



CITRUS LIMON (LEMON), CARICA PAPAYA (PAPAYA LEAVES) AND CURCUMA LONGA (TURMERIC): A REVIEW ON ITS PHYTOCHEMISTRY AND DERMATOLOGIC APPLICATIONS

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ABSTRACT

Hyperpigmentation remains a prevalent dermatological concern, prompting interest in natural alternatives to synthetic whitening agents such as hydroquinone. This review evaluates the phytochemical constituents and dermatological applications of *Citrus limon* (lemon), *Carica papaya* leaves, and *Curcuma longa* (turmeric) in skin whitening. *C. limon* contains ascorbic acid and flavonoids including hesperidin and eriocitrin, which exhibit direct tyrosinase inhibition and antioxidant activity that attenuates UV-induced melanogenesis. *C. papaya* Leaves provide proteolytic enzymes papain and chymopapain for enzymatic exfoliation of melanin-rich keratinocytes, alongside quercetin, a flavonoid with tyrosinase inhibitory and anti-inflammatory properties. *C. longa* contributes curcumin, which suppresses melanin synthesis via tyrosinase and MITF downregulation, and turmerone oil, which enhances bioavailability and provides additional antioxidant effects. Collectively, these plants demonstrate complementary, multi-target mechanisms—enzymatic desquamation, melanin synthesis inhibition, and photoprotection—that support their potential as a natural source of dermatological benefits for hyperpigmentation management. Despite promising in vitro and in silico evidence, limitations include phototoxicity risks from *C. limon*, staining and bioavailability issues with *C. longa*, and formulation stability challenges. Further clinical studies are warranted to validate optimal delivery systems for cosmeceutical applications.

KEYWORDS: This review evaluates the phytochemical constituents and dermatological applications of *Citrus limon* (lemon), *Carica papaya* leaves, and *Curcuma longa* (turmeric) in skin whitening.

INTRODUCTION

Skin whitening is a widespread cosmetic focus worldwide, including the Philippines, where individuals seek a lighter and more uniform skin tone. Hyperpigmentation (excess melanin production), friction, and the accumulation of dead skin cells can induce localized darkening of the skin, particularly on highly mobile regions such as the elbows and knees. Commercial whitening products are often financially prohibitive and can contain hazardous chemical constituents such as mercury (Food and Drug Administration [FDA], 2022), hydroquinone (Serrano et al., 2019), and topical corticosteroids. These substances

are strictly prohibited in cosmetic preparations under the ASEAN Cosmetic Directive due to their capacity to cause severe cutaneous irritation, allergic contact dermatitis, and permanent structural skin damage (FDA, 2023).

Consequently, researchers are actively exploring natural and herbal alternatives. Botanical resources have been utilized in traditional medicine and ethnodermatological skincare for centuries due to their accessibility, favorable safety profiles, and therapeutic efficacy. The present review establishes the scientific framework for a Polyherbal Whitening Cream consisting of combined

extracts from three plants: lemon (*Citrus limon*), papaya (*Carica papaya*) leaves, and turmeric (*Curcuma longa*). Despite individual studies demonstrating the skin-lightening potential of these isolated extracts, there is

limited consolidated data evaluating their combined efficacy and safety when formulated together as a polyherbal oil-in-water (O/W) cream for targeted hyperpigmented regions.

