



## REGENERATIVE PROPERTIES OF PHARMACEUTICAL CREAMS BASED ON *CARTHAMUS TINCTORIUS* L. EXTRACT: PHARMACOLOGICAL MECHANISMS OF ACTION AND FUTURE PERSPECTIVES

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### Abstract

*Carthamus tinctorius*, commonly known as safflower, has attracted increasing scientific interest due to its diverse pharmacologically active compounds and broad therapeutic potential in topical pharmaceutical formulations. The plant is rich in flavonoids, phenolic compounds, polyunsaturated fatty acids, hydroxysafflor yellow A, and other bioactive constituents exhibiting antioxidant, anti-inflammatory, antimicrobial, and tissue-regenerative activities. In recent years, pharmaceutical creams containing *Carthamus tinctorius* L. extract have emerged as promising candidates for the management of skin injuries, inflammatory dermatoses, burns, chronic wounds, and cosmetic skin regeneration.

The present review aims to summarize current knowledge regarding the regenerative properties of pharmaceutical creams based on safflower extract, with particular emphasis on the pharmacological mechanisms underlying their therapeutic activity and future perspectives for clinical and cosmeceutical applications. Relevant scientific literature published in international databases including PubMed, ResearchGate, Google Scholar, and related pharmaceutical sources was analyzed to evaluate phytochemical composition, formulation characteristics, pharmacological effects, and biomedical applications of safflower-based topical preparations.

The analyzed studies demonstrate that safflower-derived formulations contribute to accelerated wound healing through stimulation of fibroblast proliferation, enhancement of collagen synthesis, promotion of angiogenesis, reduction of oxidative stress, and modulation of inflammatory mediators. Furthermore, the antioxidant capacity of safflower flavonoids plays a critical role in protecting skin tissues from reactive oxygen species-induced cellular damage. Topical creams formulated with safflower extract also exhibit favorable physicochemical stability, skin compatibility, and moisturizing properties, supporting their potential use in pharmaceutical and dermatological practice.

Despite promising experimental and preclinical findings, further standardized clinical investigations remain necessary to establish optimal formulations, dosage parameters, long-term safety, and therapeutic efficacy in humans. Future research should additionally focus on advanced delivery systems, nanoformulations, and synergistic combinations with other bioactive compounds to improve transdermal penetration and regenerative performance. Overall, *Carthamus tinctorius* L.-based pharmaceutical creams represent a перспективный and multifunctional approach in regenerative dermatology and modern topical drug development.

**Keywords**

*Carthamus tinctorius* L.; safflower extract; pharmaceutical cream; wound healing; skin regeneration; antioxidant activity; anti-inflammatory activity; flavonoids; topical formulation; regenerative dermatology.

**Introduction**

*Carthamus tinctorius* L., commonly known as safflower, is an annual medicinal plant belonging to the Asteraceae family and has been traditionally used in Asian and Middle Eastern medicine for the treatment of inflammatory diseases, circulatory disorders, wounds, and skin injuries [1,10]. In addition to its medicinal value, safflower has historically been utilized as a natural dye source and cosmetic plant because of its biologically active pigments and oil-rich composition [1]. In recent years, increasing scientific interest in plant-derived topical therapeutics has stimulated extensive research on safflower extracts and their potential pharmaceutical applications in regenerative dermatology [4,10].

Skin injuries, burns, chronic wounds, and inflammatory dermatological disorders remain major healthcare challenges worldwide. Delayed wound healing is frequently associated with excessive inflammation, oxidative stress, microbial infection, and impaired collagen synthesis. Although synthetic topical agents are widely available, many are associated with adverse effects, allergic reactions, microbial resistance, and limited regenerative efficacy. Consequently, medicinal plants containing multifunctional bioactive compounds have become promising alternatives for the development of safer and more effective topical pharmaceutical formulations [4,6].

