

Turmeric as a Key Ingredient in Cosmeceuticals: New Scientific Evidence

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Abstract

Turmeric (Curcuma longa), particularly its active compound curcumin, is gaining recognition in cosmetics and medicine for its therapeutic properties. Its antioxidants, anti-inflammatory, and antimicrobial effects make it a popular skincare ingredient, helping reduce inflammation, brighten skin, and fight aging. In addition to treating dandruff and promoting hair growth, Turmeric is also good for scalp health. Curcumin increases the body's antioxidant defenses. Inhibits inflammation and antioxidants. Curcumin, a powerful compound found in turmeric, enhances the body's antioxidant defenses by neutralizing free radicals, reducing oxidative stress, and supporting cellular health. It also inhibits inflammation, promoting overall well-being. While some may experience mild irritation, turmeric's safety and effectiveness in both skincare and pharmaceuticals make it a promising natural solution for beauty and wellness. Turmeric's broad versatility extends to treating conditions like acne, eczema, and wrinkles, while ongoing research is enhancing its formulation for even greater efficacy. Additionally, its anti-inflammatory and antioxidant properties contribute to its ability to soothe skin, reduce redness, and promote a healthy complexion. As more studies explore its potential, turmeric continues to gain recognition as an essential ingredient in holistic wellness and cosmetic products. As a natural powerhouse in both beauty and therapeutic treatments, turmeric is poised to lead the next wave of skincare and haircare innovation.

Keywords: Antiaging, anti-inflammatory, antioxidant, curcumin, NF-kB pathway

INTRODUCTION

Cosmeceuticals are cosmetic products with bio-active ingredients that have medical benefits and are synthesized from botanical, animal, or chemical sources. The term “cosmetic” and “pharmaceutical” comes from the words cosmetic and pharmaceutical, meaning cosmetics designed to beautify the body and pharmaceuticals connected with industrial medicine production. Cosmeceuticals contain active ingredients like vitamins, phytochemicals, enzymes, antioxidants, and essential oils. Curcumin (diferuloylmethane), the active ingredient in turmeric. It was first identified and extracted in the 1910s [1].

Turmeric, a spice with a strong yellow pigment, with a strong yellow pigment, has been used for centuries in cooking, cosmetics, dye, and medicinal remedies. With 8.46 lakh tons produced in 2014–2015, India is the world's largest producer, exporter, and consumer of turmeric. Turmeric (*curcuma longa*) are rhizomatous herbs from the zingiberaceae family. Their rhizomes are commonly used in traditional medicine due to their pharmacological properties, which are attributed to various secondary metabolites, such as alkaloids, flavonoids, tannins, and terpenoids. Curcumin, a

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polyphenol, is especially notable for its diverse clinical benefits. The medicinal uses of *Karakuma* and *Zingiber* plants are diverse. Including anti-inflammatory properties Anti-aging, cosmetic, antifungal and antibacterial. In addition to their therapeutic benefits, these plants have bioactive properties and a strong safety profile, making them useful in cosmetics, pharmaceuticals, and some medical formulations. Curcumin can be extracted from the dried roots of the rhizomes of curcuma and zingiber species. The extraction involves grinding the raw material into powder and using a solvent to selectively extract the pigment. The powdered rhizomes of these species are widely applied in cosmetics and medicinal fields. In herbal processing, proper drying practices are essential to remove moisture that promotes bacterial growth and spoilage, while preserving the phenolic and bioactive compounds, such as curcumin. Curcumin is a key ingredient in skin care and dermatology, offering antioxidant, anti-inflammatory, and anti-aging benefits. Clinical studies have shown both oral and topical application of curcumin from turmeric (*curcuma longa*) is effective in treating various skin conditions and enhancing skin health. Turmeric (*Curcuma longa*) is emerging as a cornerstone in cosmeceuticals, bridging ancient phytomedicine with cutting-edge skincare innovation. Unlike synthetic ingredients, turmeric's bioactive compounds, especially curcumin, work in harmony with the skin's natural processes, delivering deep therapeutic benefits without harsh side effects. This botanical powerhouse not only targets visible skin issues like acne, hyperpigmentation, and aging but also addresses underlying cellular inflammation and oxidative stress. As science uncovers more about its regenerative properties, turmeric is redefining the role of phytomedicine in beauty, offering a unique synergy of tradition and advanced dermatology [2].

