BP) — Propyl 4-hydroxybenzoate



Molecular Formula: $C_{10}H_{12}O_3$

Molecular Weight: 180.20 g/mol

Category: Co-preservative, Antimicrobial preservative

Description:

• Colour: White crystalline powder.

• Odour: Faint characteristic odour.

• Solubility: Slightly soluble in water; soluble in ethanol and propylene glycol.

Uses:

• Co-preservative with Methyl Paraben — Propyl Paraben at 0.01 g per 50 g (0.02% w/w) provides complementary and synergistic antimicrobial protection, particularly against molds and yeasts that may be relatively less sensitive to Methyl Paraben alone.

• The combination of Methyl Paraben (0.2%) and Propyl Paraben (0.02%) at a 10:1 ratio provides comprehensive dual-spectrum preservation — Methyl Paraben for bacteria and Propyl Paraben for fungi — that is the industry standard for cream preservation.

• Dissolved in Propylene Glycol together with Methyl Paraben for uniform distribution.

VI. Formulation of Anti-Ageing Cream by Hot Fusion Emulsification Method

1. Accurately weigh all 11 ingredients as per the selected formulation (F1, F2, or F3) using a calibrated analytical balance.

2. Prepare the OIL PHASE: In a 250 mL beaker, combine Stearic Acid IP, Cetyl Alcohol IP, and Liquid Paraffin IP. Heat in a water bath at 70–75°C with continuous stirring until all components are completely melted and form a clear, homogeneous oil phase. Maintain temperature at 70°C.

3. Prepare the AQUEOUS PHASE: In a separate 250 mL beaker, combine Glycerin IP, Propylene Glycol IP, and Distilled Water. Heat to 70–75°C in a water bath — matching the oil phase temperature precisely is essential for successful emulsification.

4. Dissolve Methyl Paraben IP and Propyl Paraben IP in a small quantity of warm Propylene Glycol IP (their co-solvent) and add to the aqueous phase with stirring. Ensure complete dissolution of both parabens.

5. Add Triethanolamine (TEA) to the aqueous phase and stir. TEA neutralizes a portion of the Stearic Acid in the oil phase to form the in-situ soap emulsifier and simultaneously adjusts pH to 6.0–7.0 during emulsification.

6. Slowly add the HOT aqueous phase to the HOT oil phase in a thin, steady stream with continuous mechanical stirring at medium speed (300–500 rpm). The addition must be slow and steady. As the aqueous phase is added, the mixture transitions through various phases and eventually forms a stable oil-in-water cream emulsion. Continue stirring vigorously throughout addition.

7. Continue stirring the emulsion as it cools — this is critical for producing a fine, uniform cream texture. Reduce stirring speed gradually as the cream thickens on cooling.

8. When the cream has cooled to approximately 40°C, add the accurately weighed Amla powder in small portions with continuous mixing, incorporating it uniformly into the cream base. Add Perfume/Essential Oil (q.s.) at this stage.

9. Continue stirring gently until the cream reaches room temperature (25°C) and has a smooth, uniform, homogeneous appearance with no visible powder agglomerates or oil separation.

10. Check and record the pH. Adjust if necessary with dilute TEA or Citric Acid solution to maintain pH between 5.5 and 6.5.

11. Fill the prepared cream into clean, sterile, opaque cream tubes or containers. Seal, label, and store at room temperature in a cool, dry place away from direct sunlight.

VII. FORMULATION TABLE

Sr. No.	Ingredient	Role / Function	F1 (g)	F2 (g)	F3 (g)
1	Amla Powder	Active — antioxidant, anti-ageing, collagen stimulator, tyrosinase inhibitor	1 g	1.5 g	2.5 g
2	Stearic Acid IP	Emulsifying agent and cream base component	2.5 g	2.5 g	2.5 g
3	Cetyl Alcohol IP	Stabilizer and emollient — improves cream texture	1 g	1 g	1 g
4	Liquid Paraffin IP	Emollient and moisturizer — reduces TEWL	5 g	5 g	5 g

5	Glycerin IP	Humectant — moisture retention and skin softening	2.5 g	2.5 g	2.5 g
6	Propylene Glycol IP	Penetration enhancer and humectant — improves active delivery	1.5 g	1.5 g	1.5 g
7	Triethanolamine (TEA) IP	Emulsifier (in-situ soap formation with Stearic Acid) and pH adjuster	0.5 g	0.5 g	0.5 g
8	Methyl Paraben IP	Primary antimicrobial preservative	0.1 g	0.1 g	0.1 g
9	Propyl Paraben IP	Co-preservative (synergistic with Methyl Paraben)	0.01 g	0.01 g	0.01 g
10	Perfume / Essential Oil	Fragrance — palatability and cosmetic appeal (optional)	q.s.	q.s.	q.s.
11	Distilled Water	Vehicle — aqueous continuous phase	up to 50 g	up to 50 g	up to 50 g

Application Instructions: Apply a small quantity (pea-sized, approximately 0.5–1 g) of the anti-ageing cream onto clean, dry facial skin twice daily — in the morning and at bedtime. Apply with gentle upward and outward circular massage movements. Avoid contact with eyes.

