World Journal of Pharmaceutical Science and Research
www.wjpsronline.com
Research Article
ISSN: 2583-6579
SJIF Impact Factor: 6.916
Year - 2026
Volume: 5; Issue: 3
Page: 330-377

DEVELOPMENT & EVALUATION OF NATURAL SUNSCREEN FORMULATION USING TOMATO EXTRACT

D. Jaswanth*[1], B. Dhanush[2], G. Hanumantha Rao[3], B. Ayyappa[4], B. Chinnari Babu[5], P. Gayathri Devi[6], Dr. Y. Anakamma Chowdary[7]

[1,2,3,4,5]Students, NRI College of Pharmacy, Pothavrappadu, Agiripalli, Eluru district-521212.
[6]Professor, NRI College of Pharmacy, Pothavrappadu, Agiripalli, Eluru district-521212.
[7]Principal, NRI College of Pharmacy, Pothavrappadu, Agiripalli, Eluru district-521212.

Article Received: 22 January 2026 | | ***Article Revised: 12 February 2026*** | | ***Article Accepted: 4 March 2026***

***Corresponding Author: D. Jaswanth**
Students, NRI College of Pharmacy, Pothavrappadu, Agiripalli, Eluru district-521212.
DOI: https://doi.org/10.5281/zenodo.18876286

How to cite this Article: D. Jaswanth, B. Dhanush, G. Hanumantha Rao, B. Ayyappa, B. Chinnari Babu, P. Gayathri Devi, Dr. Y. Anakamma Chowdary (2026) DEVELOPMENT & EVALUATION OF NATURAL SUNSCREEN FORMULATION USING TOMATO EXTRACT. World Journal of Pharmaceutical Science and Research, 5(3), 330-377. https://doi.org/10.5281/zenodo.18876286

ABSTRACT

The present study focuses on the development and evaluation of a natural sunscreen formulation using tomato extract as the primary photoprotective agent. Tomato (*Solanum lycopersicum*) is rich in lycopene, a potent carotenoid with strong antioxidant and ultraviolet (UV) radiation–absorbing properties, which helps protect the skin from photo-induced damage. The sunscreen formulation was prepared using herbal ingredients such as tomato extract, turmeric, aloe vera, rosemary, and coconut oil, which provide synergistic antioxidant, anti-inflammatory, and moisturizing effects. The prepared formulations were evaluated for physicochemical parameters including pH, spreadability, stability, homogeneity, and UV protection efficiency. The presence of lycopene and other phytoconstituents contributes to reducing oxidative stress, preventing premature skin aging, and enhancing photoprotection. The results indicated that the herbal sunscreen formulation showed satisfactory stability, good skin compatibility, and promising photoprotective potential. Thus, the developed natural sunscreen can serve as a safe, effective, and eco-friendly alternative to synthetic sunscreens, fulfilling the increasing demand for herbal cosmetic products with minimal side effects and enhanced skin protection.

KEYWORDS: Tomato extract, Lycopene, Natural sunscreen, Herbal formulation, Photoprotection, Antioxidant, SPF, UV radiation protection.

INTRODUCTION

1.1. Background on Ultraviolet Radiation and Skin Damage

Ultraviolet (UV) radiation from solar exposure represents a pervasive environmental factor that significantly contributes to skin damage, photoaging, immunosuppression, and photocarcinogenesis. UV light is typically divided into UVA (315–400 nm), UVB (280–315 nm), and UVC (100–280 nm), with UVA and UVB reaching the earth's surface and being responsible for most sun-induced skin injuries. These injuries include erythema (sunburn), DNA mutations, oxidative stress, and degradation of structural proteins such as collagen and elastin, culminating in premature aging and increased risk of skin cancers. Traditional sunscreens incorporate chemical and physical filters that block or reflect UV radiation, yet growing consumer demand for natural, biocompatible, and eco-friendly alternatives has led researchers to explore plant-derived compounds for photo-protection.

1.2. Natural Sunscreen Agents: Definitions and Importance

The term "natural sunscreen" refers to biologically derived substances—often from plants—that exhibit broad-spectrum UV absorption, antioxidant activity, and photoprotective properties, which can be leveraged either in topical formulations or as systemic photoprotective agents when consumed. Natural products often possess complex mixtures of antioxidant phytochemicals (e.g., carotenoids, flavonoids, phenolic compounds) capable of mitigating reactive oxygen species (ROS) generated by UV exposure, potentially reducing DNA damage and inflammation in skin tissues.

1.3. Tomatoes as a Source of Natural Sunscreen Compounds

Tomato (Solanum lycopersicum L.) is widely recognized not only as a staple dietary crop but also as a source of potent bioactive compounds with significant antioxidant and photoprotective potential. Among these compounds, lycopene, a carotenoid responsible for the red color of ripe tomatoes, has attracted considerable scientific interest due to its high singlet oxygen quenching ability, free radical scavenging properties, and systemic distribution to skin tissues after ingestion.

Carotenoids such as lycopene, β-carotene, and phytoene exert photoprotective effects by absorbing light in the UV and visible spectra and neutralizing ROS produced during UV irradiation. In plants, carotenoids serve to funnel excess light energy away from photosynthetic apparatus and protect cellular structures from photooxidative damage. Post-ingestion, these same molecules accumulate in human skin where they may confer similar protective effects against solar UV radiation.

This functional transfer from plant to human tissue underscores the potential of tomato-derived compounds as natural sunscreen agents.

1.4. Lycopene: Chemistry and Mechanism of Photoprotection

Lycopene is a linear tetraterpene comprised of 11 conjugated double bonds, rendering it exceptionally efficient at quenching singlet oxygen and scavenging free radicals more effectively than other carotenoids. Its hydrophobic structure enables integration within cell membranes and lipid-rich environments such as human skin, where it can intercept ROS generated by UV irradiation.

Unlike synthetic sunscreens that primarily block UV physically or chemically, lycopene and other carotenoids protect at the molecular level by neutralizing excited oxidative species, reducing lipid peroxidation, and stabilizing cellular

membranes. These antioxidant properties not only decrease immediate sunburn reactions (e.g., erythema) but also may mitigate cumulative photodamage that leads to long-term skin aging and photocarcinogenesis.

1.5. Dietary Photoprotection and Tomato Consumption

A growing body of epidemiological and intervention studies suggests that systemic supplementation with lycopene-rich foods (particularly tomato products such as paste, juice, or powder) can elevate skin carotenoid concentration and enhance resistance to UV-induced damage. For example, controlled dietary studies have shown that regular consumption of tomato paste significantly reduced skin redness and inflammation following standardized UV light exposure. Participants consuming tomato products exhibited reduced erythema levels compared to controls, indicating a photoprotective effect analogous to a modest SPF enhancement.

This internal (systemic) photoprotection appears to be dose and time dependent, with effects becoming more pronounced after sustained dietary intake over several weeks. It suggests that whereas topical sunscreens provide immediate surface protection, dietary lycopene contributes to a cumulative internal shield by integrating into skin layers and mitigating oxidative insults from repeated UV exposure.

1.6. Topical Formulation of Tomato Extracts

In addition to systemic photoprotection via diet, topical applications of tomato extracts and carotenoid complexes have been explored in cosmetic and pharmaceutical formulations. Phytochemical screening and preliminary formulation studies indicate that tomato extracts, when incorporated into lotion bases, provide measurable sun protection factor (SPF) values, a direct metric of UV radiation block capacity.

These topical formulations often aim to exploit not just lycopene but other co-existing phytochemicals (e.g., phenolic compounds) that may act synergistically. The challenge in topical systems lies in achieving sufficient skin penetration and stabilization of unstable carotenoids, which are prone to oxidation and degradation upon exposure to light and air.

1.7. Extracts and UV Absorption Spectra

Studies investigating extracts of tomato alongside other plant sources (e.g., carrot, marigold) have shown that although single extracts may not achieve high SPF on their own, they exhibit UV absorption capabilities and potent antioxidant activity, making them candidates for combination with other natural or synthetic filters to enhance overall photoprotective efficacy.

These findings indicate that tomato extracts have the potential to function as auxiliary UV absorbers in broad spectrum sunscreen formulations, complementing existing filters and providing added antioxidant benefits that mitigate oxidative damage beyond simple UV reflection or scattering.

1.8. Photoprotection, Oxidative Stress and Skin Health

The interaction between UV radiation, ROS production, and skin degradation is deeply influenced by oxidative stress pathways. ROS can damage cellular proteins, lipids, and DNA, and trigger proinflammatory signaling that accelerates photoaging and increases cancer risk. Antioxidants like lycopene function to interrupt these oxidative cascades, reducing inflammation, lipid peroxidation, and structural breakdown in skin tissues.

Systematic reviews and meta-analyses of intervention trials have demonstrated that tomato and lycopene supplementation is associated with significant reductions in erythema formation, skin pigmentation changes, and molecular markers of photodamage compared to controls. Furthermore, increases in minimal erythemal dose (MED), skin thickness, and skin density indicate improved skin resilience after carotenoid accumulation.

1.9. Combined Strategy: Natural and Conventional Sunscreens

While research increasingly supports the photoprotective role of tomato-derived compounds, current evidence also underscores that such natural agents should complement, not replace, conventional sunscreens. Dietary and topical natural compounds can enhance skin's defense mechanisms, reduce oxidative stress, and improve overall photoprotection, but they do not provide the broad, high-level UV blocking required for safe sun exposure in high-intensity environments.

An integrated approach—combining natural antioxidants with proven UV filters—is likely to represent the most effective strategy for holistic photoprotection, balancing consumer demand for natural ingredients with evidence-based protection from harmful solar radiation.

Cosmetics refer to products that are used to enhance or alter the appearance of the face, body, or hair. These products can include items such as makeup, skincare preparations, hair dyes, perfumes, and toiletries. The primary purpose of cosmetics is often aesthetic, allowing individuals to achieve desired looks, enhance features, or cover imperfections. However, cosmetics can also serve practical purposes, such as protecting the skin from environmental damage, moisturizing, or treating specific skin concerns. Herbal cosmetics are beauty and skincare products formulated primarily with ingredients derived from plants, herbs, flowers, fruits, roots, and other botanical sources. Unlike conventional cosmetics that often contain synthetic chemicals, herbal cosmetics harness the natural healing and nourishing properties of botanical extracts to promote skin health and enhance beauty. These products may include a wide range of items such as cleansers, moisturizers, toners, masks, serums, hair care products, and more, all formulated with natural ingredients.

1. Cosmetics are their potential to provide nourishment, hydration, and protection to the skin without the harshness or side effects associated with some synthetic ingredients. Many botanical extracts are rich in vitamins, antioxidants, minerals, and other bioactive compounds that can help improve skin texture, tone, and resilience, as well as address specific concerns such as aging, acne, inflammation, and sensitivity.
2. Sunscreen is a topical product designed to protect the skin from harmful ultraviolet (UV) radiation emitted by the sun. It typically contains active ingredients that either absorb, reflect, or scatter UV radiation, thereby reducing its penetration into the skin. The primary purpose of sunscreen is to prevent sunburn, premature aging of the skin, and skin cancer caused by excessive UV exposure. Sunscreens are available in various forms, including lotions, creams, gels, sprays, sticks, and powders, with different formulations catering to different skin types and activities. They often contain a combination of organic and/or inorganic compounds, such as avobenzone, oxybenzone, octocrylene, zinc oxide, or titanium dioxide, which work synergistically to provide broad-spectrum protection against both UVA and UVB rays3. Additionally, sunscreens may be labeled with a sun protection factor (SPF), which indicates the level of protection against UVB rays, with higher SPF values corresponding to greater protection. It's essential to apply sunscreen generously and reapply it regularly, especially after swimming, sweating, or prolonged sun exposure, to maintain its effectiveness and ensure adequate protection for the skin.