2.1 Botanical Profile	Plant Profile	References
Lemon	<i>Citrus limon</i> , Rutaceae; fruit/juice used; Common name: Lemon; widely cultivated in pH uplands.	Klimek-Szczykutowicz, M., Szopa, A., & Ekiert, H. (2020).
Papaya Leaves	<i>Carica papaya</i> , Caricaceae; young leaves used; Common name: Papaya; abundant in pH lowlands.	Lim, X. Y., Chan, J. S. W., Tan, T. Y. C., Teh, B. P., Abd Razak, M. R. M., Mohamed, S., & Syed Abdul Kadir, S. Z. (2021).
Turmeric	<i>Curcuma longa</i> , Zingiberaceae; rhizome used; Common name: Luyang dilaw, dulaw; grown nationwide.	Guo, X., Chen, Y., Li, W., & Zhang, X. (2025).
2.2 Major Phytochemicals	Constituents	
Lemon	Ascorbic acid/ Vit C, citric acid, hesperidin, eriocitrin, limonene, flavonoids	Klimek-Szczykutowicz, M., Szopa, A., & Ekiert, H. (2020).
Papaya Leaves	Papain, chymopapain, carpaine alkaloid, flavonoids quercetin +kaempferol, Vit. A/C/E	Lim, X. Y., Chan, J. S. W., Tan, T. Y. C., Teh, B. P., Abd Razak, M. R. M., Mohamed, S., & Syed Abdul Kadir, S. Z. (2021).
Turmeric	Curcuminoids: curcumin, demethoxycurcumin, bisdemethoxycurcumin, turmerone oil	Guo, X., Chen, Y., Li, W., & Zhang, X. (2025).
2.3 Extraction Method	Extraction	
	Manual Crude Extraction of Lemon, Papaya Leaves, and Turmeric were used to produce extracts.	
2.4 Quality Control		
Lemon	Ascorbic acid (Vitamin C) key tyrosinase inhibitor + antioxidant activity	Klimek-Szczykutowicz, M., Szopa, A., & Ekiert, H. (2020).
Papaya Leaves	Curcumin, main bioactive for whitening +anti-inflammatory and skin-lightening properties	Lim, X. Y., Chan, J. S. W., Tan, T. Y. C., Teh, B. P., Abd Razak, M. R. M., Mohamed, S., & Syed Abdul Kadir, S. Z. (2021).
Turmeric	Papain/ Total flavonoids, exfoliates + degrades melanin	Guo, X., Chen, Y., Li, W., & Zhang, X. (2025).

3. Dermatological Application Section

3.1 Lemon

Based on a few studies, vitamin C presence in lemon demonstrated notable anti-pigmentary and UV-protective effects, contributing to more even-toned and healthier-looking skin^{18–20}. Vitamin C can interact with copper ions at tyrosinase-active sites, inhibiting the activity of the enzyme tyrosinase, thus reducing melanin formation and making it effective in addressing hyperpigmentation issues such as melasma.

3.2 Turmeric

The present study assessed the effects of curcumin on melanin synthesis, cellular tyrosinase activity, the

expression of melanogenesis-related proteins (microphthalmia-associated transcription factor (MITF), tyrosinase, tyrosinase-related protein 1 and 2 (TRP-1, TRP-2)), and activation of melanogenesis-regulating signals including phosphatidylinositol 3-kinase (PI3K)/Akt/ glycogen synthase kinase 3 (GSK 3 β), extracellular signal-regulated kinase (ERK) and p38 MAPK in human melanocytes.

The results showed that the melanin content and tyrosinase activity, as well as the expression of melanogenesis-related proteins in human melanocytes, were significantly inhibited by curcumin in a dose dependent manner. In addition, PI3K/Akt/ GSK 3 β , ERK

and p38 MAPK were activated by curcumin, while inhibitors attenuated the inhibitory effects of curcumin on melanogenesis. Results suggest that curcumin inhibits melanogenesis in human melanocytes through activation of Akt/GSK 3 β , ERK or p38 MAPK signaling pathways.

3.3 Papaya Leaves

Carica papaya, a tropical fruit rich in phytochemicals, exhibits promising cosmeceutical potential due to its antioxidant, anti-inflammatory, exfoliating, and tyrosinase-inhibiting properties. Key bioactive constituents such as papain, chymopapain, vitamins A, C, and E, flavonoids, phenolic acids, and carotenoids contribute to its depigmenting and skin-renewing effects. Mechanistically, papaya reduces oxidative stress, inhibits melanogenic enzymes (tyrosinase, TRP-1, TRP-2), and promotes epidermal turnover, collectively leading to decreased melanin production and improved skin tone.

3.4 Why Polyherbal is Greater than Single Extract?

According to Parasuraman, S., Thing, G. S., & Dhanaraj, S. A. (2014) Even though the active phytochemical constituents of individual plants have been well established, they usually present in minute amount and always, they are insufficient to achieve the desirable therapeutic effects. For this, scientific studies have revealed that these plants of varying potency when combined may theoretically produce a greater result, as compared to individual use of the plant and also the sum of their individual effect. This phenomenon of positive herb-herb interaction is known as synergism. Certain pharmacological actions of active constituents of herbals are significant only when potentiated by that of other plants, but not evident when used alone.