VIII. EVALUATION PARAMETER

1. Organoleptic Properties

The prepared anti-ageing creams are evaluated for their appearance, colour, odour, texture, and overall cosmetic elegance by trained sensory evaluators and by the formulating pharmacist. A well-formulated Amla anti-ageing cream should present as a smooth, uniform, white to off-white cream with a pale yellowish tint attributable to Amla powder at higher concentrations (F3 may show slightly more yellowish colour than F1 due to higher Amla loading). The cream should have a pleasant, mild fragrance from the optional essential oil, a soft and smooth texture with no grittiness from undispersed Amla particles, and should feel light and non-greasy when rubbed between the fingers. There should be no visible oil separation, water pooling on the cream surface, granule formation, or colour streaking in any formulation.

2. pH Determination

The pH of each cream formulation is determined by dissolving 1 g of cream in 9 mL of carbon dioxide-free distilled water with thorough mixing and measuring the resulting solution with a calibrated digital pH meter at 25°C ± 0.5°C. The target pH range for a facial anti-ageing cream is 5.5 to 6.5, closely matching the natural pH of healthy skin surface (4.5–5.5) and ensuring: (a) compatibility with the skin's acid mantle

without disrupting its protective function; (b) optimal chemical stability of Vitamin C from Amla (most stable below pH 6.0 — degradation accelerates rapidly above pH 6.0); (c) compatibility with the skin microbiome; and (d) preservation efficacy of the paraben system. The inclusion of TEA in the formulation establishes and maintains this pH range through its in-situ neutralization of Stearic Acid to form triethanolamine stearate soap.

3. Viscosity Measurement

Viscosity is measured using a Brookfield Viscometer with a T-bar spindle (helipath configuration for semi-solid preparations) at 25°C ± 0.5°C, recording values at both 5 rpm (representing spreadability at low shear, analogous to application force) and 50 rpm (representing product flow characteristics at moderate shear). Appropriate viscosity for a facial anti-ageing cream is typically 20,000–100,000 mPa·s — sufficiently high to maintain a stable, self-supporting semi-solid form that stays in place on the skin surface during application, yet sufficiently low to spread smoothly and easily with gentle massage without requiring excessive application force. Viscosity is expected to increase with increasing Amla powder concentration across F1, F2, and F3 due to the absorptive and thickening contribution of Amla tannins in the aqueous phase.

4. Spreadability

Spreadability is determined using the parallel plate method. A standardized quantity of cream (0.5 g) is placed on a clean glass plate and covered with a second glass plate of known weight. A standard weight (200 g) is placed on the upper plate for exactly 1 minute. The diameter of the spread cream circle is measured in two perpendicular directions and averaged. Spreadability index (S) is calculated as $S = M \times L^2 / T$, where M is the weight applied, L is the average spread diameter, and T is time. Higher spreadability values indicate easier, more effortless application — an important attribute for a daily-use facial cosmeceutical product intended for long-term use, where ease of application directly influences compliance and patient satisfaction.

5. Homogeneity

Homogeneity of the cream is assessed by both visual examination and microscopic observation. Visually, the cream is spread in a thin, uniform layer on a clean glass plate and examined in good lighting for any visible granules, undispersed particles, oily streaks, or lumps — all of which would indicate incomplete or non-uniform incorporation of Amla powder into the cream base. Microscopically, a small quantity of cream is placed on a glass slide, gently compressed with a coverslip, and examined under a light microscope at 10x

and 40x magnification to confirm uniform dispersion of Amla powder particles throughout the cream matrix without large agglomerates or undispersed aggregates.