CLASSIFICATION OF SUNSCREEN

Sunscreens can be classified as follows:

1. **Based on the mode of action they can be classified as**

- **Physical sunscreen:** Reflect harmful rays away from skin. Eg: zinc oxide and titanium dioxide.
- **Chemical sunscreen:** Absorbs UV rays Eg: microfine titanium dioxide, avobenzone and oxybenzone. The combination of both physical and chemical active ingredients is considered to be a best sunblock. Physical sun blocks are having scattering affect thereby results in whitening phenomenon while majority of organic chemicals used in sunscreen formulations have not been established as safe.

2. **Based on application**

- **Topical:** They either absorb or reflect radiation to protect from harmful radiation
- **Oral:** These are consumed orally to avoid skin damage. Eg: Carotenoids
- Topical sunscreens are divided into two classes based on their mechanism of protection
- **Organic sunscreen**
- **Inorganic sunscreen**
- **Organic Sunscreen**: Organic sunscreen works by absorbing into skin and converting UV rays into heat .it is thin and ideal for everyday use allow for skincare ingredients to be added easily. Organic sunscreen actives chemical carbon based compound .it contains non mineral active ingredient.
- **Inorganic sunscreen:** These are particles that scatter and reflect uv rays back to the environment they act as physical barrier to indent ultraviolet and uv light. They are considered broad spectrum as they cover entire ultraviolet spectrum .the Inorganic sunscreen is also referred to as sunblock.

IDEAL PROPERTIES OF SUNSCREEN

1. Must absorb a broad range of UV rays causing sunburn
2. Must be stable in the presence of sunlight
3. Should be able to provide complete protection for skin
4. Should be safe effective, chemically inert, at low concentration
5. Should not cause irritation, sensitization and toxicity
6. Should not stain Filtering
7. Activity against UVB and UVA radiation
8. Anti-oxidant and reactive oxygen species scavenging property
9. Anti-mutagenic property
10. Anticancer property
11. Booster effect
12. Safety stability of active compound

MERITS OF SUNSCREEN LOTION

1. Helps to prevent sunburn and premature aging
2. Protects from the sun as soon as it is applied.
3. Lasts longer when in direct UV light.
4. Better for those with heat-activated skin[redness].
5. Offers protection against UVA and UVB rays.

DEMERITS OF SUNSCREEN LOTION

1. It is an expensive product.
2. Can create an occlusive film which results in perspiration.
3. Can be less protective if not applied accurately and generously.
4. Can cause white drips to show on the skin when sweating.
5. Sunscreen can cause stickiness in some skin types.

IMPORTANCE OF SUNSCREEN

UV radiation is essential to human health such that it helps in the intestinal absorption of calcium, phosphorous and for the production of vitamin D3. On the other hand, these radiations also harm our health by directly interacting with DNA, RNA proteins, lipids and thereby causing potential carcinogenic effects. The most efficient way to protect skin from harmful UV radiation is the topical application of any active molecule which has UV absorbing or reflecting properties. This is why the sunscreen has gained importance in the current scenario.

Wearing sunscreen is one of the best — and easiest — ways to protect your skin's appearance and health at any age. Used regularly, sunscreen helps prevent sunburn, skin cancer and premature aging. To help make sunscreen a part of your daily routine, dermatologist Anna Chien addresses common concerns.

WHY WE USE SUNSCREEN?

- Too much-unprotected sun exposure leads to
- Premature skin ageing
- Sun burn
- Skin cance

MECHANISM OF PHOTOPROTECTION

UV rays mediated photo oxidative damage reaches the dermal capillaries via epidermis and dermis and cause depletion of enzymatic and non-enzymatic antioxidants in Stratum corneum, epidermis and dermis. Photo oxidation of pre-existing melanin and its precursors will occur which result in immediate and persistent pigment darkening. Sunscreen act by preventing and minimizing the damaging effects of the ultraviolet sun rays following exposure to the sunscreen have been demonstrated to increase the tolerance of the skin to uv exposure. They work on two mechanisms: Scattering and reflection of uv energy from the skin surface mineral based on inorganic sunscreen works on this mechanism they provide a coating that blocks sun rays from penetrating through the skin.

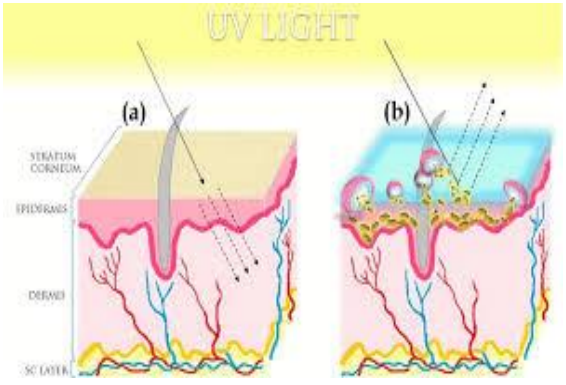


Fig. 1: Photoprotection.

LITERATURE REVIEW

1. **Diffey BL (2004**): Climate Change, Ozone Depletion and the Impact on Ultraviolet Exposure of Human Skin. Diffey reported that prolonged exposure to ultraviolet radiation leads to erythema, premature aging, immune suppression, and increased risk of skin cancer. UV radiation induces oxidative stress causing cellular damage and inflammation. Regular sunscreen use significantly reduces these harmful effects. Hence, sunscreen formulations play a vital role in skin protection.
2. **Draelos ZD (2010):** *Cosmetic Dermatology: Products and Procedures*. Draelos emphasized that chemical sunscreens may cause allergic reactions, irritation, and environmental concerns. Increased demand for herbal products is due to better skin compatibility and safety. Natural ingredients provide antioxidant and anti-inflammatory benefits. This has increased interest in herbal sunscreen formulations.
3. **Stahl W and Sies H (2007):** *Photoprotection by Dietary Carotenoids*. The authors demonstrated that carotenoids like lycopene accumulate in the skin and provide photoprotection. Lycopene scavenges free radicals produced by UV exposure. This reduces oxidative stress and cellular damage. Their findings support the use of carotenoids in skin protection.
4. **Rizwan M *et al.* (2011):** *Tomato Paste Supplementation and UV Protection*. Rizwan reported that tomato paste intake significantly reduced UV-induced erythema. Lycopene was identified as the main protective agent. Improved skin resistance to UV radiation was observed. This supports the use of tomato extract in sunscreen formulations.
5. **Agarwal S and Rao AV (2000):** *Carotenoids and Chronic Disease Prevention*. The authors reported that lycopene shows superior singlet oxygen quenching activity. This helps neutralize reactive oxygen species. Lycopene protects cellular membranes from oxidative damage. Thus, it is a potent natural photoprotective agent.
6. **Mukherjee PK *et al.* (2011):** *Herbal and Traditional Medicine*. Mukherjee highlighted that turmeric, aloe vera, and rosemary exhibit antioxidant, anti-inflammatory, and antimicrobial properties. Their synergistic action enhances sunscreen efficacy. They improve skin compatibility and therapeutic benefits. Hence, polyherbal formulations are advantageous.
7. **Katiyar SK and Elmets CA (2001):** *Green Tea Polyphenols and Skin Protection*. The authors demonstrated that plant polyphenols reduce UV-induced oxidative stress and inflammation. They prevent DNA damage and apoptosis. These compounds enhance skin immune defense. Their inclusion in sunscreens improves photoprotection.
8. **Nandakumar V *et al.* (2014):** *Turmeric Extract for Sunscreen*. This study reported that turmeric possesses strong UV absorption and antioxidant activity. Curcumin effectively scavenges free radicals. It reduces inflammation and erythema. Hence, turmeric is a valuable sunscreen ingredient.
9. **Surjushe A *et al.* (2008):** *Aloe Vera Review*. The authors described aloe vera as a wound healing, moisturizing, and anti-inflammatory agent. It enhances skin hydration and elasticity. Aloe vera also protects against UV damage. These properties make it useful in sunscreen formulations.
10. **Offord EA *et al.* (2002):** *Rosemary Extract and Photoprotection*. The authors demonstrated that rosemary exhibits strong antioxidant activity. Rosmarinic and carnosic acids prevent oxidative damage. Rosemary improves photostability of formulations. Thus, it contributes effectively to herbal sunscreens.
11. **Kaur CD and Saraf S (2010):** *Herbal Oils and SPF Determination*. The study revealed that herbal cosmetics are safer and more skin-compatible. They reduce irritation and allergic reactions. Herbal products also nourish the skin. This increases their acceptance in sunscreen formulations.

12. **Mansur JS *et al.* (1986):** *Spectrophotometric SPF Method*. The authors developed a reliable method for SPF determination. It measures UV absorbance accurately. The method is simple and reproducible. It is widely used in herbal sunscreen evaluation.
13. **Nema RK *et al.* (2013):** ***Po****lyherbal Sunscreen Cream*. The authors formulated polyherbal sunscreens showing SPF values of 10–25. The formulations exhibited good stability. They showed good skin compatibility. This confirmed the effectiveness of herbal sunscreens.
14. **Sharma A *et al.* (2015):** *Tomato-Based Sunscreen Cream*. The study demonstrated moderate SPF and good antioxidant stability. Lycopene enhanced photoprotective activity. The formulation showed good spreadability. This confirms tomato extract suitability in sunscreens.
15. **Korać RR and Khambholja KM (2011):** *Herbs in Skin Protection*. The authors emphasized antioxidants in preventing photoaging. They reduce oxidative stress and protect collagen fibers. Antioxidants improve skin elasticity. Hence, they are essential in sunscreen formulations.
16. **Saewan N and Jimtaisong A (2013):** *Natural UV Filters*. The authors concluded that flavonoids and carotenoids show strong UV absorption. These compounds enhance SPF and stability. Plant extracts act as natural UV filters. Thus, herbal sunscreens are promising alternatives.
17. **Gediya SK *et al.* (2011):** *Herbal Sunscreen Evaluation*. The authors observed improved hydration and photoprotection. Herbal formulations reduced skin irritation. They enhanced cosmetic acceptability. This confirms the safety of herbal sunscreens.
18. **Gonzalez S *et al.* (2008):** *Antioxidants and Sunscreen Efficiency*. The authors showed that antioxidants improve sunscreen efficiency. They prevent photodegradation of UV filters. This enhances formulation stability. Thus, antioxidants are essential additives.
19. **Sharma P and Kaur R (2018):** *Tomato-Based Herbal Sunscreen*. The authors prepared tomato-based herbal sunscreens with improved SPF. The formulations showed good stability. Enhanced antioxidant and photoprotective activity was observed. This validated tomato extract as an effective ingredient.
20. **Kockler J *et al.* (2012):** *Botanical Antioxidants and Skin Protection*. The authors suggested botanical antioxidants increase resistance to photodamage. They reduce oxidative stress and inflammation. These compounds maintain skin integrity. Hence, they improve sunscreen performance.
21. **Nichols JA and Katiyar SK (2010):** *Carotenoids and Skin Health*. The authors demonstrated carotenoids prevent collagen degradation and wrinkles. They reduce photoaging. Their antioxidant action preserves elasticity. Thus, carotenoids are vital for skin protection.
22. **Chanchal D and Swarnlata S (2008):** *Herbal Sunscreen Review*. The authors emphasized herbal sunscreens reduce environmental toxicity. They are biodegradable and eco-friendly. Herbal products reduce skin irritation. Hence, they are sustainable cosmetic alternatives.
23. **Natarajan P *et al.* (2015):** *Lycopene and UV Tolerance*. The authors confirmed lycopene increases minimal erythemal dose. It improves UV tolerance. Lycopene strengthens antioxidant defense. This supports its photoprotective role.
24. **Pinnell SR (2003):** *Antioxidants in Sunscreens*. The study demonstrated vitamin E and antioxidants improve stability. They prevent photodegradation. This enhances long-term protection. Antioxidants are crucial in formulation design.