PLANT AND ITS CHEMISTRY

Karakuma longa is a perennial rhizomatous herb grown in tropical countries, such as Thailand, Indonesia, China and India. With more than 40 Indian roots, it is the most used species in the *Curcuma* genus and *Zingiberaceae* family. *Curcuma* requires a lot of water and grows in hot climates, moist has large, long leaves and a short pseudo stem (Figures 1 and 2). The dominant or mother rhizome and secondary, multi-branched rhizomes are pale yellow, yellow-red or orange brown. Forms underground rhizomes that do not bear fruit and bear pale yellow flowers.



Figure 1. Plant of Curcumin.



Figure 2. Root of Curcumin.

“Madras” and “Alleppe” turmeric are the two main commercial varieties in India. The United States imports Alleppe turmeric as a spice and food coloring, even though Madras turmeric is low in essential oils and curcumin (Figure 1). Bengal turmeric is mainly used as a dye, although Madras turmeric can be used with mustard, curry powder or paste, although the oil gives off a pleasant aroma. But curcuminoids give a yellow color. Curcumin, which is abundant in *Curcuma longa*, can be extracted from other plants as well (Figure 2). It is a type of essential oil used in aromatherapy and perfumes [3].

Composition of Turmeric

Turmeric

Contains carbohydrates, fats, fiber, proteins, minerals, curcuminoids, volatile and non-volatile oils, along with moisture.

Curcuminoids

Includes curcumin (curcumin 1), desmethoxycurcumin (curcumin 11), bis methoxy curcumin (curcumin 1V).

Essential Oils

Composed of a moisture of sesquiterpene ketones and alcohols, along with compounds like d-sabinene, borneol, zingiberene, cineol, and alpha -phellandrene (Figure 3) [4].

SCIENTIFIC CLASSIFICATION OF CURCUMA LONGA

- *Kingdom:* Plantae.
- *Subkingdom:* Tracheobionta.
- *Super Division:* Spermatophyta.
- *Division:* Mangoliophyta.
- *Order:* Zingiberales.
- *Family:* Zingiberaceae.
- *Genus:* Curcuma.
- *Species:* Longa.
- *Scientific Name:* Curcuma Longa.

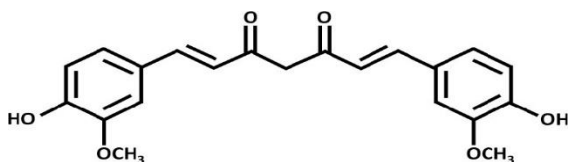


Figure 3. Anti-Inflammatory and Antioxidant Properties.

Anti- Inflammatory Mechanism

Blocking the NF-KB Pathway

NF-KB (Nuclear Factor-B) is a protein complex that plays a key role in the body’s inflammatory response by triggering the production of pro-inflammatory molecules, such as cytokines.

Curcumin inhibits the activation of NF- κ B, thus lowering the levels of inflammatory markers like TNF- α and IL-6. This reduction in inflammation helps calm irritated skin, reducing redness and swelling in conditions like acne or dermatitis.

Reducing COX-2 and LOX Enzymes

COX-2 (Cyclooxygenase-2) and LOX (Lipoxygenase) are enzymes that promote the production of inflammatory compounds, including prostaglandins and leukotrienes.

By suppressing these enzymes, curcumin decreases the formation of these inflammatory molecules, leading to reduced skin irritation and inflammation in conditions, such as rosacea and eczema.

Neutralizing Reactive Oxygen Species (ROS)

Inflammation often leads to the generation of harmful molecules known as reactive oxygen (ROS), which can cause oxidative damage to skin cells.

Turmeric's antioxidant properties help neutralize ROS, which in turn reduces skin damage and prevents inflammation from worsening. In addition to helping reduce inflammation, this process also protects the skin from premature aging.

- Inflammation.
- Generation of Reactive Oxygen Species (ROS).
- Oxidative Damage to Skin Cells.
- Turmeric's Antioxidant Properties.
- Neutralization of ROS.
- Reduction of Skin Damage.
- Prevention of Worsening Inflammation.
- Protection from Premature Aging.

Antioxidant Mechanism

Direct Neutralization of Free Radicals

Curcumin directly interacts with and neutralizes harmful radicals, including reactive oxygen species (ROS) and reactive nitrogen species (RNS). By donating electrons or hydrogen atoms, curcumin stabilizes these unstable molecules, reducing oxidative stress, which can otherwise damage cellular structure like lipids, proteins, and DNA.