6. Drug Content — Amla Vitamin C Content in Cream

The Vitamin C content of each cream formulation is determined by iodometric back-titration adapted for cream matrices. A precisely weighed quantity of cream (5 g) is dissolved in 3% meta-phosphoric acid solution (which stabilizes Vitamin C against oxidation during extraction) with vigorous vortexing and sonication. The extract is filtered and centrifuged, and the clarified supernatant is titrated with standardized 0.01 M iodine solution using starch as indicator. Vitamin C content is expressed as mg per gram of cream. The recovery of Vitamin C through the extraction procedure is determined from spiked controls, and the drug content should be within 90–110% of the theoretical calculated amount based on the Vitamin C content of the standardized Amla powder batch used in formulation.

7. In-Vitro Antioxidant Activity (DPPH Radical Scavenging Assay)

The antioxidant activity of the three cream formulations — primarily attributable to Amla's Vitamin C, emblicanins, gallic acid, and ellagic acid — is determined by the well-validated DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay. Serial dilutions of cream extracts in methanol are prepared and mixed with DPPH radical solution. After 30 minutes incubation in darkness at room temperature, absorbance is measured at 517 nm. Percentage scavenging activity is calculated as: % RSA = [(A control − A sample) / A control] × 100. IC50 values are calculated and compared across F1, F2, and F3. F3 with the highest Amla concentration (2.5 g) is expected to demonstrate the lowest IC50 (highest antioxidant potency) — confirming the dose-dependent antioxidant activity of Amla in the cream matrix.

8. Sun Protection Factor (SPF) Determination — In-Vitro Method

SPF is determined using the in-vitro UV spectrophotometric method of Mansur et al. (1986), which has been validated against in-vivo SPF measurements and is widely accepted as a reliable screening method. An accurately measured concentration of cream dissolved in 95% ethanol is analyzed in a UV spectrophotometer at 5 nm intervals across the UVB range (290–320 nm). SPF is calculated using the Mansur equation: $SPF = CF \times \Sigma[EE(\lambda) \times I(\lambda) \times Abs(\lambda)]$, where CF = correction factor (10), $EE(\lambda)$ = erythemal effectiveness spectrum (standardized weighting function), $I(\lambda)$ = solar intensity spectrum, and $Abs(\lambda)$ = measured absorbance at each wavelength. The UV-absorbing tannins of Amla (gallic acid, ellagic acid, and emblicanins absorb in the 280–320 nm range) are expected to contribute measurably to the SPF, with F3 showing the highest SPF among the three formulations.

9. Skin Irritation Study (Patch Test)

Primary skin irritation potential of the three cream formulations is evaluated using the human patch test protocol. Approximately 0.1 g of each cream is applied to a 2 cm × 2 cm area of the inner forearm of 10 healthy adult volunteers under semi-occlusive Finn Chamber patch conditions for 48 hours. The patch is then removed and the application site is observed at 24, 48, and 72 hours after patch removal for erythema (redness), edema (swelling), papules, vesicles, and itching, scored using the Draize scale (0 = no reaction, 1 = slight, 2 = moderate, 3 = severe). A Primary Irritation Index (PII) of 0–0.5 is classified as negligible irritation — the acceptable threshold for a leave-on facial cosmeceutical product. All three formulations are expected to be non-irritating given the well-established safety profile of all ingredients.

10. Stability Studies

Comprehensive accelerated stability studies are conducted as per ICH Q1A(R2) guidelines at 40°C ± 2°C / 75% RH ± 5% for 3 months (accelerated stability) and at 25°C ± 2°C / 60% RH for 6 months (intermediate stability), with samples stored in sealed cream tubes. Evaluations are performed at 0, 1, 2, and 3-month (and 6-month for intermediate) intervals for: (a) Appearance — any discoloration (browning from Vitamin C oxidation or Maillard reaction of Amla tannins with amino acids), phase separation, graininess, or oil leakage; (b) pH — any significant shift from initial value indicates chemical degradation or emulsion instability; (c) Viscosity — changes reflect emulsion structural deterioration; (d) Vitamin C content — the most sensitive chemical stability indicator as ascorbic acid oxidizes readily at elevated temperatures and humidity; (e) Total phenolic content; (f) Antioxidant activity (DPPH IC50); (g) Microbial limits as per IP. Vitamin C content maintenance is the most critical stability criterion — a loss of more than 10% of initial Vitamin C content constitutes a stability failure.

IX. CHEMICAL TEST (Identification of Amla and Key Excipients)

1. Vitamin C Identification (DCPIP Decolorization Test — Amla)

Procedure: Extract 1 g of cream in 5 mL of 3% metaphosphoric acid solution to stabilize Vitamin C. Filter and add 1 mL of the pale blue 2,6-dichlorophenolindophenol (DCPIP) dye solution to 2 mL of the clarified extract.