Due to synergism, polyherbalism confers some benefits not available in single herbal formulation. It is evident that better therapeutic effect can be reached with a single multi-constituent formulation. For this, a lower dose of the herbal preparation would be needed to achieve desirable pharmacological action, thus reducing the risk of deleterious side-effects. Besides, PHFs bring to improved convenience for patients by eliminating the need of taking more than one different single herbal formulation at a time, which indirectly leads better compliance and therapeutic effect (Parasuraman, S., Thing, G. S., & Dhanaraj, S. A. (2014)

3.5 Safety/ Toxicity

Photosensitivity of Lemon

According to Mioduszewski, M., & Beecker, J. (2015), phytophotodermatitis from making sangria: a phototoxic reaction to lime and lemon

Exposure to both ultraviolet light and light-sensitizing botanical substances in certain plants is required for phytophotodermatitis to develop. Erythema, bullae and eventual hyperpigmentation develop after skin becomes photosensitive due to contact with plants or fruits containing furocoumarins and is exposed to UVA

radiation.¹ The lesions can have bizarre shapes and are often painful, not pruritic, and appear only in sun-exposed areas, which helps differentiate the condition from plant-related contact dermatitis.² Common culprits include citrus fruits (lime and lemon), parsnip, fennel, celery, parsley and giant hogweed. Phytophotodermatitis often occurs in the summer, but it can also develop during sun holidays in the winter: the so-called “Mexican beer (or margarita) dermatitis.”

3.6 Staining from Turmeric

Turmeric contains curcumin, the pigment responsible for turmeric’s color and staining power. Curcumin molecules bind to the fibers in clothes, instantly transferring their vivid color; and because turmeric particles are slightly oily, they slip into porous surfaces instead of washing off. Water doesn’t dissolve curcumin, so wiping only spreads the mess. Curcumin attaches even faster when fat is involved, which is basically every time turmeric hits a pan. So, be extra cautious of splatter when simmering turmeric in ghee or oil when whipping up curry or dhal — or in dairy for golden milk. The trouble doesn’t stop at clothing, either. Turmeric stains wood, silicone, plastic storage containers, cutting boards, and even light stone countertops which absorb oil quickly. Once color binds, heat and fat make it even tougher to remove.

3.7 Papain Allergy

Previous studies suggested that papain allergy can occur in both atopic and non-atopic individuals as in our case with an atopic background. Baur et al.³ reported that although 14 out of the 33 workers had occupational exposure to papain, none of them had pre-existing allergic disease. However, Novey et al.¹⁷ demonstrated that atopic workers develop pulmonary symptoms and anti-papain antibodies significantly earlier after papain exposure than did others and that the concentration of papain, rather than the length of the exposure, is the most important factor for the development of clinical symptoms. Workers who have the greatest amount of dust exposure per workday have significantly more pulmonary symptoms.

3.8 Clinical studies each extract (reduction in melanin index)

Protective effects of *Carica papaya* leaf against skin photodamage by blocking production of matrix metalloproteinases and collagen degradation in UVB-irradiated normal human dermal fibroblasts

In the present study, *Carica papaya* leaf was investigated for its skin anti-aging effects in UVB-irradiated normal human dermal fibroblasts (NHDFs). *Carica papaya* leaf significantly suppressed UVB-induced activation of mitogen-activated protein kinases (MAPKs) and activator protein-1 (AP-1) signaling by scavenging reactive oxygen species (ROS) generation. Furthermore, our results indicated that CPL prevented degradation of Type I procollagen by positively modulating

transforming growth factor- β 1 (TGF- β 1) activity and negatively regulating matrix metalloproteinases (MMPs) expression. Thus, the synthesis of Type I procollagen, a major component of the extracellular matrix (ECM) was increased. In addition, a combination of both active compounds suggests they were active compounds of CPL. Taken together, the results suggest that *Carica papaya* leaf is promising for further investigation and development of a cosmetic product for the treatment of various skin conditions, including photoaging and Respiratory Disease (South African Journal of Botany 131 July 2020)

3.9 Curcumin inhibits melanogenesis in human melanocytes

The present study assessed the effects of curcumin on melanin synthesis, cellular tyrosinase activity, the expression of melanogenesis-related proteins (microphthalmia-associated transcription factor (MITF), tyrosinase, tyrosinase-related protein 1 and 2 (TRP-1, TRP-2)), and activation of melanogenesis-regulating signals including phosphatidylinositol 3-kinase (PI3K)/Akt/ glycogen synthase kinase 3 (GSK 3 β), extracellular signal-regulated kinase (ERK) and p38 MAPK in human melanocytes. The results showed that the melanin content and tyrosinase activity, as well as the expression of melanogenesis-related proteins in human melanocytes, were significantly inhibited by curcumin in a dose dependent manner. In addition, PI3K/Akt/ GSK 3 β , ERK and p38 MAPK were activated by curcumin, while inhibitors of these signals attenuated the inhibitory effects of curcumin on melanogenesis. These results suggest that curcumin inhibits melanogenesis in human melanocytes through activation of Akt/GSK 3 β , ERK or p38 MAPK signaling pathways.