Enhancement of Endogenous Antioxidant Enzymes

Curcumin is known to activate the body's own defense mechanism by boosting antioxidant enzymes, such as superoxide dismutase (SOD), catalase, and glutathione peroxidase. These enzymes are required to neutralize reactive species to protect the skin from oxidative damage.

Inhibition of Pro-Oxidant Enzymes

Curcumin reduces oxidative damage by inhibiting pro-oxidant enzymes, such as lipoxygenase (LOX) and cyclooxygenase-2 (COX-2). These enzymes contribute to the generation of free radicals during inflammatory processes. By modulating their activity, curcumin reduces oxidative stress triggered by inflammation [5].

Cell Signaling Pathways

NF κ B is a key protein complex that plays a central role in regulating inflammation, cell death (apoptosis), immune responses, and cellular growth and development. It comprises five transcription factors: NF κ B1 (p50), NF κ B2 (p52), RelA (p65), RelB, and c-Rel. In most cells, NF κ B remains inactive in the cytoplasm, bound to its inhibitor, I κ B. Various kinases, such as protein kinase B (PKB/ Akt), phosphoinositide-3 kinase (PI3K), and I κ B kinase (IKK), can activate NF κ B. During oxidative stress, IKK is activated, phosphorylated I κ B and NF κ B are released and translocated to the nucleus. Once

there, NFkB promotes the transcription of several proinflammatory mediators, including interleukins (IL-1, IL-2, IL-6), granulocyte- macrophage colony-stimulating factor (GM-CSF), tumor necrosis factor-alpha (TNF- α), inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), and 5-lipoxygenase (LOX-5).

Curcumin (CUR) is believed to inhibit NFkB activation and reduce the expression of proinflammatory genes by blocking the phosphorylation of the I κ B inhibitor. Research suggests that CUR modulates the activity of serine/ threonine-protein kinase Akt, a molecule involved in signaling pathways that activate NFkB.

Additionally, CUR influences crosstalk between the Nrf2 and NFkB pathways. For example, the NFkB pathway interacts with the keap1/Nrf2/ARE (antioxidant response element) pathway through mechanisms like:

1. Keap1-mediated degradation of I κ B β via ubiquitination, inhibiting NFkB activation.
2. Activation of IKK by oxidative stress, which promotes NFkB translocation to the nucleus, triggering proinflammatory cytokines, such as COX-2, in turn, interacts with keap1, enhancing Nrf2 activation and leading to simultaneous gene transcription and NFkB inhibition.
3. Nrf2 binding to CBP (CREB- binding protein) transcription cofactors, such as small Maf proteins, to initiate ARE- driven gene expression.
4. Competition between NFkB and Nrf2 for CBP binding, where NFkB may inhibit Nrf2 activity [6].

Anti-Aging and Skin Benefits

Skin Elasticity and Firmness

Skin firmness indicates the firmness and tone of the skin. While skin elasticity describes the skin's ability to stretch and regain its natural shape. Both of which are essential for maintaining a youthful appearance. Collagen, hyaluronic acid. And flexibility is a key ingredient that contributes to these qualities [7].

Topical treatments Retinoids, derived from vitamin A, have been widely studied for their effectiveness in promoting collagen synthesis and enhancing skin texture. Regular applications can lead to improved elasticity and firmness by accelerating cell turnover and reducing fine lines [8].

Skin firmness indicates the firmness and tone of the skin. While skin elasticity describes the skin's ability to stretch and regain its natural shape. Both of which are essential for maintaining a youthful appearance. Collagen, hyaluronic acid. And flexibility is a key ingredient that contributes to these qualities [9] Wrinkle reduction.

Curcumin neutralizes free radicals, which are unstable molecules that contribute to skin aging. By mitigating oxidative stress, turmeric may help preserve skin elasticity and reduce the appearance of fine lines (Figure 4).

Collagen is vital for maintaining skin structure and firmness. Curcumin has been shown to stimulate collagen production, which can help restore skin's youthful appearance [10].

Skin Brightening and Even Tone

- *Blocks Melanin Production:* Turmeric, rich in curcumin, inhibits tyrosinase enzyme, a key melanin-creating enzyme, thereby reducing pigmentation and fading dark spots, thereby enhancing skin tone [11].
- *Boost Natural Radiance:* Turmeric is known to improve skin health by gently exfoliating dead skin cells. Make your skin look more beautiful [12].
- *Spots Dark Spots from Reappearing:* Turmeric not only reduces existing discoloration but also prevents new dark spots by regulating skin melanin levels [13].