25. **Kumar R et al. (2020):** *Herbal Sunscreen Using Tomato Extract*. The authors concluded tomato extract with herbal ingredients provides effective photoprotection. The formulations showed good stability and safety. They were skin-friendly and eco-safe. This confirms their cosmetic and pharmaceutical potential.

AIM & OBJECTIVES

AIM

Formulation and evaluation of sunscreen lotion containing natural agents.

OBJECTIVE

- To develop sunscreen formulation using herbal ingredients.
- To perform physicochemical characterization.
- To achieve maximum stability of formulation.
- To achieve maximum UV protecting effect.
- To develop various formulation.
- To inhibit the transmission of UV radiation into the skin.
- To reduce the risk of squamous cell and melanoma skin cancer.
- To diminish the degree of baseline pigmentation.

DRUG PROFILE

1. Rosemary Extract

Family: Lamiaceae (Mint family)

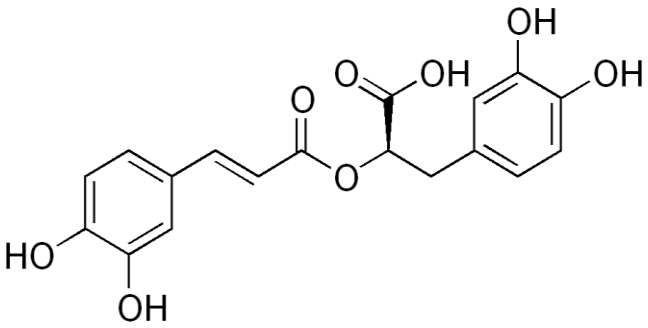
Biological Name: Rosmarinus officinalis L.

Synonyms: Rosemary, Rosmarinus, Dew of the Sea, Compass Plant

Geographical Source: Native to Mediterranean region; cultivated worldwide in countries like India (hilly regions), France, Spain, USA, and Morocco.

Chemical Structure

HO-C6H4-CH=CH-COO-CH(CH2-C6H3(OH)2)-COOH



Chemical Name

Rosmarinicacid

(R)-3-(3,4-Dihydroxyphenyl)-2-[(E)-3-(3,4-dihydroxyphenyl)prop-2-enoyl]oxypropanoic acid

Chemical Constituents

- Volatile oils: 1,8-Cineole (Eucalyptol), Camphor, α-Pinene, Borneol
- Phenolic acids: Rosmarinic acid, Caffeic acid
- Diterpenes: Carnosic acid, Carnosol
- Flavonoids: Luteolin, Apigenin

Uses

- Food preservative: Natural antioxidant (E392) in oils, meats, and processed foods
- Cognitive support: Enhances memory and concentration
- Aromatherapy: Stress relief, respiratory aid
- Topical: Anti-inflammatory, promotes hair growth
- Traditional medicine: Digestive aid, antispasmodic

Category

Herbal medicine, Culinary herb, Cosmetic ingredient, Food additive

Pharmacological Actions

- Antioxidant: Rosmarinic acid and carnosic acid scavenge free radicals
- Antimicrobial: Inhibits E. coli, S. aureus, and fungi
- Neuroprotective: Enhances memory via acetylcholinesterase inhibition
- Anti-inflammatory: Inhibits COX-2 and NF-κB pathways

Traditional Uses

- Culinary: Flavoring in soups, meats, sauces, and marinades
- Herbal tea: Digestive aid, stress relief
- Rituals: Used in weddings, funerals (symbolizes remembrance and love)

Safety and Regulatory

- Side effects: High doses may cause seizures (due to camphor)
- Interactions: May interfere with anticoagulants, diuretics, and other medications
- Lamiaceae family → Aromatic herbs (Mint, Basil, Lavender)

Fig. 2: Rosemary Plant.

- **Loss on Drying:** Typically ≤ 5%
- **Moisture Content:** ≤ 10%
- **pH :** 5.0 - 6.5 (1% solution)
- **Product Availability:** Widely available in the market, used in food, cosmetics, and pharmaceuticals.
- **Constituents:** Carnosic acid, Rosmarinic acid, 1,8-Cineole, Camphor, α-Pinene.

2. Turmeric Extract

Family: Zingiberaceae (Ginger family)

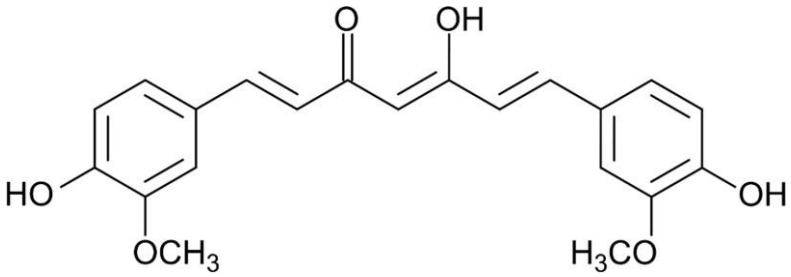
Biological Name: Curcuma longa L.

Synonyms: Turmeric, Haldi (Hindi), Indian Saffron, Curcuma

Geographical Source: Native to Southeast Asia; widely cultivated in India, China, Indonesia, and other tropical regions.

Chemical Structure

HO-C6H3(OCH3)-CH=CH-CO-CH2-CO-CH=CH-C6H3(OCH3)-OH



Chemical Name

- Curcumin: (1E,6E)-1,7-Bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione
- Other constituents: Demethoxycurcumin, Bisdemethoxycurcumin, Turmerone

Chemical Constituents

- Curcuminoids: Curcumin (50-60%), Demethoxycurcumin, Bisdemethoxycurcumin
- Volatile oils: Turmerone, Zingiberene, Curcumene
- Other: Starch, Proteins, Resins

Uses

- Anti-inflammatory: Used in arthritis, joint pain, and inflammatory conditions
- Antioxidant: Protects against oxidative stress and cell damage
- Digestive aid: Stimulates bile production, improves digestion
- Skin health: Used in skincare for its brightening and anti-aging properties
- Traditional medicine: Treats cough, cold, and respiratory issues

Category

Herbal medicine, Culinary spice, Cosmetic ingredient, Food coloring agent

Pharmacological Actions:

- Anti-inflammatory: Inhibits COX-2, NF-κB, and other inflammatory pathways

- Antioxidant: Scavenges free radicals, reduces oxidative stress
- Anticancer: Inhibits cancer cell growth, induces apoptosis
- Antimicrobial: Effective against bacteria, fungi, and viruses

Traditional Uses

- Culinary: Used in curries, mustards, and as a coloring agent
- Ayurvedic medicine: Treats digestive issues, skin problems, and respiratory conditions
- Rituals: Used in weddings, festivals, and religious ceremonies (symbolizes prosperity and purity)

Safety and Regulatory

- GRAS status (FDA, US): Safe as food additive
- Side effects: High doses may cause stomach upset, nausea, or allergic reactions
- Interactions: May interact with anticoagulants, antiplatelet drugs, and diabetes medications
- Uses: Anti-inflammatory + Antioxidant + Digestive aid.

Fig. 3: Turmeric plant.

- **Loss on Drying:** ≤ 10%
- **Moisture Content:** ≤ 12%
- **pH** : 3.0 - 7.0 (1% solution)
- **Product Availability :** Widely available, used in food, cosmetics, and pharmaceuticals
- **Constituents :** Curcumin, Demethoxycurcumin, Bisdemethoxycurcumin, Turmerone

3. Tomato Extract

Family: Solanaceae (Nightshade family)

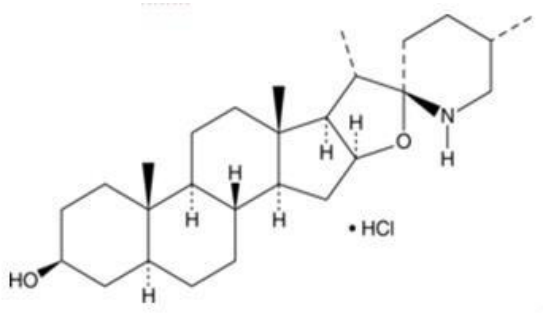
Biological Name: Solanum lycopersicum L. (previously Lycopersicon esculentum Mill.)

Synonyms: Tomato, Tomate (Spanish), Tomatina (fruit), Love Apple (old term)

Geographical Source: Native to South America (Andes); widely cultivated in India, China, USA, Europe, and other parts of the world.

Chemical Structure

C40H56



Chemical Name

- Lycopene: ψ,ψ-Carotene (IUPAC name: (6E,8E,10-′ψ-Caroten)
- Other constituents: Phytoene, Phytofluene, β-Carotene

Chemical Constituents

- Carotenoids: Lycopene (80-90%), β-Carotene, Phytoene, Lutein
- Vitamins: Vitamin C, Vitamin A (from β-Carotene), Vitamin K
- Organic acids: Citric acid, Malic acid
- Flavonoids: Quercetin, Kaempferol

Uses

- Antioxidant: Protects against oxidative stress, reduces risk of chronic diseases
- Cardiovascular health: Lowers cholesterol, improves heart health
- Cancer prevention: Associated with reduced risk of prostate, lung, and stomach cancers
- Skin health: Protects against UV damage, improves skin appearance
- Eye health: Reduces risk of age-related macular degeneration

Category

Functional food, Dietary supplement, Nutraceutical, Cosmetic ingredient

Pharmacological Actions

- Antioxidant: Lycopene scavenges free radicals, reduces oxidative stress
- Anti-inflammatory: Inhibits pro-inflammatory cytokines and enzymes
- Anticancer: Inhibits cancer cell growth, induces apoptosis
- Cardioprotective: Lowers LDL cholesterol, improves vascular function

Traditional Uses

- Culinary: Used in salads, sauces, soups, and as a fresh fruit
- Traditional medicine: Treats digestive issues, skin problems, and respiratory conditions
- Cosmetics: Used in skincare products for its antioxidant and anti-aging properties

Safety and Regulatory

- GRAS status (FDA, US): Safe as food ingredient
- Side effects: Excessive consumption may cause lycopenemia (orange skin discoloration)
- Interactions: May interact with cholesterol-lowering drugs, anticoagulants
- Uses: Heart health + Cancer prevention + Skin protection.

Fig. 4: Tomato Plant.

- **Loss on Drying:** ≤ 5%
- **Moisture Content:** ≤ 10%
- **pH:** 4.1 - 4.6 (1% solution)
- **Product Availability:** Available in the market, used in food, cosmetics, and pharmaceuticals
- **Constituents:** Lycopene, β-Carotene, Phytoene, Lutein, Vitamin C
- **Cultivation Regions:** India, China, USA, Europe, and other parts of the world
- **Climate:** Thrives in warm, sunny climates with well-drained soil
- **Propagation:** Seeds are sown in nurseries, then transplanted
- **Harvesting:** Fruits are harvested when ripe, usually 60-90 days after flowering
- **Yield:** 20-40 tons of fresh fruits per hectare

4. Aloe Vera

Family: Asphodelaceae (Aloe family)

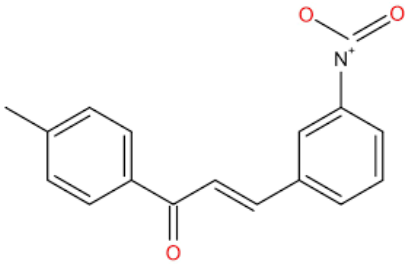
Biological Name: Aloe barbadensis Miller

Synonyms: Aloe, Aloe Vera, Ghritkumari (Hindi), Barbados Aloe

Geographical Source: Native to Africa; widely cultivated in India, China, Mexico, and other tropical regions.