Phytochemical investigations have demonstrated that *Carthamus tinctorius* L. contains numerous biologically active constituents including flavonoids, phenolic compounds, alkaloids, lignans, serotonin derivatives, polysaccharides, and polyunsaturated fatty acids, particularly linoleic acid [10,13]. Among the major active compounds, hydroxysafflor yellow A and carthamin have attracted considerable attention due to their potent antioxidant and anti-inflammatory activities [4,7]. Quantitative analyses also revealed a high flavonoid content in safflower extracts, contributing significantly to free radical scavenging activity and cellular protection against oxidative damage [13].

Oxidative stress is considered one of the principal pathological mechanisms involved in tissue injury and delayed wound healing. Reactive oxygen species (ROS) generated during inflammation can damage cellular membranes, proteins, and DNA, thereby impairing fibroblast proliferation and collagen deposition. Several studies have reported that safflower-derived compounds exhibit significant antioxidant properties capable of reducing lipid peroxidation and neutralizing ROS-induced cellular injury [6,10,13]. Furthermore, anti-inflammatory mechanisms associated with safflower extracts include inhibition of pro-inflammatory cytokines and modulation of molecular signaling pathways involved in inflammatory responses [4,7].

Topical pharmaceutical creams remain among the most commonly used dosage forms in dermatological therapy because of their favorable spreadability, moisturizing capacity, patient compliance, and direct local delivery of active compounds. Recent formulation studies have demonstrated that creams containing *Carthamus tinctorius* L. extract possess satisfactory physicochemical stability, suitable pH characteristics, and promising regenerative activity [11]. These formulations may accelerate wound healing through stimulation of fibroblast

proliferation, enhancement of angiogenesis, promotion of epithelialization, and increased collagen synthesis [4,10].

In addition to pharmaceutical applications, safflower-based formulations are increasingly investigated in the field of cosmeceuticals due to their antioxidant, moisturizing, and anti-aging properties [1]. Safflower oil, rich in essential fatty acids, may improve skin barrier function and support tissue regeneration, making it a valuable ingredient for modern dermatological and cosmetic preparations [3].

Despite promising experimental findings, several limitations remain unresolved. Variability in phytochemical composition depending on extraction techniques, cultivation conditions, and plant origin may influence therapeutic efficacy and formulation standardization [10]. Moreover, although numerous *in vitro* and preclinical investigations support the regenerative potential of safflower extract, further clinical studies are required to establish long-term safety, optimal concentrations, and therapeutic effectiveness in humans [5,8].

Therefore, the present review aims to summarize current scientific evidence regarding the regenerative properties of pharmaceutical creams based on *Carthamus tinctorius* L. extract, with particular emphasis on phytochemical composition, pharmacological mechanisms of action, formulation characteristics, and future perspectives in regenerative dermatology and topical drug delivery systems.

### Materials and Methods

A literature review was conducted using scientific databases including PubMed, Google Scholar, ResearchGate, and pharmaceutical journals published between 2010 and 2026. The keywords used for literature retrieval included “*Carthamus tinctorius*”, “safflower extract”, “pharmaceutical cream”, “wound healing”, “skin regeneration”, “antioxidant activity”, and “topical formulation”. Relevant studies focusing on phytochemical composition, pharmacological activity, regenerative mechanisms, and topical pharmaceutical applications of *Carthamus tinctorius* L. were included in the review. Articles unrelated to dermatological or pharmaceutical applications were excluded.

### Discussion

#### Botanical and Phytochemical Characteristics of *Carthamus tinctorius* L.

*Carthamus tinctorius* L. is an annual herbaceous plant belonging to the Asteraceae family and is widely cultivated in Asia, the Middle East, and Mediterranean regions for medicinal, nutritional, and industrial purposes [1,10]. The plant is characterized by branched stems, spiny leaves, and brightly colored yellow-orange flowers rich in biologically active pigments and secondary metabolites. Traditionally, safflower flowers and seeds have been utilized in herbal medicine for the treatment of inflammatory diseases, skin disorders, cardiovascular conditions, and wound healing processes [1,10].

Phytochemical investigations have revealed that safflower contains a wide spectrum of bioactive constituents including flavonoids, phenolic acids, alkaloids, lignans, polysaccharides, serotonin derivatives, fatty acids, and quinone chalcones [10]. Among these compounds, hydroxysafflor yellow A and carthamin are considered major pharmacologically active pigments responsible for antioxidant and anti-inflammatory effects [4,7]. In addition, safflower oil contains high concentrations of polyunsaturated fatty acids, particularly linoleic acid, which contributes to maintenance of skin barrier integrity and tissue regeneration [3].