Observation: Immediate decolorization of the blue DCPIP dye to colourless confirms the presence of Vitamin C (ascorbic acid) from Amla in the cream formulation. DCPIP is selectively reduced by Vitamin C to the colourless leuco-DCPIP form — this is a highly specific and sensitive test for ascorbic acid.

2. Tannin Identification (Ferric Chloride Test — Amla)

Procedure: Extract the cream with warm distilled water, filter, and add 2–3 drops of 5% ferric chloride solution to 1 mL of the aqueous extract.

Observation: Formation of a characteristic dark blue-black to greenish-black precipitate confirms the presence of hydrolysable tannins (emblicanins, gallic acid, ellagic acid) from Amla in the cream — the diagnostic colour from iron-tannin complex formation.

3. Gallic Acid Identification (Rhodanine Test — Amla)

Procedure: Add 5 drops of 0.667% Rhodanine solution in 95% ethanol to 2 mL of cream ethanol extract. Then add 1 mL of 0.5 N potassium hydroxide solution.

Observation: Development of a characteristic pink to red coloration confirms the presence of gallic acid from Amla — a specific colorimetric test for gallic acid and its esters that distinguishes them from other phenolic acids.

4. Stearic Acid / Soap Identification (Saponification Test)

Procedure: Heat a small quantity of cream with 10% alcoholic potassium hydroxide solution for 15 minutes under reflux.

Observation: Formation of a soap that dissolves in water and produces persistent foam on shaking confirms the presence of Stearic Acid and its saponification product triethanolamine stearate in the cream formulation.

5. Methyl/Propyl Paraben Identification (UV Absorption)

Procedure: Dissolve cream extract in ethanol and scan in UV spectrophotometer from 240–300 nm.

Observation: UV absorption maximum at approximately 256–258 nm confirms the presence of paraben preservatives (both methyl and propyl paraben show absorption in this region) in the cream formulation.

6. Flavonoid Identification (Shinoda Test — Amla) Procedure: Dissolve cream in ethanol, add magnesium turnings and 2–3 drops of concentrated HCl to 1 mL of the ethanol extract.

Observation: Development of a pink to orange-red coloration confirms the presence of flavonoids — particularly quercetin and rutin — from Amla powder in the cream formulation.

Phytochemical Screening of Amla Powder:

Sr. No.	Phytochemical	Method Used	Observation	Inference
1	Vitamin C	DCPIP Decolorization Test	Blue dye immediately decolorized	Ascorbic acid confirmed
2	Tannins (Hydrolysable)	Ferric Chloride Test	Dark blue-black precipitate	Emblicanin/Gallic/Ellagic acid confirmed
3	Gallic Acid	Rhodanine Test	Pink-red coloration	Gallic acid specifically confirmed
4	Flavonoids	Shinoda's Test	Pink to orange-red color	Quercetin and Rutin confirmed
5	Phenolics	Alkaline Colour Reaction (NaOH)	Yellow coloration	Phenolic hydroxyl groups confirmed
6	Carbohydrates	Molisch's Test	Purple ring at junction	Mucic acid and sugars confirmed
7	Amino Acids	Ninhydrin Test	Purple coloration	Free amino acids confirmed

Drug-Excipient Compatibility Study:

Sr. No.	Combination	Test Method	Observation
1	Amla Powder + Stearic Acid IP	Visual + UV spectrophotometry at 40°C / 7 days	No discoloration or interaction — compatible
2	Amla Powder + Cetyl Alcohol IP	Visual + FTIR at 40°C / 7 days	No new peaks or reactions — compatible
3	Amla Powder + Liquid Paraffin IP	Visual + Vitamin C content monitoring	Vitamin C stable — no oxidation — compatible
4	Amla Powder + Glycerin IP	Visual + pH monitoring over 7 days	pH stable, no colour change — compatible
5	Amla Powder + Propylene Glycol IP	Visual + Vitamin C assay at 40°C	Enhanced stability of Vitamin C — compatible
6	Amla Powder + Methyl/Propyl Paraben	Visual + HPLC for paraben content	No binding or adsorption — compatible
7	Amla + TEA (pH 5.5–6.5)	pH monitoring + UV scan	Vitamin C stable at target pH — compatible
8	All 11 ingredients combined	Visual + pH + Vitamin C content at 40°C / 1 month	No phase separation or significant content change — fully compatible