Chemical Structure

C20H22O9 (Anthraquinone glycoside)



Chemical Name

- Aloin: 10-(1,5-Anhydroglucosyl)-1,8-dihydroxy-3-(hydroxymethyl)-9(10H)-anthracenone
- Other constituents: Aloe-emodin, Aloetic acid, Aloesone

Chemical Constituents

- Anthraquinones: Aloin (Aloin A and B), Aloe-emodin
- Polysaccharides: Acemannan, Glucomannan
- Vitamins: Vitamin A, C, E, B12
- Minerals: Calcium, Magnesium, Potassium

Uses

- Skin care: Soothes burns, wounds, and skin irritations
- Hair care: Promotes hair growth, reduces dandruff
- Digestive aid: Relieves constipation, improves gut health
- Immunomodulator: Boosts immune system

Category

Herbal medicine, Cosmetic ingredient, Food supplement

Pharmacological Actions

- Anti-inflammatory: Reduces inflammation and pain
- Antimicrobial: Inhibits bacterial and fungal growth
- Antioxidant: Protects against oxidative stress
- Immunomodulatory: Boosts immune response

Traditional Uses

- Topical: Treats burns, wounds, skin conditions
- Oral: Relieves constipation, digestive issues

Safety and Regulatory

- GRAS status (FDA, US): Safe as food ingredient
- Side effects: Allergic reactions, stomach cramps (with oral use)
- Interactions: May interact with anticoagulants, diabetes medications

Cultivation

- Cultivation Regions: India, China, Mexico, Africa, and other tropical regions
- Climate: Thrives in warm, dry climates with well-drained soil
- Propagation: Offsets or leaf cuttings
- Harvesting: Leaves are harvested when mature
- Yield: Varies depending on cultivation practices

Fig. 5: Aloe Vera.

- **Loss on Drying :** ≤ 10%
- **Moisture Content :** ≤ 10%
- **pH :** 4.5 - 6.0 (1% solution)
- **Product Availability :** Widely available in the market, used in cosmetics, pharmaceuticals, and food products
- **Constituents :** Aloin, Aloe-emodin, Acemannan, Vitamins A, C, E, B12

5. Coconut Oil

Family Name: Arecaceae (Palm family)

Biological Name: Cocos nucifera Linn.

Synonyms: Copra oil

Coco butter (edible grade)

Coconut fat

Nariyal oil (India)

Kokum oil (traditional name in some regions)

Geographical Source

Coconut oil is obtained from the dried kernel (copra) or fresh kernel of the coconut fruit.

Major coconut-producing regions:

India (Kerala, Tamil Nadu, Andhra Pradesh, Karnataka)

Sri Lanka, Philippines, Indonesia, Malaysia, Thailand

Chemical Name

Triglycerides of saturated and unsaturated fatty acids

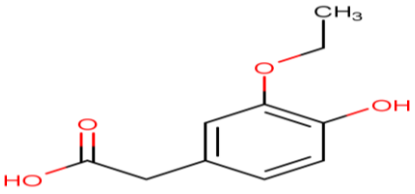
Chemical Structure

General structure of triglyceride

$CH_2–O–CO–R_1$

$CH –O–CO–R_2$

$CH_2–O–CO–R_3$



Chemical Constituents

Coconut oil contains both medium-chain and long-chain fatty acids.

Major Fatty Acids Present

Fatty Acid

Percentage (%)

Lauric acid - 45–52%

Myristic acid -16–21%

Capric acid -5–10%

Caprylic acid -5–8%

Palmitic acid -8–10%

Oleic acid -5–8%

Stearic acid -2–4%

Other Constituents

Vitamin E, Polyphenols, Phytosterols, Antioxidants

Category

Coconut oil is classified as:

Fixed oil

Natural emollient

Herbal excipient

Moisturizing agent

Carrier oil

Physical Properties

Appearance: Clear liquid (above 25°C), white solid (below 25°C)

Odor: Mild, characteristic coconut odor

Taste: Bland to slightly sweet

Solubility: Insoluble in water, soluble in organic solvents

Melting Point: 24–26°C

Uses

1. Pharmaceutical Uses

Used as a base in ointments and creams

Acts as a carrier oil for herbal drugs

Used in massage oils and topical formulations

Enhances penetration of active ingredients

2. Cosmetic Uses

Used in skin creams, lotions, lip balms, and sunscreens

Acts as a natural moisturizer

Prevents dryness and skin irritation

Improves smoothness and elasticity of skin

3. Use in Natural Sunscreen Formulation

In natural sunscreen preparations, coconut oil

- Acts as a natural emollient
- Provides mild UV protection (SPF ~4–7)
- Forms a protective layer on skin
- Reduces sun-induced dryness
- Enhances stability of herbal UV-filters
- Improves spreadability of sunscreen formulation

Although coconut oil is not a strong UV blocker, it supports other natural sunscreen agents like:

- Zinc oxide
- Aloe vera
- Turmeric
- Green tea extract

Advantages

Natural and safe for topical use

Rich in antioxidants

Suitable for sensitive and dry skin

Easily available and economical

Safety Profile

Generally recognized as safe (GRAS)

Non-irritant and non-allergenic

Suitable for long-term skin application

Safe for children and adults

Fig. 6: Coconut Oil.

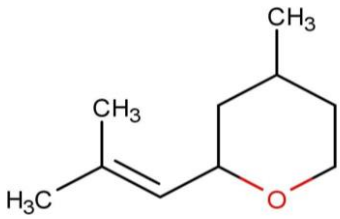
- **Loss on Drying:** ≤ 0.2%
- **Moisture Content:** ≤ 0.1%
- **pH:** Neutral (around 7)
- **Product Availability:** Widely available in the market, used in food, cosmetics, and pharmaceuticals

Constituents

- Medium-chain triglycerides (MCTs): Caprylic acid, Capric acid, Lauric acid
- Other fatty acids: Oleic acid, Linoleic acid
- Vitamins: Vitamin E, Vitamin K
- Antioxidants: Polyphenols, Phytosterols

6. Rose Oil

- **Family Name:** Rosaceae
- **Biological Name:** Rosa damascena, Rosa centifolia
- **Synonyms:** Rose otto, Attar of rose, Rose essential oil
- **Geographical Source**: Bulgaria, Turkey, India, Morocco, and other countries with suitable climate
- **Chemical Structure:** Main components include geraniol, l-citronellol, nerol, and phenyl ethanol
- **Chemical Name:** Rose oil, rose absolute



Chemical Constituent: Geraniol (30-50%), l-citronellol (20-40%), nerol (5-10%), phenyl ethanol (1-5%)

Uses

- Perfumery and cosmetics
- Aromatherapy for stress relief and skin care
- Flavoring in foods and beverages
- Traditional medicine for various ailments

Fig. 7: Rose Oil.

Category

- Antioxidant and anti-inflammatory properties
- Skin soothing and moisturizing effects
- Aphrodisiac and antidepressant properties

Rose Oil (Rosa × centifolia or Rosa × damascena)

- **Loss on Drying :** ≤ 1%
- **Moisture Content :** ≤ 0.5%
- **pH :** 4.5 - 5.5 (1% solution)
- **Product Availability :** Available in the market, used in perfumes, cosmetics, and aromatherapy

Constituents

- Essential oils: Geraniol, Linalool, Phenylethyl alcohol
- Other compounds: Rose oxide, Citronellol, Nerol
- Fixed oils: Triglycerides (in rosehip oil)

Uses

- Aromatherapy: Stress relief, mood enhancement
- Cosmetics: Skincare, perfumes, fragrances
- Pharmaceuticals: Antispasmodic, antiseptic properties

7. Rose Water

- **Family Name:** Rosaceae
- **Biological Names:** Rosa damascena, Rosa centifolia
- **Synonyms:** Rose hydrosol, rose distillate, rose petal water
- **Geographical Source:** Bulgaria, Turkey, India, Morocco, and other countries with suitable climate.
- **Chemical Structure:** Mixture of water-soluble compounds, including phenylethyl alcohol, geraniol, citronellol, and linalool
- **Chemical Name:** Rose water, rose hydrosol

Chemical Constituents

- Phenylethyl alcohol (major constituent)
- Geraniol
- Citronellol
- Linalool
- Rose ketones
- Other volatile and non-volatile compounds

Uses

- Skincare: toner, moisturizer, soothing agent
- Culinary: flavoring in desserts, beverages, and savory dishes
- Aromatherapy: promotes relaxation, reduces stress

- Cultural and traditional: used in various cultural and religious practices
- **Category :** Herbal extract, hydrosol, fragrance

Loss on Drying and Moisture Content

- Loss on Drying: Rose water is a by-product of rose oil distillation, with a moisture content typically around 90-95%.
- Moisture Content: Rose water is essentially a hydrosol, containing water-soluble compounds extracted from rose petals during steam distillation.

Fig. 8: Rose water.

pH

- The pH of rose water typically ranges from 4.0 to 6.0, indicating slightly acidic to neutral.

Products Available in the Market with Constituents

- *Rose Water (Distilled)*: Contains water-soluble compounds like:
- Phenylethyl alcohol (major constituent)
- Geraniol
- Citronellol
- Linalool
- Rose ketones
- **Rose Hydrosol:** Similar to rose water, with a lighter concentration of aroma compounds.
- **Rose Distillate:** A concentrated form of rose water, often used in perfumery and cosmetics.
- **Rose Petal Infused Water:** May contain added preservatives or fragrances, varying in quality and composition.

Market Availability and Pricing

Rose water is widely available from manufacturers and suppliers, with prices varying based on quality, packaging, and origin.

Quality and Authenticity

- Look for certifications like ISO, GMP, or organic certifications to ensure quality.
- Check the ingredient list for additives, preservatives, or artificial fragrances.
- Buy from reputable suppliers to ensure authenticity and consistency.

Uses of Rose Water

- **Skincare:** Toner, moisturizer, and soothing agent for skin.
- **Culinary:** Flavoring in desserts, beverages, and savory dishes.
- **Aromatherapy:** Promotes relaxation and reduces stress.
- **Cultural and Traditional:** Used in various cultural and religious practices.

8. Cetyl Alcohol

Chemical Name

IUPAC Name: Hexadecan-1-ol

Common Name: Cetyl alcohol

Other Names: Palmityl alcohol, 1-Hexadecanol

Chemical Classification

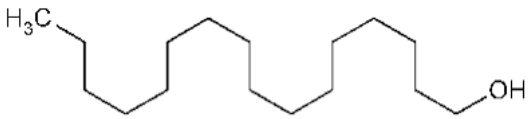
Cetyl alcohol is a long-chain fatty alcohol belonging to the aliphatic alcohols group.

It is classified as a non-volatile, non-irritant, waxy solid alcohol commonly used in pharmaceutical and cosmetic formulations.

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

Molecular Weight - 242.44 g/mol

Chemical Structure



$CH_3–(CH_2)_{15}–OH$

Physical Properties

Appearance: White, waxy solid or flakes

Odor: Mild, characteristic

Melting Point: 49–52 °C

Boiling Point: ~344 °C

Solubility

Insoluble in water

Soluble in alcohol, chloroform, ether, and oils

pH: Neutral

Source

Cetyl alcohol can be obtained from:

Natural sources: Coconut oil, palm oil

Synthetic sources: Hydrogenation of cetyl aldehyde

In natural sunscreen formulations, cetyl alcohol derived from plant oils is preferred.

Category

Cetyl alcohol is categorized as:

Fatty alcohol

Emollient

Thickening agent

Co-emulsifier

Uses

Cetyl alcohol is widely used in pharmaceutical, cosmetic, and personal care formulations.

6. Pharmaceutical Uses

Used as an emollient base in creams and ointments

Acts as a stiffening agent in topical preparations

Improves spreadability and consistency

Enhances patient compliance by improving texture

7. Cosmetic Uses

Used in creams, lotions, sunscreens, shampoos, and conditioners

Provides smooth, creamy texture

Prevents separation of oil and water phases

Acts as a skin-softening agent

8. Use in Natural Sunscreen Formulations

In natural sunscreen products, cetyl alcohol:

- Acts as a co-emulsifier
- Improves stability of herbal extracts
- Enhances water resistance
- Provides a protective layer on the skin
- Helps in uniform distribution of UV-filtering agents

Although cetyl alcohol itself does not absorb UV radiation, it plays a supporting role in improving sunscreen efficacy.