Flavonoids represent one of the most therapeutically important groups of phytochemicals in safflower extract. Quantitative analyses demonstrated significant concentrations of flavonoid compounds exhibiting potent free radical scavenging activity and reduction of oxidative cellular damage [13]. Phenolic compounds present in safflower also contribute to membrane stabilization, inhibition of lipid peroxidation, and protection against inflammatory tissue injury [6,10]. These biological properties support the application of safflower extract in regenerative topical formulations intended for wound healing and dermatological therapy.

The pharmacological activity of safflower is strongly associated with synergistic interactions among its multiple bioactive constituents. Experimental studies have shown that safflower-derived compounds may regulate inflammatory mediators, improve microcirculation, stimulate fibroblast activity, and enhance collagen synthesis, thereby promoting tissue repair and regeneration [4,10]. Such multifunctional biological activity makes *Carthamus tinctorius* L. a promising medicinal plant for pharmaceutical and cosmeceutical applications.

### Pharmaceutical Cream Formulations Based on Safflower Extract

Topical pharmaceutical creams remain among the most commonly utilized dosage forms in dermatological and regenerative medicine because they allow direct delivery of active substances to damaged tissues while improving patient compliance and therapeutic efficacy. Cream formulations based on *Carthamus tinctorius* L. extract have attracted increasing scientific attention due to their emollient, antioxidant, moisturizing, and anti-inflammatory properties [11].

Most safflower-based pharmaceutical creams are formulated as oil-in-water or water-in-oil emulsions depending on the intended therapeutic application and skin penetration characteristics. Safflower oil, rich in essential fatty acids, serves not only as an active ingredient but also as a natural emollient improving hydration and restoration of epidermal barrier function [3]. Formulation studies demonstrated that creams containing safflower extract exhibit acceptable physicochemical characteristics including homogeneity, spreadability, viscosity, and stability under various storage conditions [11].

The pH of topical preparations plays a critical role in maintaining skin compatibility and minimizing irritation. Studies evaluating safflower-containing creams reported pH values within physiologically acceptable dermatological ranges, indicating good tolerability for topical application [11]. Furthermore, the presence of bioactive flavonoids and phenolic compounds may enhance skin penetration and local pharmacological activity through interaction with epidermal lipid structures.

Viscosity and rheological properties are also essential parameters influencing drug release and patient acceptability. Creams formulated with safflower extract demonstrated suitable consistency and stability, facilitating effective topical administration and prolonged retention on the skin surface [11]. These characteristics support the pharmaceutical potential of safflower-based creams for regenerative dermatology and wound management.

Recent pharmaceutical investigations additionally suggest that incorporation of safflower extract into advanced topical delivery systems such as nanoemulsions and liposomal carriers may improve bioavailability and transdermal penetration of active compounds [5].

Such approaches may further enhance regenerative efficacy and therapeutic performance of safflower-derived formulations.

## **Pharmacological Mechanisms of Regenerative Action**

### **Anti-inflammatory Mechanisms**

Inflammation represents a fundamental physiological response during tissue injury and wound healing; however, prolonged or excessive inflammatory activity may impair regeneration and contribute to chronic skin damage. Bioactive compounds isolated from *Carthamus tinctorius* L. demonstrate significant anti-inflammatory properties through modulation of multiple cellular and molecular pathways [4,7].

Experimental studies revealed that safflower-derived flavonoids and hydroxysafflor yellow A suppress the production of pro-inflammatory cytokines including tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), interleukin-1 $\beta$ , and interleukin-6 [4]. Inhibition of these inflammatory mediators may reduce tissue edema, cellular destruction, and oxidative injury associated with chronic inflammation.

Several investigations additionally demonstrated that safflower compounds may inhibit cyclooxygenase-mediated inflammatory pathways and regulate activation of nuclear factor-kappa B (NF- $\kappa$ B), a key transcription factor involved in inflammatory signaling [7]. Suppression of NF- $\kappa$ B activation contributes to decreased expression of inflammatory enzymes and cytokines, thereby supporting tissue regeneration and wound repair.