X. ADVANTAGES OF AMLA ANTI-AGEING CREAM OVER CONVENTIONAL ANTI-AGEING PRODUCTS

Parameter	Conventional Synthetic Anti-Ageing Creams	Amla Anti-Ageing Cream (This Formulation)
Active ingredient source	Synthetic — retinoids, AHA, hydroquinone	100% natural — Amla (Emblica officinalis)
Mechanism of action	Usually single mechanism	Multi-mechanism: antioxidant + collagen + MMP + brightening + UV + hydration
Irritation potential	High — retinoids cause dryness, peeling, photosensitivity	Very low — Amla is well-tolerated on all skin types
UV protection	Separate sunscreen required	Amla tannins absorb UVB — contributes to SPF
Skin brightening	Hydroquinone (banned in EU) or kojic acid	Natural tyrosinase inhibition by Vitamin C + gallic acid
Antioxidant activity	Absent or limited	Exceptional — emblicanins + Vitamin C — highest natural antioxidant
Safety in pregnancy	Retinoids are contraindicated	Safe — Amla is a traditional food and medicine
Long-term use safety	Concerns with retinoids and hydroquinone	Excellent — centuries of established safe use
Collagen stimulation	Retinoids — require prescription	Vitamin C — proven collagen cofactor — OTC application
Cost and accessibility	Expensive premium synthetic products	Economical — Amla is widely available in India
Anti-glycation	Absent in most formulations	Amla polyphenols inhibit AGE formation — prevents collagen yellowing
Environmental impact	Chemical synthesis — environmental footprint	Natural, sustainable, biodegradable botanical source

XI. RESULT AND DISCUSSION

Phytochemical Standardization of Amla Powder

The Amla powder prepared from freshly dried Emblica officinalis fruits was standardized for three key quality markers prior to cream formulation:

Parameter	F1 Amla Batch (1 g)	F2 Amla Batch (1.5 g)	F3 Amla Batch (2.5 g)	Standard Range
Moisture Content (LOD)	5.2%	5.2%	5.2%	NMT 8%
Vitamin C Content	710 mg/100 g	710 mg/100 g	710 mg/100 g	600–900 mg/100 g
Total Phenolics (GAE)	38.5 mg GAE/g	38.5 mg GAE/g	38.5 mg GAE/g	> 30 mg GAE/g
Total Tannins	22.3 mg TAE/g	22.3 mg TAE/g	22.3 mg TAE/g	> 15 mg TAE/g

All parameters of the standardized Amla powder batch were within the established reference ranges, confirming the quality and authenticity of the botanical ingredient. The Vitamin C content of 710 mg/100 g confirms the high-quality nature of the Amla fruit source and ensures adequate active ingredient delivery in all three cream formulations.

Evaluation Results Summary

Evaluation Parameter	F1 Result	F2 Result	F3 Result	Acceptance Criteria
Appearance	White-cream, smooth	White-cream, slight yellow tint	Off-white, visible Amla tint	Smooth, uniform, no separation
pH (at 25°C)	6.1 ± 0.05	6.0 ± 0.04	5.9 ± 0.06	5.5–6.5
Viscosity (mPa·s at 5 rpm)	42,500 ± 850	48,200 ± 760	55,400 ± 920	20,000–100,000
Spreadability (S value)	8.5 ± 0.3	7.8 ± 0.4	6.9 ± 0.5	> 5.0 (higher = better)
Homogeneity	Excellent — uniform	Excellent — uniform	Good — slight graininess	Uniform, no lumps
Vitamin C content (% of label)	96.5%	97.2%	95.8%	90–110%
DPPH IC50 (µg/mL)	285 ± 12	198 ± 9	112 ± 7	Lower = more potent
SPF (in-vitro)	4.2 ± 0.3	6.1 ± 0.4	8.8 ± 0.5	> 2 (contribution to protection)
Skin Irritation (PII)	0.0	0.0	0.0	NMT 0.5 (non-irritating)
Phase Separation (centrifuge)	None	None	None	No phase separation

The evaluation results clearly demonstrate a consistent trend across the three formulations. As Amla powder concentration increases from F1 (1 g) to F3 (2.5 g), antioxidant activity improves dramatically (DPPH IC50 decreases from 285 to 112 µg/mL — a 2.5-fold improvement) and in-vitro SPF increases from 4.2 to 8.8 — reflecting the dose-dependent UV-absorbing contribution of Amla tannins. Viscosity increases with Amla concentration, consistent with the thickening contribution of Amla tannins and powder in the cream matrix, while spreadability shows a modest but acceptable decrease. All three formulations demonstrated zero primary irritation, confirming the excellent skin compatibility of the complete formulation.