- *Smooths Skin Texture:* Regular use can enhance uneven skin texture by addressing pigmentation issues, resulting in a smoother, more even complexion [14].

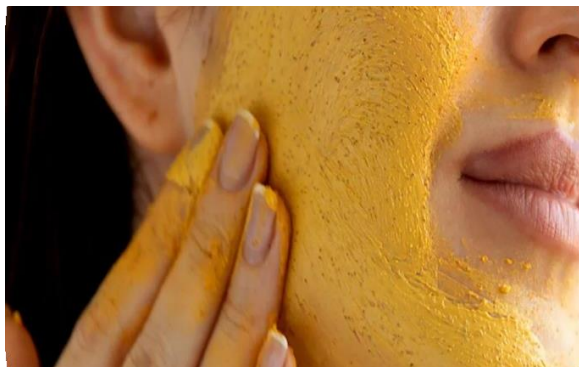


Figure 4. Skin Brightening.

Hair Care Application

Turmeric is a popular natural remedy for improving scalp health. This is because it has well-known anti-inflammatory and antibacterial properties. It can reduce scalp inflammation, reduce dandruff, and even stimulate hair growth by increasing blood flow [15].

SCALP HEALTH

Benefits of Turmeric for Scalp Health

- *Reduces Inflammation:* Curcumin, the active compound in turmeric, can alleviate inflammation in the skin, potentially aiding in conditions like psoriasis and scalp eczema.
- *Fights Dandruff:* Turmeric's antimicrobial properties effectively combat the yeast responsible for causing dandruff, thereby promoting a healthier scalp.
- *Promotes Hair Growth:* Turmeric enhances blood circulation, which can stimulate hair follicles, thereby promoting hair growth [16].

How to Use Turmeric for Scalp Health

- *Turmeric Masks:* Applying turmeric powder mixed with coconut oil or yogurt as a scalp mask can provide nourishment and alleviate irritation [17].
- *Turmeric Shampoo:* Certain shampoos contain turmeric to help maintain scalp health over time [18].

HAIR GROWTH AND DENSITY

What Turmeric Supports Hair Growth

- *Stimulates Hair Growth:* Curcumin boosts scalp blood flow, supplying more nutrients to hair follicles, potentially promoting stronger hair growth.
- *Prevents Hair Thinning:* Turmeric, by reducing inflammation and controlling scalp oil buildup, can help prevent hair thinning and promote thicker hair.
- *Fights Scalp Infections:* Turmeric's antimicrobial properties effectively shield the scalp from potential infections that could potentially lead to hair loss [19].

How to Use Turmeric for Hair Growth

- *Turmeric Oil Treatment:* Massage turmeric and coconut or castor oil into the scalp to nourish hair follicles and stimulate growth.
- *Turmeric Hair Masks:* Mix turmeric powder with natural ingredients like aloe vera or honey to create a hair mask that enhances scalp health and increases hair thickness [20].

Hair Loss And Splitting Reduction

How Turmeric Aids in Hair Loss and Spilt Ends

- *Minimizes Hair Loss:* Curcumin can alleviate scalp inflammation, improve blood circulation, and

offer essential nutrients to hair follicles, potentially reducing hair loss.

- *Prevents Split Ends:* Turmeric's antioxidants enhance hair strand strength, reducing the risk of breakage and split ends.
- *Maintains Scalp Health:* Turmeric's antimicrobial qualities support a clean and healthy scalp, preventing issues like dandruff and infections that can lead to thinning and breakage [21].

Methods to Use Turmeric for Hair Loss and Spilt Ends

- *Turmeric Oil Treatment:* Apply turmeric and beneficial oils like organ or olive oil to both the scalp and hair to reduce shedding and protect the ends.
- *Turmeric Hair Rinse:* Apply a rinse with turmeric-infused water or herbal solutions after shampooing to protect hair from damage and splits [22].

CLINICAL STUDIES AND TRIALS

Human Studies

Preclinical and in vitro studies have provided a strong foundation for moving forward with human clinical trials on curcumin. The molecular effects of curcumin in animal models and cell cultures are largely similar to human research on NF-KB, COX-2, and inflammatory cytokines including IL-1, IL-6, TNF-a are among the anti-inflammatory targets of curcumin, which results in a clinically significant reduction of psoriasis, chronic anterior uveitis, inflammation after surgery rheumatoid arthritis The results of orbital pseudo-inflammatory tumors also improved.