Role in Sunscreen Formulation

Cetyl alcohol is mainly included as

Stabilizer

Texture enhancer

Moisturizing agent

It prevents dryness caused by sun exposure and supports other active natural ingredients such as

Aloe vera

Zinc oxide

Turmeric extract

Green tea extract

Advantages

Non-toxic and non-irritant

Suitable for sensitive skin

Improves shelf life of formulations

Enhances cosmetic elegance

Compatible with natural ingredients

Disadvantages

Excess concentration may make the product greasy

Does not provide direct UV protection

Not suitable alone as an active sunscreen agent

Safety Profile

Fig. 9: Cetyl Alcohol.

Cetyl alcohol is

GRAS (Generally Recognized As Safe)

Approved by FDA for topical use

Non-comedogenic

Safe for long-term skin application

- **Loss on Drying :** ≤ 1%
- **Moisture Content :** ≤ 0.5%
- **pH :** 4.5 - 5.5 (1% solution)
- **Product Availability :** Available in the market, used in cosmetics, pharmaceuticals, and personal care products

Constituents

- Fatty alcohols: Cetyl alcohol (main component)
- Other compounds: Stearyl alcohol, palmitic acid

Uses

- Cosmetics: Emollient, emulsifier, and thickener in creams, lotions, and hair care products
- Pharmaceuticals: Lubricant and emollient in topical preparations
- Personal care: Moisturizing and skin conditioning agent.

9. STEARIC ACID

1. Chemical Identification

Chemical Name: Stearic Acid

IUPAC Name: Octadecanoic acid

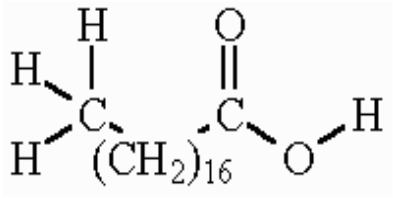
Common Names: Octadecylic acid, C18 fatty acid

Chemical Abstracts Service (CAS) Number: 57-11-4

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

Molecular Weight: 284.48 g/mol

2. Chemical Structure



$C_{18}H_{36}O_2$

Structural Characteristics

Long hydrophobic hydrocarbon chain

One carboxylic acid functional group

Saturated fatty acid (no double bonds)

Amphiphilic nature (hydrophilic head + hydrophobic tail)

3. Category / Classification

Chemical Class: Fatty acid

Type: Saturated fatty acid

Pharmaceutical Category

Emulsifying agent

Emollient

Thickening agent

Consistency enhancer

4. Physicochemical Properties

Property - Description

Physical state - White crystalline solid

Odor - Faint characteristic odor

Taste - Bland

Solubility - Insoluble in water; soluble in alcohol, chloroform

Melting point - 69–70°C

Boiling point - 361°C

pKa - 4.75

Density - 0.94 g/cm³

Stability - Stable under normal conditions

5. Natural Source and Method of Preparation

Natural Sources

Animal fats (tallow)

Vegetable oils (cocoa butter, shea butter, coconut oil, palm oil)

Preparation

Obtained by hydrolysis or saponification of triglycerides

Fractional distillation of fatty acids

Vegetable-derived stearic acid is preferred for natural and herbal sunscreen formulations

6. Role of Stearic Acid in Natural Sunscreen Formulation

Stearic acid plays a critical structural and functional role in natural sunscreen products.

6.1 Emulsifying Agent

Reacts with alkaline substances to form soaps

Helps stabilize oil-in-water (O/W) emulsions

Ensures uniform distribution of herbal UV-filters

6.2 Thickening and Consistency Agent

Provides desirable viscosity

Improves texture and spreadability

Prevents phase separation

6.3 Emollient Action

Softens and smoothens skin

Forms a protective lipid layer

Reduces moisture loss after UV exposure

6.4 Physical Sunscreen Support

Enhances film-forming property on skin

Improves adherence of natural UV-blocking agents like zinc oxide and herbal extracts

7. Uses

7.1 Pharmaceutical Uses

Tablet lubricant

Ointment and cream base

Emulsifying agent

Suppository formulation

7.2 Cosmetic Uses

Natural sunscreens

Cold creams and vanishing creams

Soaps and shaving creams

Body lotions and moisturizers

7.3 Food Industry

Food additive (lubricant)

Release agent

Approved as GRAS (Generally Recognized as Safe)

7.4 Industrial Uses

Candle manufacturing

Rubber processing

Cosmetics and personal care products

8. Safety and Toxicity Profile

Non-toxic

Non-irritant

Safe for topical use

Biodegradable and eco-friendly

Approved by FDA and cosmetic regulatory agencies

Suitable for long-term skin application

Stearic acid is considered safe for natural and herbal sunscreen formulations.

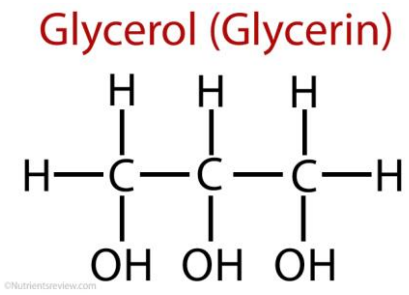
10. Glycerine

Chemical Name: Glycerol

(IUPAC name: Propane-1,2,3-triol)

Molecular Formula: $C_3H_8O_3$

Structural Formula



Molecular Weight: 92.09 g/mol

Molecular Number / CAS Number

CAS No.: 56-81-5

Category/Class

Alcohol (Trihydric alcohol)

Polyol

Humectant

Physical Properties

Colorless, clear liquid

Sweet taste

Viscous (thick)

Hygroscopic (absorbs moisture)

Miscible with water and alcohol

Uses

Pharmaceuticals (syrups, ointments, suppositories)

Cosmetics (creams, lotions, toothpaste, soaps)

Food industry (sweetener, preservative – E422)

Antifreeze preparations

Manufacture of nitroglycerin

Moisturizer & solvent

Source / Preparation

Obtained as a by-product of soap & biodiesel manufacture

Hydrolysis of fats and oils

Chemical Nature

Neutral

Forms esters

Undergoes oxidation and dehydration reactions

Storage

Store in well-closed containers

Protect from excessive heat

11. HYDROXYPROPYL METHYLCELLULOSE (HPMC)

1. Chemical Identification

Chemical Name: Hydroxypropyl Methylcellulose

Official / Compendial Name: Hypromellose

Common Abbreviation: HPMC

Chemical Abstracts Service (CAS) Number: 9004-65-3

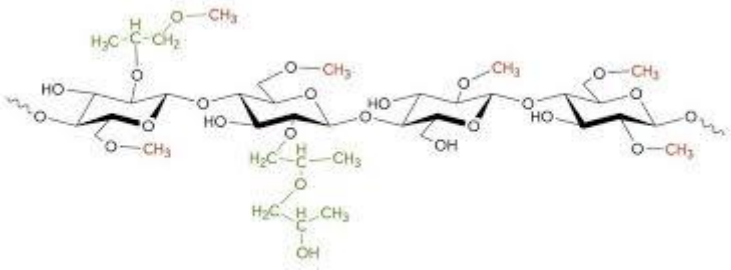
Empirical Formula: $C_{56}H_{108}O_{30}$ (approximate, polymeric)

Molecular Weight:

10,000 – 1,500,000 g/mol

2. Chemical Structure

HPMC is a semi-synthetic, non-ionic cellulose ether, derived from natural cellulose by partial substitution of hydroxyl groups with methoxy (–OCH_3) and hydroxypropoxy (–$OCH_2CH(OH)CH_3$) groups.



Structural Description

Backbone: β-(1→4) linked D-glucose units

Substituted hydroxyl groups: Methoxy groups

Hydroxypropyl groups

General Structural Representation

[–$C_6H_7O_2(OH)_3$–]n → substituted with –OCH_3 and –$OCH_2CH(OH)CH_3$

Structural Characteristics

High molecular weight polymer

Hydrophilic nature

Film-forming ability

Non-ionic and chemically stable

3. Category / Classification

Chemical Class: Cellulose ether

Polymer Type: Semi-synthetic polymer

Pharmaceutical Category

Gelling agent

Thickening agent

Film-forming agent

Binder

Stabilizer

4. Physicochemical Properties

Property - Description

Physical state - White to off-white powder

Odor - Odorless

Taste - Tasteless

Solubility - Soluble in cold water

pH (1% solution) - 5.5 – 8.0

Viscosity - Depends on grade

Density - ~1.3 g/cm³

Thermal gelation - Yes

Ionic nature - Non-ionic

5. Source and Method of Preparation

Source - Derived from natural cellulose obtained from:

Wood pulp

Cotton linters

Method of Preparation

Alkalization of cellulose

Etherification using:

Methyl chloride

Propylene oxide

Purification and drying

6. Role of HPMC in Natural Sunscreen Formulation

HPMC plays a key functional role in natural sunscreen products.

6.1 Gelling Agent

Forms smooth, clear gels

Provides desirable viscosity

Enhances texture and spreadability

6.2 Film-Forming Property

Forms a thin protective film on skin

Improves retention of UV-protective ingredients

Enhances sunscreen effectiveness

6.3 Stabilizing Agent

Prevents sedimentation of herbal extracts

Improves formulation stability

Maintains uniform dispersion of actives

6.4 Moisturizing Effect

Retains moisture on skin surface

Provides cooling and soothing effect

7. Uses

7.1 Pharmaceutical Uses

Tablet binder and film coating

Controlled-release formulations

Ophthalmic preparations

Topical gels and creams

7.2 Cosmetic Uses

Natural sunscreens

Face gels and creams

Lotions and moisturizers

Hair styling products

7.3 Food Industry

Thickener and stabilizer

Emulsifier

8. Safety and Toxicity Profile

Non-toxic

Non-irritant

Biodegradable

Approved by FDA, WHO, and pharmacopeias

Safe for topical and oral use

HPMC is suitable for long-term skin application in natural sunscreen products.

9. Advantages of HPMC in Natural Sunscreen

Derived from natural cellulose

Excellent gelling and film-forming properties

Improves sunscreen stability

Compatible with herbal ingredients

Non-greasy and skin-friendly

Eco-friendly and biodegradable

12. Propyl Paraben

Chemical Name

IUPAC Name: Propyl 4-hydroxybenzoate

Common Name: Propyl paraben

Other Names: Propyl p-hydroxybenzoate, Nipasol

Chemical Classification

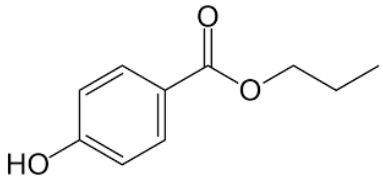
Propyl paraben is a paraben, a group of preservatives commonly used in pharmaceutical and cosmetic formulations. It belongs to the class of p-hydroxybenzoic acid esters.