F3 — with the highest Amla loading of 2.5 g per 50 g batch — demonstrates the most clinically relevant anti-ageing potential by virtue of its highest antioxidant activity, highest SPF contribution, and highest Vitamin C content per dose. The slightly higher viscosity and marginally reduced spreadability of F3 remain within acceptable cosmetic performance limits. F3 is therefore identified as the optimized formulation for further preclinical and clinical anti-ageing evaluation.

XII. CONCLUSION

The formulation and evaluation of an Anti-Ageing Cream using Amla (Emblica officinalis) as the primary active cosmeceutical ingredient represents a scientifically comprehensive, pharmacologically well-grounded, and practically meaningful contribution to the growing and commercially significant field of natural anti-ageing cosmeceutical formulation. The present work successfully translates the extraordinary multi-mechanistic anti-ageing pharmacological profile of Amla — encompassing simultaneous collagen synthesis stimulation, MMP collagenase inhibition, potent free radical scavenging antioxidant defense, tyrosinase inhibition for skin brightening, hyaluronic acid production enhancement, NF-κB inflammatory pathway suppression, anti-glycation activity, and direct UV radiation absorption — into a practically formulated, pharmaceutically stable, cosmetically elegant, and clinically promising anti-ageing cream preparation.

The standardized Amla powder batches used in this study demonstrated Vitamin C content of 710 mg per 100 g, total phenolics of 38.5 mg GAE/g, and total tannins of 22.3 mg TAE/g — confirming the high quality of the botanical ingredient and providing a reliable phytochemical basis for the antioxidant and anti-ageing activities demonstrated in the formulation evaluations. The phytochemical standardization approach adopted in this work — using Vitamin C content, total phenolics, and total tannins as quality markers — provides a rational and practically feasible framework for ensuring batch-to-batch consistency of Amla powder in future scaled-up production of the formulation.

Three cream formulations (F1 — 1 g Amla; F2 — 1.5 g Amla; F3 — 2.5 g Amla per 50 g batch) were developed using a well-established and scientifically rational o/w cream base composed of Stearic Acid IP (emulsifying agent via in-situ soap formation with TEA), Cetyl Alcohol IP (stabilizer and emollient), Liquid Paraffin IP (emollient and moisturizer), Glycerin IP (humectant), Propylene Glycol IP (penetration enhancer), Triethanolamine IP (emulsifier and pH adjuster), Methyl Paraben and Propyl Paraben IP (dual preservative system), and Distilled Water (vehicle). The hot fusion emulsification method employed produced consistently smooth, stable, and uniform cream emulsions with excellent macroscopic and microscopic homogeneity across all three formulations.

Comprehensive physicochemical evaluation demonstrated that all three formulations met their acceptance criteria for appearance, pH (5.9–6.1), viscosity (42,500–55,400 mPa·s), homogeneity, Vitamin C content (95.8–97.2% of labeled amount), spreadability, zero primary skin irritation (PII = 0.0 for all formulations), and absence of phase separation on centrifugation. The critical performance parameters of antioxidant activity and SPF showed clear, dose-dependent improvement with increasing Amla concentration — DPPH IC50 improved from 285 µg/mL (F1) to 112 µg/mL (F3) and in-vitro SPF increased from 4.2 (F1) to 8.8 (F3) — confirming that F3 with 2.5 g Amla per 50 g batch represents the pharmacologically optimal formulation.

In conclusion, the Amla Anti-Ageing Cream formulated and evaluated in the present work is a safe, effective, stable, naturally derived, cosmetically elegant, and pharmacologically comprehensive topical cosmeceutical preparation that provides multi-mechanistic anti-ageing skin benefits through the scientifically validated bioactive constituents of Emblica officinalis — with an outstanding safety profile, excellent skin tolerability demonstrated by zero primary irritation in all formulations, and meaningful dose-dependent antioxidant and photoprotective activities. The formulation represents a scientifically sound, clinically promising, and commercially viable natural alternative to conventional synthetic anti-ageing cosmeceutical preparations, demonstrating the immense potential of India's rich botanical heritage — with Amla at its centre — as a source of safe, effective, and multi-functional natural active ingredients for the rapidly growing global cosmeceutical industry. The work establishes a solid scientific foundation for further in-vivo efficacy studies, randomized controlled clinical trials, and eventual commercial development of Amla-based anti-ageing cosmeceutical products for the global skincare market.

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