Moreover, due to curcumin's ability to achieve high concentration in gastrointestinal tissue, it has shown clinical benefits for irritable bowel syndrome, tropical pancreatitis, gall bladder and biliary motility issues, gastric ulcers, and familial adenomatous polyposis coli. The clinical potential of curcumin to lower serum cholesterol and improve endothelial cell function in patients with type 2 diabetes supports in vitro findings of increased PPAR-g expression and Modulates NOS, glutathione, and other antioxidant activities. Curcumin also improves the function of early kidney transplants. The post-implantation period occurs mainly through various mechanisms [23].

Curcumin shows potential in treating Crohn's disease in humans. This is consistent with interesting preclinical data in animal models of inflammatory bowel disease. In a small open-label study, 9 out of 10 patients with ulcerative proctitis developed ulcerative proctitis. Helps improve clinical laboratory symptoms. and required fewer booster doses of -89 individuals with UC A large multicenter, randomized, double-blind, controlled trial yielded more positive results [24].

Invitro and in Vivo Studies

Curcumin has been shown to have many different effects on cells, such as acting as an antioxidant, reducing inflammation, preventing cell growth, promoting cell death, fighting bacteria, and helping to fight cancer [25].

SAFETY AND TOXICOLOGY

Acute and Chronic Toxicity

- *Acute Toxicity:* Acute toxicity refers to harmful effects that occur after short-term exposure to a substance. There are very few reports of acute toxicity of curcumin, the main ingredient in turmeric. Animal studies have demonstrated that even at high doses, curcumin is generally safe. For example, the oral LD50 (dose lethal to 50% of subjects) in rats is reported to be greater than 2,000mg/kg, indicating that curcumin presented minimal acute toxicity risks [26].
- *Chronic Toxicity:* Chronic toxicity is associated with prolonged exposure to a substance over time. When eaten at a moderate level Curcumin will be less toxic. According to studies that look at long-term effects. In animal studies, doses up to 1,800 mg/kg/day over a period of 90 days have been administered without causing significant adverse effects. However, very high doses in humans over extended periods may cause mild gastrointestinal symptoms like nausea and diarrhea. Overall, no

serious long-term toxicity has been observed at normal consumption levels [27].

- *Safety Profile:* The world health organization (WHO) has recommended an acceptable daily intake (ADI) of 0-3 mg/kg of body weight, reinforcing its safety when used within these limits.

SKIN IRRITATION AND ALLERGIC REACTIONS

While turmeric is widely used for its anti-inflammatory and antioxidant properties, some individuals may experience skin irritations or allergic reactions Contact. These reactions are more common with topical applications rather than ingestion.

Curcumin, the active compound in turmeric, is generally considered safe; however, allergic reactions, such as contact urticaria (hives) have been noted in sensitive materials. Patch tests have revealed that turmeric can act as a sensitizer in some people, leading to allergic contact dermatitis upon repeated exposure. Despite these cases, turmeric-related skin reactions are relatively rare [28].

CONCLUSIONS

Turmeric shows great potential in medicine and cosmetics. Especially the active ingredient curcumin. Its long-standing use in traditional medicine, coupled with its well-researched antioxidant, anti-inflammatory, and antimicrobial properties, positions it as a valuable ingredient in modern cosmeceuticals. The versatile nature of turmeric makes it effective for a variety of applications, including skin care, hair care, and therapeutic treatments for inflammatory.

Studies have highlighted the effectiveness of curcumin in promoting skin health, reducing inflammation, and enhancing skin elasticity, while also showing promising results in reducing signs of aging, such as wrinkles and uneven skin tone. Furthermore, its role in scalp health and hair growth makes it a multifaceted ingredient with broad appeal.

Turmeric has many benefits. But sometimes it can irritate the skin or even trigger an allergic reaction. Especially in people who are sensitive. However, these occurrences are rare, and the overall safety of curcumin remains favorable, as confirmed by both acute and chronic toxicity studies.

In conclusion, with its broad therapeutic benefits, safety, and minimal side effects, turmeric holds great promise in the cosmetic, pharmaceutical, and medicinal industries. Further research and development into more bioavailable formulations will likely continue to expand their applications and efficacy, making it a key ingredient in future dermatological and cosmeceutical products.

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