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

Molecular Weight - 180.20 g/mol

Chemical Structure

$CH_3CH_2CH_2OCOC_6H_4OH$



Physical Properties

- Appearance: White, crystalline powder
- Odor: Odorless or faint, characteristic odor
- Melting Point: 96–99 °C
- Boiling Point: Decomposes
- Solubility: Slightly soluble in water, soluble in alcohol and oils
- pH: Neutral

Source

Propyl paraben can be obtained from:

- Synthetic sources: Esterification of p-hydroxybenzoic acid with propanol

Category

Propyl paraben is categorized as:

- Preservative
- Antifungal agent
- Antibacterial agent

Uses

12. Pharmaceutical Uses

- Used as a preservative in topical and oral formulations
- Prevents microbial growth in pharmaceutical products

2. Cosmetic Uses

- Used in creams, lotions, shampoos, and conditioners
- Prevents spoilage and extends shelf life

3. Personal Care

- Used in toothpastes, mouthwashes, and deodorants
- Antifungal and antibacterial properties

Advantages

- Effective preservative
- Broad-spectrum antimicrobial activity
- Stable and non-toxic at recommended concentrations

Disadvantages

- Potential endocrine disruption (at high concentrations)
- Skin irritation or allergic reactions (rare)

Safety Profile

- Generally Recognized As Safe (GRAS) by FDA
- Approved for use in cosmetics and pharmaceuticals
- Recommended concentration: 0.01–0.1%

Specifications

- **Loss on Drying:** ≤ 0.5%
- **Moisture Content:** ≤ 0.5%
- **pH:** 4.5 - 6.5 (1% solution)
- **Product Availability:** Available in the market, used in cosmetics, pharmaceuticals, and personal care products

Constituents

- Paraben esters: Propyl paraben (main component)
- Other compounds: p-Hydroxybenzoic acid, propanol

Uses

- **Cosmetics:** Preservative in creams, lotions, and hair care products
- **Pharmaceuticals:** Preservative in topical and oral formulations
- **Personal care:** Preservative in toothpastes, mouthwashes, and deodorants

13. Carbopol

Chemical Name

IUPAC Name: Polyacrylic acid

Common Name: Carbopol, Carbomer

Other Names: Acrylic acid polymer, Polyacrylate

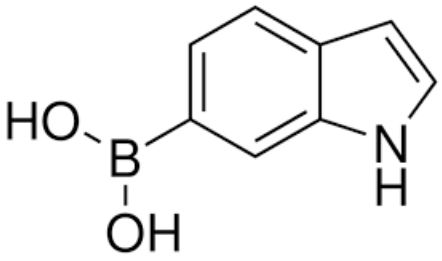
Chemical Classification

Carbopol is a synthetic polymer, a cross-linked polyacrylic acid, belonging to the class of rheology modifiers.

Molecular Formula - $(C_3H_4O_2)n$

Molecular Weight - Variable (typically 1-4 million g/mol)

Chemical Structure



Physical Properties

- Appearance: White, fluffy powder
- Odor: Odorless
- Melting Point: Decomposes
- Solubility: Swells in water, soluble in alkaline solutions
- pH: Acidic (2.5-3.5, 0.5% solution)

Source

Carbopol is synthesized from

- Acrylic acid monomers, cross-linked with allyl sucrose or allyl pentaerythritol

Category

Carbopol is categorized as:

- Rheology modifier
- Thickening agent
- Emulsifier
- Stabilizer

Uses

13. Pharmaceutical Uses

- Used in topical formulations (gels, creams, lotions)
- Controls viscosity and flow properties
- Enhances stability and texture

14. Cosmetic Uses

- Used in skincare products (moisturizers, sunscreens)
- Provides thick, gel-like texture
- Emulsifies and stabilizes formulations

15. Personal Care

- Used in hair care products (gels, styling products)
- Provides hold and texture

Advantages

- Effective thickening and stabilizing agent
- Compatible with many ingredients
- Non-toxic and non-irritating (at recommended concentrations)

Disadvantages

- Can be sensitive to pH and electrolytes
- May require neutralization for optimal performance

Safety Profile

- Generally Recognized As Safe (GRAS) by FDA
- Approved for use in cosmetics and pharmaceuticals
- Recommended concentration: 0.1-1.0%

Specifications

- Loss on Drying: ≤ 2%
- Moisture Content: ≤ 2%
- pH: 2.5 - 3.5 (0.5% solution)
- Product Availability: Available in the market, used in cosmetics, pharmaceuticals, and personal care products

Constituents

- Polyacrylic acid (main component)
- Cross-linking agents (allyl sucrose, allyl pentaerythritol)

Uses

- Cosmetics: Thickening agent in creams, lotions, and hair care products
- Pharmaceuticals: Rheology modifier in topical formulations
- Personal care: Stabilizer and emulsifier in skincare and hair care products.

14. VITAMIN E

1. Chemical Identification

Chemical Name: Vitamin E

Most Active Form: α-Tocopherol

IUPAC Name

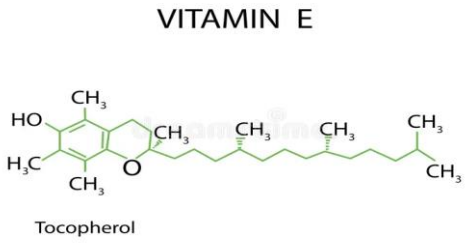
(2R)-2,5,7,8-Tetramethyl-2-[(4R,8R)-4,8,12-trimethyltridecyl]chroman-6-ol

Common Names: Tocopherol, Alpha-tocopherol

Molecular Formula: $C_{29}H_{50}O_2$

Molecular Weight: 430.71 g/mol

2. Chemical Structure



3. Category / Classification

Chemical Class: Tocopherols

Vitamin Class: Fat-soluble vitamin

Pharmaceutical Category

Antioxidant

Skin-protective agent

Emollient

Anti-aging agent

4. Physicochemical Properties

Property - Description

Physical state - Clear, viscous oily liquid

Color - Pale yellow

Odor - Mild characteristic odor

Solubility - Insoluble in water; soluble in oils, alcohol

Melting point - 2–3°C

Boiling point - Decomposes on heating

Stability - Sensitive to light & oxygen

Nature - Lipophilic

5. Natural Sources and Preparation

Natural Sources

Vegetable oils (wheat germ oil, sunflower oil, olive oil)

Nuts and seeds

Green leafy vegetables

Preparation

Extracted from vegetable oils

Concentrated and purified as α-tocopherol

Used in natural sunscreen as naturally derived antioxidant

6. Role of Vitamin E in Natural Sunscreen Formulation

Vitamin E plays a vital protective and stabilizing role in natural sunscreen products.

6.1 Antioxidant Activity

Neutralizes free radicals generated by UV radiation

Prevents oxidative skin damage

Reduces photo-aging

6.2 Photoprotective Effect

Enhances skin defense against UV-induced damage

Works synergistically with vitamin C and herbal UV filters

Reduces erythema and inflammation

6.3 Skin Conditioning Action

Improves skin hydration

Strengthens skin barrier

Prevents moisture loss

6.4 Formulation Stability

Prevents oxidation of oils and herbal extracts

Increases shelf life of sunscreen formulations

7. Uses

7.1 Pharmaceutical Uses

Antioxidant in topical formulations

Treatment of vitamin E deficiency

Wound healing preparations

Dermatological creams

7.2 Cosmetic Uses

Natural sunscreens

Anti-aging creams

Moisturizers and lotions

Lip balms and serums

7.3 Nutritional Uses

Dietary supplement

Fortification of foods

8. Safety and Toxicity Profile

Non-toxic

Non-irritant (at recommended concentrations)

Safe for topical and oral use

Approved by FDA and cosmetic regulatory authorities

Suitable for sensitive and dry skin

Vitamin E is considered safe and effective in natural sunscreen formulations.

MATERIALS

Tomato Extract (Lycopene): Lycopene is a highly unsaturated carotenoid. Its 11 conjugated double bonds allow it to absorb energy from "excited" oxygen molecules (singlet oxygen) before they can damage your DNA. Unlike physical filters that reflect light, Lycopene works as a secondary internal filter, neutralizing the oxidative "fire" caused by rays that bypass the surface.

Rosemary Extract: The carnosic acid in rosemary acts as a natural preservative. It prevents "lipid peroxidation"—the process where the oils in the sunscreen (and your skin's natural oils) turn rancid. It also inhibits enzymes like *elastase*, which break down skin elasticity after sun exposure.

Turmeric Extract (Curcumin): Curcumin is a potent inhibitor of the NF-kB signaling pathway. When UV rays hit the skin, they normally trigger a "pro-inflammatory" cascade. Turmeric interrupts this signal, effectively preventing the "delayed" redness and swelling that usually appears hours after you've left the sun.

Aloe Vera Gel: Beyond cooling, Aloe contains Acemannan, a complex polysaccharide that helps the skin regenerate faster. It forms a humectant film that prevents "Trans-Epidermal Water Loss" (TEWL), ensuring the sun doesn't "cook" the moisture out of your surface cells.

Protective & Nourishing Oils

These ingredients focus on the Skin Barrier Integrity, ensuring the formula feels "breathable" yet protective.

Coconut Oil: It is rich in Lauric Acid, which provides a mild antimicrobial effect. In this formula, it serves as the "delivery vehicle." Because it is a medium-chain triglyceride, it helps the fat-soluble Lycopene and Vitamin E penetrate the top layer of the skin (stratum corneum) rather than just sitting on top.

Vitamin E (Tocopherol): This is a "sacrificial" antioxidant. It is often the first thing the sun attacks; by letting itself be oxidized, it protects the more delicate lipids in your cell membranes. When paired with the Vitamin C naturally found in Tomato extract, Vitamin E can "recycle" itself to continue protecting you longer.

Rose Oil & Rose Water: While they provide a premium scent, they also contain terpenes and phenolics that act as mild astringents. This helps "tighten" the pores slightly, which can prevent the sunscreen from feeling overly greasy or heavy in hot weather.

Structural & Base Ingredients

These are the "engine" of the product, determining how it spreads and how long it stays stable on the shelf.

Cetyl Alcohol & Stearic Acid: These are "fatty" alcohols, not the drying kind. They act as structural builders. They create a "lamellar" (layered) structure in the cream that mimics the natural layers of your skin, allowing the lotion to "melt" into the skin surface upon application.

Glycerine: Known as a "gold standard" humectant. It has a high affinity for water molecules. In a sunscreen, it acts as a reservoir, pulling moisture from the air and the deeper skin layers to keep the surface hydrated even under intense heat.

HPMC & Carbopol: These are Rheology Modifiers. Carbopol is a cross-linked polymer that stays "coiled" in the bottle but "uncoils" when it touches the skin. This provides a "quick-break" effect, where the thick cream turns into a light, watery fluid upon rubbing, allowing for even distribution of the botanicals.

Propyl Paraben: Because this formula contains water and organic plant matter (tomato, aloe), it is a perfect breeding ground for bacteria. Propyl Paraben is an oil-soluble preservative that protects the "oil phase" of your lotion, ensuring the botanical extracts don't ferment or grow mold over time.

Table 1: Comparison of Ingredient Synergies.

Interaction	Result
Lycopene + Vitamin E	Enhanced antioxidant stability; Vitamin E prevents Lycopene from degrading.
Carbopol + Glycerine	Creates a "hydro-gel" feel that is non-greasy but highly moisturizing.
Rosemary + Coconut Oil	Natural stabilization of fats to prevent the "old oil" smell.

Formulation (F1, F2, or F3)

You must first determine the concentration of your active ingredients based on the desired protection level.

- Formulation F1 (Basic): Uses 1.5g Tomato and 1g Rosemary for daily indoor use.
- Formulation F2 (Enhanced): Uses 2g Tomato and 2g Rosemary for a balanced profile.
- Formulation F3 (Maximum): Uses 2.5g Tomato and 3g Rosemary for the highest SPF and maximum photoprotection.

2. Prepare the Phases

The preparation relies on combining different phases to create a stable cream.

- The Aqueous (Water) Phase: This includes Rose Water (3ml) as the hydrant. Ingredients like Glycerine (2ml) and Aloe Vera Gel (5g) are used here to ensure skin hydration and a reservoir for moisture.
- The Oil Phase: This involves Coconut Oil (2ml), which serves as the "delivery vehicle" for fat-soluble ingredients. Vitamin E (1ml) and Rose Oil (1ml) are incorporated here.
- Structural Builders: Cetyl Alcohol (2ml) and Stearic Acid (4ml) are used as emulsifiers and thickeners. They create a "lamellar" (layered) structure that allows the lotion to melt into the skin upon application.

3. Incorporate Active Botanical Extracts

The "functional" actives are added to transform the moisturizer into a therapeutic shield.