The anti-inflammatory activity of safflower extract is particularly important in topical pharmaceutical applications because excessive inflammation frequently delays epithelialization and collagen formation. Therefore, incorporation of safflower-derived compounds into pharmaceutical creams may provide both symptomatic relief and acceleration of regenerative processes [4,10].

### **Antioxidant Activity**

Oxidative stress plays a major role in skin aging, inflammatory tissue injury, and delayed wound healing. Reactive oxygen species generated during pathological conditions may damage cellular proteins, lipids, and DNA, resulting in impaired regeneration and increased tissue destruction [6].

Safflower extract possesses strong antioxidant activity primarily due to its flavonoids, phenolic compounds, and quinone chalcones [10,13]. These compounds effectively scavenge reactive oxygen species and inhibit lipid peroxidation, thereby protecting cellular membranes and maintaining tissue integrity [6,13].

Experimental studies demonstrated that safflower-derived antioxidants may enhance endogenous antioxidant defense systems and reduce oxidative cellular injury [4,10]. Reduction of oxidative stress creates favorable conditions for fibroblast proliferation, angiogenesis, and collagen synthesis during wound healing processes.

Furthermore, antioxidant activity is highly valuable in dermatological and cosmetic applications because ultraviolet radiation and environmental pollutants induce oxidative damage responsible for premature skin aging. Consequently, safflower-containing creams may contribute to skin protection, hydration, and preservation of dermal elasticity [1].

### **Wound Healing and Tissue Regeneration**

Wound healing is a complex biological process involving inflammation, fibroblast proliferation, collagen deposition, angiogenesis, and epithelialization. Several studies have demonstrated that safflower extract positively influences multiple stages of tissue regeneration [4,10].

Bioactive constituents of safflower stimulate fibroblast proliferation and collagen synthesis, both of which are essential for restoration of damaged connective tissue [10]. Increased collagen deposition contributes to improved tensile strength and structural integrity of healing skin tissues.

Safflower-derived compounds may additionally promote angiogenesis through enhancement of local microcirculation and vascular endothelial activity [4]. Improved blood supply facilitates oxygen and nutrient delivery to injured tissues, thereby accelerating regenerative processes and reducing healing time.

Experimental investigations also reported enhanced epithelialization following treatment with safflower-containing formulations [11]. Faster epithelial regeneration contributes to restoration of skin barrier function and protection against microbial invasion. The combined antioxidant, anti-inflammatory, and angiogenic effects of safflower extract therefore support its therapeutic potential in wound management and regenerative dermatology.

### **Antimicrobial Properties**

Microbial infection remains one of the major complications associated with chronic wounds and skin injuries. Several phytochemical constituents of safflower exhibit moderate antimicrobial activity against pathogenic microorganisms involved in skin infections [10].

Phenolic compounds and flavonoids present in safflower extract may disrupt microbial cell membranes and inhibit growth of certain bacteria and fungi [6]. Although antimicrobial activity of safflower is generally weaker than conventional antibiotics, its combination with antioxidant and anti-inflammatory properties may provide additional protection during wound healing processes.

Topical creams containing safflower extract may therefore contribute to prevention of secondary skin infections while simultaneously supporting tissue regeneration and reduction of inflammation [11]. Such multifunctional activity increases the pharmaceutical value of safflower-derived dermatological formulations.

### **Clinical and Cosmeceutical Potential**

The pharmacological properties of safflower extract suggest broad therapeutic potential in both pharmaceutical dermatology and cosmetic science. Topical safflower-based formulations may be useful in the management of burns, chronic wounds, inflammatory skin disorders, diabetic ulcers, and postoperative skin injuries [4,10].

In diabetic wounds, impaired microcirculation and excessive oxidative stress frequently delay tissue repair. Due to its antioxidant and angiogenic activity, safflower extract may improve local blood circulation and accelerate regenerative processes in damaged tissues [7]. These findings support its potential application in chronic wound therapy.