4. Formulation Aspects

According to Amanda Caldwell, MSN, APRN-C- written by Kristeen Cherney, and Jessica Timmons (February 14, 2022);

4.1 Absorption

Due to their high-water content, creams are easily absorbed, so they can cover large areas of skin. Their oil content also means they stay on your skin's surface to help protect against moisture loss, which makes them ideal for treating dry skin, rashes, or skin lesions.

4.2 Consistency

These have a smooth texture with a thicker consistency than lotions, which tend to be runnier. They can be non-greasy to mildly greasy.

4.3 Appearance

Because of their oil-to-water ratio, creams tend to be thick enough to maintain their shape whether squeezed from a tube or scooped from a jar. An older 2005 study that obtained scientifically based, systematic classifications for topical drugs described creams as opaque and viscous. which can also work well for dry

skin, may offer a better alternative if you don't want the greasy feel that many oil-based products leave behind. That's especially true with hand creams. While ointments tend to work best for patches of skin, the water contained in creams makes them more useful for widespread use. If you have typical, dry, or sensitive skin, you may find that cream-based moisturizers provide a good level of hydration — though you might prefer to use a lotion during the hot summer months.

4.4 Effect of pulsed light on curcumin chemical stability and antioxidant capacity

Curcumin is the major bioactive component in turmeric with potent antioxidant activity. Little is known about how pulsed light (PL) technology (an emerging non-thermal food processing technology relying on high intensity short duration flashes of light) can affect the chemical stability and antioxidant capacity of curcumin. This study found that PL treatment of fluence levels from 0 to 12.75 J/cm² produced a fluence-dependent reduction in curcumin content. These results paralleled the production of a tentative curcumin dimer, identified as a potential photochemical transformation product. PL-treated curcumin at relatively higher fluence levels decreased chemical-based ORAC and ABTS antioxidant capacity, relative to control ($P < 0.05$). This contrasted the effect observed to increase coincidentally both intracellular antioxidant capacity (e.g., DCFH-DA ($P < 0.05$)) and GSH/GSSG ratio ($P < 0.05$), respectively, in cultured differentiated Caco-2 cells. In conclusion, the application of PL on curcumin results in photochemical transformation reactions, such as dimerization, which in turn, can enhance biological antioxidant capacity in differentiated Caco-2 cells.

The ideal concentration of turmeric, lemon and papaya leaves extract are the following

4.5 Turmeric

Clinical studies report topical curcumin concentrations of 1% to 4% in cream formulations, which demonstrated efficacy for skin conditions with good tolerability (Vaughn AR et al. 2023).

4.6 Lemon

Crude lemon ethanol extract creams have been studied at 5%, 10%, and 20% concentrations in rats, with 10% showing the best protective effect against UVB-induced erythema. For human cosmetics, lemon is used at low concentrations to avoid irritation due to low pH, and the Cosmetic Ingredient Review panel states lemon juice extract is safe (Dewanti et al. 2020).

4.7 Papaya leaves

Topical formulations containing papaya leaves extract have been developed at 5%, 10%, and 15% concentrations for moisturizing stick preparations, with all concentrations showing acceptable physical stability and pH 6 (Marlina D, et al. 2021)

5 Evaluation Parameter

5.1 pH

The pH of the cream was measured using a calibrated digital pH meter at 25°C. Cosmetics cream are ideally formulated at pH 5.0-6.5 to match skin pH and ensure stability (Balan, G. G., et al. 2024).

5.2 Spreadability

Spreadability was assessed by the parallel-plate/extensometric method. 1g of cream was placed between two glass plates and incremental weights applied; spreading diameter was measured and area calculated as $S = \pi r^2$ (Mohammad, S. A., et al. 2024).

5.3 Stability

Accelerated stability testing was performed by storing samples at 4°C, 25°C, and 40°C for 30 days. Physical Changes in color, odor, pH, and phase separation were monitored. Oxidative stability was determined by the induction period using accelerated oxidation (Juncan, A. M., & Rus, L. L. 2018).