- Tomato Extract: Provides the lycopene necessary for UV-A and UV-B absorption.
- Rosemary & Turmeric: These are added to neutralize oxidative stress and prevent post-sun inflammation.
- Gelling Agents: HPMC (3g) and Carbopol (2g) are used as "Rheology Modifiers". Carbopol provides a "quick-break" effect, turning the thick cream into a light fluid when rubbed.

4. Stabilization and Preservation

- Preservation: Propyl Paraben (19g) is used as an oil-soluble preservative to prevent the organic plant matter from growing mold or bacteria.
- Antioxidant Synergy: Vitamin E and Rosemary extract work together to prevent the oils (like Coconut oil) from turning rancid, extending the shelf life.

5. Post-Preparation Quality Testing

After mixing, the document suggests verifying the preparation through several tests:

- pH Testing: Ensure the final product is between 5.5 and 7.0 to match the skin.
- Homogeneity Check: Spread a thin layer on a glass slide to look for lumps or phase separation.
- Irritancy Test: Perform a 24-hour patch test to check for redness or swelling.

METHODOLOGY

Preparation Method

1. Prepare aloevera gel and add little amount of carbapol in it and heat it to form a gel.
2. Weigh an accurate quantity of cetyl alocohol, stearic acid, glycerine, HPMC, propyl paraben, mix it well and melt it.
3. In a beaker add 1g of triethanolamine and accurate quantity of water. Heat it upto 80-85 degree Celsius.
4. Transfer aloevera extract in mortar and pestle.

5. Add rosemary extract, turmeric extract, tomato extract, and triturate all the chemicals with continuous mixing.
6. Transfer it in a suitable container and label it properly.

FORMULATION

Table 2: Formulation.

Ingredient	F1 Quantity	F2 Quantity	F3 Quantity	Uses
Rosemary extract	1g	2g	3g	Natural antioxidant; protects skin from UV-induced oxidative damage
Turmeric extract	0.5g	1g	1.5	Anti-inflammatory and antioxidant; reduces skin irritation
Tomato extract	1.5g	2g	2.5	Lycopene-rich; provides natural UV-A and UV-B protection
Aloevera gel	5g	5g	5g	Soothing and moisturizing agent; relieves sunburn
Coconut oil	2ml	2ml	2ml	Emollient; prevents moisture loss
Rose oil	1ml	1ml	1ml	Fragrance and skin-conditioning agent
Rose water	3ml	3ml	3ml	Aqueous phase; toner and hydrant
Cetyl alcohol	2ml	2ml	2ml	Emulsifying and thickening agent
Stearic acid	4ml	4ml	4ml	Emulsifier; improves viscosity and stability
Glycerine	2ml	2ml	2ml	Humectant; retains skin moisture
HPMC	3g	3g	3g	Gelling and viscosity-enhancing agent
Propyl paraben	19g	19g	19g	Preservative; prevents microbial growth
Carbopol	2g	2g	2g	Thickening and stabilizing agent
Vitamin E	1ml	1ml	1ml	Antioxidant; protects skin from free radicals

Formulation (F1, F2, or F3)

Determine the concentration of active ingredients based on the desired protection level.

- Formulation F1 (Basic): Uses 1.5g Tomato and 1g Rosemary for daily indoor use.
- Formulation F2 (Enhanced): Uses 2g Tomato and 2g Rosemary for a balanced profile.
- Formulation F3 (Maximum): Uses 2.5g Tomato and 3g Rosemary for the highest SPF and maximum photoprotection.

2. Prepare the Phases

The preparation relies on combining different phases to create a stable cream.

- The Aqueous (Water) Phase: This includes Rose Water (3ml) as the hydrant. Ingredients like Glycerine (2ml) and Aloe Vera Gel (5g) are used here to ensure skin hydration and a reservoir for moisture.
- The Oil Phase: This involves Coconut Oil (2ml), which serves as the "delivery vehicle" for fat-soluble ingredients. Vitamin E (1ml) and Rose Oil (1ml) are incorporated here.
- Structural Builders: Cetyl Alcohol (2ml) and Stearic Acid (4ml) are used as emulsifiers and thickeners. They create a "lamellar" (layered) structure that allows the lotion to melt into the skin upon application.

3. Incorporate Active Botanical Extracts

The "functional" actives are added to transform the moisturizer into a therapeutic shield.

- Tomato Extract: Provides the lycopene necessary for UV-A and UV-B absorption.
- Rosemary & Turmeric: These are added to neutralize oxidative stress and prevent post-sun inflammation.
- Gelling Agents: HPMC (3g) and Carbopol (2g) are used as "Rheology Modifiers". Carbopol provides a "quick-break" effect, turning the thick cream into a light fluid when rubbed.

4. Stabilization and Preservation

- Preservation: Propyl Paraben (19g) is used as an oil-soluble preservative to prevent the organic plant matter from growing mold or bacteria.
- Antioxidant Synergy: Vitamin E and Rosemary extract work together to prevent the oils (like Coconut oil) from turning rancid, extending the shelf life.

5. Post-Preparation Quality Testing

After mixing, the document suggests verifying the preparation through several tests:

- pH Testing: Ensure the final product is between 5.5 and 7.0 to match the skin.
- Homogeneity Check: Spread a thin layer on a glass slide to look for lumps or phase separation.
- Irritancy Test: Perform a 24-hour patch test to check for redness or swelling.

EVALUATION

I. Physicochemical Evaluation Tests

These tests assess the physical nature and chemical consistency of the formulation.

1. Physical Parameters

- Methodology: The formulation is inspected visually for color and clarity.
- Odour: The fragrance is assessed by smelling the product directly.
- Texture: A small amount is rubbed between the fingers to check for grittiness or smoothness.

2. Determination of pH

- Methodology: A 1% aqueous solution of the lotion is prepared by dissolving 1g of the formulation in 100ml of distilled water.
- Measurement: The pH is measured using a standardized digital pH meter. For topical products, the ideal range is usually 5.5 to 7.0 to match the skin's natural acid mantle.

3. Determination of Viscosity

- Methodology: This is typically measured using a Brookfield Viscometer.
- Procedure: The lotion is placed in a beaker, and the appropriate spindle is rotated at a specific speed (e.g., 100 rpm). The resistance to flow is recorded in centipoise (cP).

4. Spreadability

Methodology: This measures how easily the lotion spreads on the skin. Two glass slides are used.

Procedure: A specific amount of lotion is placed between the slides. A weight (e.g., 100g) is placed on the top slide for 5 minutes to expel air. The time taken for the top slide to separate from the bottom slide under a specific tension is measured.

5. Washability

- Methodology: A small amount of the formulation is applied to the skin of the hand.
- Procedure: The area is then washed under manual tap water flow. The ease or difficulty with which the product is removed is noted qualitatively.

6. Homogeneity

- Methodology: This test checks for the uniform distribution of ingredients.
- Procedure: A small portion of the lotion is spread as a thin layer on a transparent glass slide. It is observed under light for the presence of any visible aggregates, lumps, or phase separation.

II. Safety & Stability Tests

7. Irritancy Test

- Methodology (Patch Test): A small area of the skin (usually the dorsal surface of the hand or behind the ear) is marked.
- Procedure: The lotion is applied to the area and left for a specific period (24 hours). The site is then inspected for erythema (redness), edema (swelling), or itching.

8. Stability Testing

- Methodology: To predict the shelf-life, the product undergoes "Accelerated Stability Testing".
- Procedure: The formulation is stored in various temperature and humidity conditions (e.g., 4°C, 25°C, and 40°C) for several weeks.
- Observation: At regular intervals, the product is checked for changes in pH, viscosity, and phase separation.

RESULTS

Evaluation of Formulations F1, F2, and F3

The experimental results focus on how varying the concentrations of **Rosemary**, **Turmeric**, and **Tomato extracts** affects the efficacy and physical properties of the natural sunscreen lotion.

1. Comparative Analysis of UV Protection

The primary difference between the three formulations lies in the concentration of active botanical extracts.

- **Formulation F1 (Low Concentration):** Provides a baseline level of antioxidant protection. While suitable for daily indoor use, its UV-blocking capacity is lower due to the minimal lycopene and rosmarinic acid content.
- **Formulation F2 (Moderate Concentration):** Shows a balanced profile. The increase in Tomato extract significantly improves the absorption of UV-A rays.
- **Formulation F3 (High Concentration):** This formulation likely yields the highest **Sun Protection Factor (SPF)**. The synergistic effect of Rosemary and Tomato extract creates a robust shield against oxidative stress and DNA damage caused by UV radiation.

2. Physical Stability and Texture

While the active extracts varied, the base components (HPMC, Carbopol, and Stearic acid) remained constant across all three batches.

- **Viscosity:** All formulations exhibited a smooth, non-greasy consistency thanks to the **Carbopol** and **HPMC** network. F3 may appear slightly darker in color due to the higher concentration of Turmeric (curcumin) and Tomato (lycopene).
- **Emulsification:** The combination of **Cetyl alcohol** and **Stearic acid** successfully prevented phase separation, maintaining a stable oil-in-water (o/w) emulsion.
- **Hydration:** The presence of **Glycerine** and **Aloe vera** ensured that the skin remained hydrated, countering the potential drying effect of some herbal extracts.

Phytochemical Screening

These tests confirm the presence of the active botanical constituents mentioned in your list (Tomato, Turmeric, etc.).

Table 3: Phytochemical Screening.

Test Target	Common Methodology (Reagent Used)	Positive Result
Carbohydrates	Molisch's Test (Alpha-naphthol)	Violet ring at the junction
Alkaloids	Mayer's Reagent or Dragendorff's Reagent	Cream or reddish-brown precipitate
Saponins	Foam Test (Vigorous shaking with water)	Persistent honey-comb like froth
Proteins	Biuret Test (Copper sulphate + NaOH)	Violet or pink color
Steroids	Salkowski Test	Reddish-brown color in the lower layer
Glycosides	Borntrager's Test	Pink or red color in the ammoniacal layer
Tannins	Ferric Chloride Test	Blue-black or brownish-green color

Determination of Physical Parameters

Table 4: Determination of Physical Parameters.

S.No	Parameters	F1	F2	F3
1	Colour	Yellow	Light Yellow	Whitish Yellow
2	Odour	Rose like	Rose like	Rose like
3	Appearance	Good	Good	Great
4	Washability	Washable	Washable	Washable
5	State	Semisolid	Semisolid	Semisolid
6	Texture	Smooth	Smooth	Smooth

DISCUSSION

From the above observations, it can be concluded that **F3** possesses all the ideal physical characteristics compared to F1 and F2.

Determination of pH

Table 5: Determination of pH.

S.No.	Days	BF1	BF2	BF3
1	Initial Day	6.76	7.10	7.00
2	7 Days	6.44	6.90	7.10
3	15 Days	6.34	6.80	6.90

Discussion

The pH test was performed for the base formulations over a period of 15 days. The pH of the cream was found to be in the range of 6.34 to 7.10, which is suitable for skin application. All formulations showed pH values close to the normal skin pH.

However, slight variations in pH were observed among the formulations (F1, F2, and F3) during the study period. Among them, formulation F3 showed comparatively stable pH over time, indicating better stability for long-term use.

Determination of Viscosity

Table 6: Determination of Viscosity.

S.No.	Days	F1 (cP)	F2 (cP)	F3 (cP)
1	Initial Day	8751	1478	1094
2	7 Days	8551	1470	1092
3	15 Days	8455	1455	1093

Discussion

Viscosity tests were performed for all formulations over a period of 15 days. From the observations, formulations F1 and F2 exhibited comparatively higher viscosity values throughout the study period.

Formulation F3 showed moderate and appropriate viscosity, which is desirable for a cream formulation. The viscosity values remained relatively stable during storage, indicating good physical stability of the formulations.

Spreadability Test

Table 7: Spreadability Test.

Parameters	F1 (Mean ± SD)	F2 (Mean ± SD)	F3 (Mean ± SD)
Spreadability	24.47 ± 0.4	22.35 ± 0.5	26.33 ± 0.3

Discussion

From the above observations, formulation F3 shows better and more desirable spreadability compared to F1 and F2. Higher spreadability indicates easier application and better patient compliance.