Safflower-derived formulations are also increasingly investigated in cosmeceutical products because of their moisturizing and anti-aging effects [1]. Essential fatty acids present in safflower oil contribute to restoration of epidermal barrier function and maintenance of skin hydration. Additionally, antioxidant compounds may reduce oxidative damage induced by ultraviolet radiation and environmental stressors, thereby helping preserve skin elasticity and appearance.

Modern cosmetic formulations incorporating safflower extract include moisturizing creams, anti-aging products, soothing emulsions, and skin-repair preparations. The natural origin and multifunctional biological activity of safflower compounds make them attractive alternatives to synthetic cosmetic ingredients [1,3].

### Limitations and Future Perspectives

Despite promising pharmacological and regenerative properties, several limitations continue to restrict broader clinical application of safflower-based pharmaceutical creams. One of the major challenges involves variability in phytochemical composition depending on plant origin, cultivation conditions, extraction methods, and storage parameters [10]. Such variability may influence therapeutic efficacy and complicate standardization of pharmaceutical formulations.

Another important limitation is the insufficient number of large-scale clinical trials evaluating long-term safety and effectiveness of safflower-derived topical products in human subjects [5]. Although numerous *in vitro* and preclinical studies demonstrate positive regenerative activity, further randomized clinical investigations remain necessary before widespread therapeutic implementation.

Future pharmaceutical research should focus on development of advanced delivery systems capable of improving stability, bioavailability, and skin penetration of safflower bioactive compounds. Nanoemulsions, liposomal carriers, hydrogels, and transdermal systems represent promising approaches for optimization of topical therapeutic efficacy [5,8].

In addition, synergistic combinations of safflower extract with other medicinal plant compounds, peptides, or biomaterials may further enhance regenerative performance and broaden clinical applicability. Personalized topical therapy based on patient-specific dermatological conditions may also represent an important future direction in regenerative medicine and pharmaceutical dermatology.

Overall, existing evidence suggests that *Carthamus tinctorius* L.-based pharmaceutical creams possess significant therapeutic potential as multifunctional regenerative formulations combining antioxidant, anti-inflammatory, wound healing, and skin-protective activities.

### Conclusion

*Carthamus tinctorius* L. represents a promising medicinal plant with considerable potential for the development of regenerative pharmaceutical creams and modern topical therapeutic formulations. The rich phytochemical composition of safflower, including flavonoids, phenolic compounds, hydroxysafflor yellow A, carthamin, and essential fatty acids, contributes to its diverse pharmacological properties such as antioxidant, anti-inflammatory, antimicrobial, and wound healing activities [4,10,13].

The analyzed studies demonstrate that safflower-based topical formulations may accelerate tissue regeneration through multiple biological mechanisms including suppression

of inflammatory mediators, reduction of oxidative stress, stimulation of fibroblast proliferation, enhancement of collagen synthesis, promotion of angiogenesis, and acceleration of epithelialization [4,7,10]. In addition, safflower-containing pharmaceutical creams exhibit favorable physicochemical properties, acceptable skin compatibility, and significant moisturizing potential, supporting their suitability for dermatological and cosmeceutical applications [11].

Current evidence suggests that safflower-derived creams may be beneficial in the management of burns, chronic wounds, inflammatory skin disorders, diabetic ulcers, and age-related skin damage. Furthermore, the natural origin and multifunctional therapeutic activity of safflower compounds make them attractive alternatives to synthetic topical agents frequently associated with adverse effects and limited biocompatibility [1,3].

Nevertheless, despite encouraging experimental and preclinical findings, further standardized clinical investigations remain essential to establish optimal formulations, dosage parameters, long-term safety, and therapeutic efficacy in human subjects [5,8]. Future research should additionally focus on advanced pharmaceutical technologies including nanoformulations, liposomal systems, and transdermal delivery approaches capable of enhancing bioavailability and regenerative performance of safflower bioactive compounds.

Overall, pharmaceutical creams based on *Carthamus tinctorius* L. extract represent a scientifically promising and multifunctional strategy in regenerative dermatology and topical drug development, with significant future potential for both pharmaceutical and cosmetic applications.

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