5.4 Tyrosinase Inhibition Assay

Tyrosinase inhibition was determined using mushroom tyrosinase (*Agaricus bisporus*) with L-DOPA or L-tyrosine as substrate. Activity was measured spectrophotometrically at 490 nm, and % inhibition calculated relative to control. Kojic acid was used as positive control (Mann, T., et al 2018).

5.5 Melanin Content in B16F10 Cells

B16F10 murine melanoma cells were treated with extracts for 72 h. Cells were lysed with 1N NaOH + 10% DMSO at 80°C for 30 min. Melanin content was quantified by absorbance at 405 nm and normalized to total protein (Jeon H. J., et al. 2023).

Clinical efficacy was evaluated using the modified Melasma Area and Severity Index (mMASI), which assesses area and darkness of hyperpigmentation on forehead, right malar, left malar, and chin. Scores range 0-24 (Pandya, A. G., et al. 2011).

6. Comparison with existing products

The polyherbal combination of lemon, papaya leaves, and turmeric are safer and cost-effective alternatives compared to synthetic whitening agents such as hydroquinone (Serrano, D. R., Gordo, M. J., Matji, A., González, S., Lalatsa, A., & Torrado, J. J., 2019), kojic acid Gopilongo, M. S. (2020), and salicylic acid (Johnson et al., s2025). While synthetic agents are often more potent, they carry significant risks of adverse effects including irritation and harmful side effects, whereas the natural extracts work synergistically through multiple mechanisms such as tyrosinase inhibition Singh, R., Patel, A., & Kumar, V. (2025), exfoliation Manimegalai, K., & Devi, V. (2016), and antioxidant Ebu Bridget, Funmilayo Deborah Ijebor, Isa Shehu (2025). Furthermore, natural ingredients work together gently to lighten the skin by stopping dark pigment

production, removing dead skin cells, and protecting the skin from damage. Since these 3 alternative plants are easy to find and inexpensive in the Philippines, compare the commercial product that can cause irritation and side effects.

When compared to other alternative plants like bearberry, aloe vera, and saffron, they are good for whitening creams but Bearberry does not grow here in the Philippines but you can buy extract or powder in finished product in online or store and it needs to be imported, while saffron is very expensive and hard to find. Although aloe vera is easy to get but its whitening effect is not as strong for whitening (Choi et al., 2019). Because aloe Vera is good for moisturizing (Razia et al., 2021). On the other hand, lemon, papaya leaves, and turmeric are very common, grow everywhere, and are sold at a very low price. Because they are easy to find and cheap, making this cream affordable, yet it still gives very good results for the skin.

7. Challenges and Future directions

Benefits of the three plant extracts by addressing gaps in the present literatures. In addition, future research studies should focus on comprehensive human clinical trials testing the combination of the three extracts for effectiveness and safety especially in specific skin conditions which is currently lacking. Secondly, the Standardization includes the source variability and analytical methods in measuring the accurate concentration of three distinct extracts. In addition, regulatory compliance specifically FDA guidelines should be taken into consideration. Further research is needed to determine the ideal and non-irritating ratio of these extracts. Hence, addressing these gaps will strengthen the dermatological effects and validate the combined efficacy of extracts of Papaya Leaves, Lemon, and Turmeric. These gaps remain unresolved mainly because existing studies focus on one or two plant extracts rather than combining the three extracts. Future studies should include thorough clinical trials to validate the dermatological benefits and applications of combining these three plant extracts as existing studies focuses only on one to two extracts incorporating it in making whitening products. Additionally, future studies should also address the gaps in identifying accurate ratio of distinct extracts, standardization methods, and understand the potential dermatological applications in humans

8. CONCLUSION

This review outlines the phytochemical profiles and dermatological potential of combining lemon, papaya leaves, and turmeric extracts. *Citrus limon* supplies ascorbic acid to inhibit tyrosinase activity alongside antioxidant flavonoids. *Carica papaya* leaves provide proteolytic enzymes (papain and chymopapain) for epidermal exfoliation, supported by the anti-inflammatory action of quercetin. *Curcuma longa* contributes curcumin to downregulate melanogenesis,

along with volatile turmerone oil to enhance skin penetration.

Together, *Citrus limon*, *Carica papaya*, and *Curcuma longa* offer complementary mechanisms—tyrosinase inhibition, enzymatic exfoliation, and antioxidant activity—that support their development as a natural topical treatment for hyperpigmentation. Further *in vitro* and randomized clinical trials are recommended to validate the safety and efficacy of this polyherbal cream in cosmetic applications.

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