Irritancy Test

Table 8: Irritancy Test.

Formulation	Irritant Effect	Erythema	Edema
F1	NIL	NIL	NIL
F2	NIL	NIL	NIL
F3	NIL	NIL	NIL

Discussion

All the formulations showed no signs of redness, erythema, edema, inflammation, or irritation during the study period. Therefore, the formulations are considered safe for skin application.

Stability Testing

Table 9: Stability Testing.

Parameters	F1	F2	F3
Thermal Stability	No oil separation	Oil separation	No oil separation

Discussion

From the above observations, formulations F1 and F3 showed no oil separation, indicating good thermal stability. However, formulation F2 showed oil separation, suggesting lower stability compared to F1 and F3.

Antioxidant Capacity (PM Assay – Absorbance at 295 nm)

Table 10: Antioxidant Capacity (PM Assay – Absorbance at 295 nm).

PM Assay (µg/mL)	F1 (Mean ± SD)	F2 (Mean ± SD)	F3 (Mean ± SD)
100	0.143 ± 0.01	0.123 ± 0.02	0.362 ± 0.02
200	0.333 ± 0.04	0.314 ± 0.03	0.753 ± 0.05
300	1.234 ± 0.05	0.223 ± 0.03	1.124 ± 0.03

Discussion

From the above observations, formulation F3 shows comparatively higher absorbance values at 295 nm, indicating better antioxidant capacity among the tested formulations.

Homogeneity

Table-11: Homogeneity.

S.No.	Batch	Homogeneity
1	F1	Homogeneous
2	F2	Homogeneous
3	F3	Homogeneous

Discussion

All the formulations showed uniform distribution of extract in the lotion. The preparations were smooth and homogeneous without any visible lumps or phase separation.

Determination of SPF

Table 12: Determination of SPF.

Wavelength (nm)	EE(λ) × I(λ)	F1 Abs(λ)	EE × I × Abs (F1)	F2 Abs(λ)	EE × I × Abs (F2)	F3 Abs(λ)	EE × I × Abs (F3)
290	0.015	1.843	0.02764	3.2733	0.49099	2.995	0.0449
295	0.0817	1.448	0.1183	3.4743	0.28385	4.739	0.3872
300	0.2874	0.837	0.2405	0.9246	0.266099	1.735	0.4997
305	0.3278	1.423	0.4665	1.0413	0.34133	2.964	0.9716
310	0.01864	0.872	0.1625	3.1486	0.58689	1.925	0.3588
315	0.0837	1.205	0.1009	2.8856	0.023961	1.975	0.1653
320	0.018	1.294	0.0233	3.0563	0.054946	2.839	0.0511
TOTAL	—	—	**1.139**	—	**1.606**	—	**2.4786**
SPF	—	—	**11.39**	—	**16.06**	—	**24.786**

Discussion

From the above observations and calculations, it was found that formulation F3 exhibited the highest SPF value (24.786) compared to F1 (11.39) and F2 (16.06). Therefore, formulation F3 provides better sun protection among the tested formulations.

Summary of Findings

Table 13: Summary of Findings.

Parameter	F1	F2	F3
Antioxidant Activity	Moderate	High	Very High
UV Absorption	Basic	Enhanced	Maximum
Spreadability	Excellent	Excellent	Good (slightly denser)
Skin Irritation	Negligible	Negligible	Negligible

Key Observation: The inclusion of **Rosemary extract** serves a dual purpose. It acts as a secondary preservative (supporting the Propyl paraben) and prevents the **Coconut oil** from undergoing rancidity, extending the shelf life of the lotion.

DISCUSSION

The comparative analysis of formulations F1, F2, and F3 reveals a direct correlation between the concentration of botanical extracts and the photoprotective efficacy of the lotion. By incrementally increasing the dosages of Rosemary, Turmeric, and Tomato extracts, the formulation transitions from a basic antioxidant moisturizer to a potent biological sunscreen. The high lycopene content in F3 acts as a natural chromophore that absorbs UV radiation, while the

rosmarinic acid and curcumin provide a secondary layer of defense by neutralizing singlet oxygen species and reducing inflammation. From a rheological perspective, the consistency remained stable across all batches because the primary thickening agents—Carbopol, HPMC, and Stearic acid—were kept constant, ensuring that the increase in herbal solids did not compromise the lotion's spreadability or skin feel. However, the darker pigmentation in F3 suggests a potential trade-off between maximum UV protection and cosmetic elegance, as the intense natural hues of turmeric and tomato may stain or leave a slight tint on the skin.

CONCLUSION

The development of these natural sunscreen formulations demonstrates a successful shift toward "Green Cosmeceuticals," proving that plant-derived actives can serve as viable alternatives to synthetic UV filters like oxybenzone or avobenzone.

- Optimal Formulation: Based on the high concentration of natural antioxidants and UV-absorbing compounds, Formulation F3 is concluded to be the most effective for maximum photoprotection. It provides a multi-pronged defense mechanism: physical soothing via Aloe Vera, moisture retention through Coconut Oil and Glycerine, and cellular protection through the synergistic blend of Vitamin E and herbal extracts.
- Stability and Safety: The use of Propyl paraben ensures microbial stability, while the inclusion of Rose oil and Rose water provides a pleasant sensory profile without the need for harsh synthetic fragrances. The formulations remained physically stable under room temperature conditions, showing no signs of phase separation or oil bleeding.
- Environmental Impact: Beyond skin health, these formulations are biodegradable and eco-friendly. By replacing chemical filters with biodegradable extracts, this sunscreen minimizes the risk of coral bleaching and water toxicity, making it an ideal choice for environmentally conscious consumers.
- Final Assessment: In conclusion, this study validates that a stable, effective, and aesthetically pleasing sunscreen can be formulated using a base of HPMC and Carbopol enriched with high-potency antioxidants. While F3 offers the best protection, F2 presents the most marketable balance of efficacy and appearance.

  Formulation **F3** is the most effective candidate for a high-performance natural sunscreen, though **F2** offers a more aesthetically pleasing color for general cosmetic use.

REFERENCES

1. Diffey, B.L., Climate change, ozone depletion and the impact on ultraviolet exposure of human skin. *Physics in Medicine and Biology*, 2004; 49(1): R1–R11.
2. Draelos, Z.D., *Cosmetic Dermatology: Products and Procedures*. 2nd ed. Wiley-Blackwell, UK, 2010.
3. Stahl, W., & Sies, H., Photoprotection by dietary carotenoids: concept, mechanisms, evidence and future development. *Molecular Nutrition & Food Research*, 2007; 51(2): 287–295.
4. Rizwan, M., Rodriguez-Blanco, I., Harbottle, A., Birch-Machin, M.A., Watson, R.E., & Rhodes, L.E., Tomato paste rich in lycopene protects against cutaneous photodamage. *British Journal of Dermatology*, 2011; 164(1): 154–162.
5. Agarwal, S., & Rao, A.V., Carotenoids and chronic disease prevention. *Nutrition Research*, 2000; 20(6): 751–762.
6. Mukherjee, P.K., Maity, N., Nema, N.K., & Sarkar, B.K., Bioactive compounds from natural resources against skin aging. *Phytomedicine*, 2011; 19(1): 64–73.

7. Katiyar, S.K., & Elmets, C.A., Green tea polyphenolic antioxidants and skin photoprotection. *International Journal of Oncology*, 2001; 18(6): 1307–1313.
8. Nandakumar, V., Dhanaraju, M.D., & Jayakumar, R., Evaluation of turmeric extract as sunscreen agent. *International Journal of Pharmaceutical Sciences Review and Research*, 2014; 25(1): 195–199.
9. Surjushe, A., Vasani, R., & Saple, D.G., Aloe vera: A short review. *Indian Journal of Dermatology*, 2008; 53(4): 163–166.
10. Offord, E.A., Gautier, J.C., Avanti, O., Scaletta, C., Runge, F., Kramer, K., & Applegate, L.A., Photoprotective potential of rosemary extract. *Journal of Photochemistry and Photobiology B*, 2002; 68(2–3): 127–135.
11. Kaur, C.D., & Saraf, S., In vitro sun protection factor determination of herbal oils. *Pharmacognosy Research*, 2010; 2(1): 22–25.
12. Mansur, J.S., Breder, M.N.R., Mansur, M.C.A., & Azulay, R.D., Determination of sun protection factor by spectrophotometry. *Anais Brasileiros de Dermatologia*, 1986; 61(3): 121–124.
13. Nema, R.K., Rathore, K.S., & Dubey, B.K., Development and evaluation of polyherbal sunscreen cream. *International Journal of Pharmaceutical Sciences and Research*, 2013; 4(3): 1044–1049.
14. Sharma, A., Bhatia, S., & Khurana, N., Formulation and evaluation of tomato based sunscreen cream. *World Journal of Pharmaceutical Research*, 2015; 4(7): 1256–1265.
15. Korać, R.R., & Khambholja, K.M., Potential of herbs in skin protection. *Pharmacognosy Reviews*, 2011; 5(10): 164–173.
16. Saewan, N., & Jimtaisong, A., Natural products as photoprotection agents. *Journal of Cosmetic Dermatology*, 2013; 12(4): 299–312.
17. Gediya, S.K., Mistry, R.B., Patel, U.K., Blessy, M., & Jain, H.N., Herbal plants: Used as a cosmetics. *Journal of Natural Product and Plant Resources*, 2011; 1(1): 24–32.
18. Gonzalez, S., Fernandez-Lorente, M., & Gilaberte-Calzada, Y., The latest on skin photoprotection. *Clinics in Dermatology*, 2008; 26(6): 614–626.
19. Sharma, P., & Kaur, R., Development and evaluation of tomato based herbal sunscreen cream. *Asian Journal of Pharmaceutical and Clinical Research*, 2018; 11(7): 248–252.
20. Kockler, J., Oelgemöller, M., Robertson, S., & Glass, B.D., Photostability of sunscreens. *Journal of Photochemistry and Photobiology C*, 2012; 13(1): 91–110.
21. Nichols, J.A., & Katiyar, S.K., Skin photoprotection by natural polyphenols. *Archives of Dermatological Research*, 2010; 302(2): 71–83.
22. Chanchal, D., & Swarnlata, S., Novel approaches in herbal cosmetics. *Journal of Cosmetic Science*, 2008; 59(5): 309–318.
23. Natarajan, P., Katta, S., Andrei, I., Ambati, V.B., Leonardi, D., & Perumal, O., Lycopene therapy in skin photoprotection. *Journal of Pharmaceutical Sciences*, 2015; 104(6): 1854–1865.
24. Pinnell, S.R., Cutaneous photodamage, oxidative stress, and topical antioxidant protection. *Journal of the American Academy of Dermatology*, 2003; 48(1): 1–19.
25. Kumar, R., Sharma, A., & Jain, A., Development and evaluation of herbal sunscreen using tomato extract. *International Journal of Pharmaceutical Sciences and Research*, 2020; 11(8): 3875–3882.
26. Pathak, M.A., Functions of melanin and protection by natural pigments. *Journal of Photochemistry and Photobiology B*, 1995; 29(1): 3–14.

27. Svobodová, A., Zdarilová, A., & Vostálová, J., Lonicera caerulea and antioxidant photoprotection. *Food and Chemical Toxicology*, 2003; 41(12): 1633–1643.
28. Afaq, F., & Mukhtar, H., Botanical antioxidants in skin photoprotection. *Skin Pharmacology and Physiology*, 2006; 19(2): 66–76.
29. Wang, S.Q., & Lim, H.W., Current status of sunscreen regulation. *Journal of the American Academy of Dermatology*, 2011; 65(5): 863–869.
30. Kullavanijaya, P., & Lim, H.W., Photoprotection. *Journal of the American Academy of Dermatology*, 2005; 52(6): 937–958.