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# Review on Ferulic Acid in Cosmeceuticals

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***Abstract***

*Ferulic acid is low in toxicity and possesses a variety of physiological qualities, including anti-inflammatory, antioxidant, antibacterial, anticancer, and antidiabetic effects. Science has demonstrated that ferulic acid, a potent antioxidant, has beneficial benefits on skin care. In addition to preventing pigmentation and whitening the skin, ferulic acid also prevents acne. Ferulic acid which is a strong natural antioxidant is necessary in protecting the skin against oxidative stress caused by the free radicals. It suppresses the total oxidative injury as it is a free radical scavenger and an inhibitor of significant enzymes which generate reactive oxygen species. Also, ferulic acid enhances the numbers of scavenger enzymes and activates endogenous antioxidant defense system in the body by improving cellular defense.*

**Keywords:** Ferulic acid, antioxidant, skin care, UV protection, cosmeceuticals

## INTRODUCTION

Ferulic acid has many physiological properties, such as anti-inflammatory, antioxidant, antibacterial, anticancer, and antidiabetic actions. It is very low in toxicity [1]. Ferulic acid are many types of secondary metabolites with different chemical and biological characteristics. The majority of the plants are discovered bonded together as hydrolysis tannins, lignin components, and ester or glycosides [2, 3]. Chemically speaking, they may be separated into phenolic acids of peculiar nature and derivatives of benzoic and cinnamic acid, which differ in the quantity and replacement of hydroxyl and methoxy groups. The depside, a mixture of two or more phenolic acids, is an extra group [2]. Ferulic acid is the most prevalent derivative of cinnamic acid, along with caffeic, p-coumaric, synapine, syryte, and vanillin acids [3].

Sources of ferulic acid found in variety of functionals food such as tomatoes, citrus fruits, wheat, rice, soyabeans, oats, fruits and barley [4]. FA has been shown to significantly protect skin from UV-induced oxidative stress [5]. FA has been demonstrated in multiple studies to reduce the breakdown of collagen fibres and to inhibit the expression of cytotoxic and inflammation-associated matrix metalloproteinases [6, 7]. one common flavonoid polyphenolic found in vegetables, i.e., ferulic acid [8]. It also has a pharmaceutical property that includes antioxidant [9]. Anti-inflammatory [10] and anti-tumour [11] effect. An essential component of the plant cell wall both biologically and structurally is ferulic acid. Because of its capacity to halt radical chain reactions by polymerization and resonance. After UV radiation protection, FA is in charge of cross-linking other cell wall polymers, such as polysaccharides [12]. Whole grains, spinach,

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parsley, grapes, rhubarb, and cereal seeds-primarily those of wheat, oats, rye, and barley–are the most prevalent sources of ferulic acid. The antioxidant activity of phenolic acids, particularly cinnamic acid derivatives, is one of its most significant roles. This activity is largely dependent on the quantity of hydroxyl and methoxy groups that are connected to the phenyl ring [3, 13]. Compared to other phenolic acids, ferulic acid enters the body more readily and remains in the bloodstream for a longer period of time. It is believed that ferulic acid is a better antioxidant [14]. Ferulic acid which is low-toxic, multifaceted in its physiological effects, has been shown to have antidiabetic, immunostimulant, anti-inflammatory, anticancer (against lung, breast, colon, and skin cancer), antiarrhythmic and antithrombotic activity.

## PROPERTIES OF FERULIC ACID

The phenolic acid group, which is frequently present in plant tissues, includes ferulic acid ([E]-3-[4-hydroxy-3-methoxy-phenyl] prop-2-enoic acid) (Figure 1) [15]. Secondary metabolites with different chemical structures and biological characteristics are called phenolic acids. The majority of the plants are discovered bonded together as hydrolysis tannins, lignin components, and ester or glycosides [16, 17].

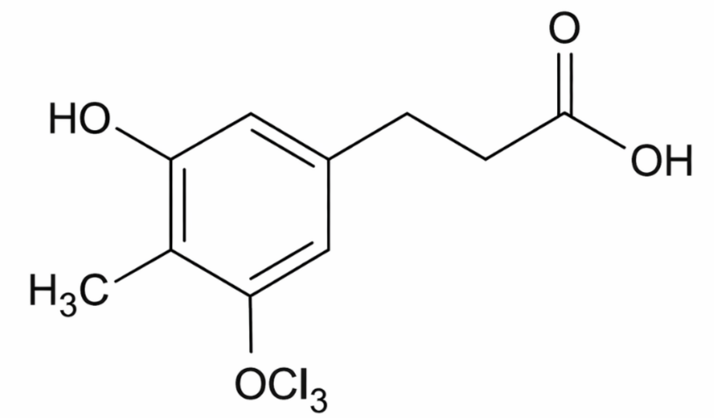


**Figure 1.** Structure of ferulic acid ([E]-3-[4-hydroxy-3-methoxy-phenyl] prop-2-enoic acid).

They are chemically classified as amendments of the cinnamic and benzoic acid, which alter in the quantity and replacement of the hydroxyl and methoxy groups, and uncommon phenolic acids. The depside, a mixture of two or more phenolic acids, is an extra group [16]. Ferulic acid is the most prevalent derivative of cinnamic acid, along with caffeic, p-coumaric, synapine, syryte, and vanillin acids [17]. Whole grains, spinach, parsley, grapes, rhubarb, and cereal seeds–mostly those of wheat, oats, rye, and barley–are the most prevalent sources of folic acid (Table 1).

**Table 1.** Sources of ferulic acid.

| Source | Details |
|---|---|
| Whole Grains | Wheat, oats, rye, barley. |
| Fruits | Tomatoes, citrus fruits. |
| Vegetables | Spinach, parsley, rhubarb. |
| Seeds | Cereal seeds, especially those of wheat, oats, rye, and barley. |
| Other | Soybeans, rice, and barley. |

The antioxidant activity of phenolic acids, particularly cinnamic acid derivatives, is one of its most significant roles. This activity is largely dependent on the quantity of hydroxyl and methoxy groups that are joined to the phenyl ring [17, 18]. Compared to other phenolic acids, ferulic acid enters the body more readily and remains in the bloodstream for a longer period of time. It is believed that ferulic acid is a better antioxidant [19]. With low toxicity and a wide range of physiological effects, ferulic acid has been shown to have antidiabetic effects, immunostimulant qualities, anti-inflammatory, antimicrobial, anticancer (including lung, breast, colon, and skin cancer), anti-arrhythmic, and antithrombotic activity. It also lessens damage to nerve cells and may even be able to repair broken cells. It is also a sports supplement as it reduces muscular fatigue by neutralising free radicals in muscle tissue. additionally it is frequently used as a photoprotective agent (sunscreen), a skin photoaging process delayer, and a brightening ingredient in skin care products. However, because of its propensity to oxidise quickly, its usage is restricted [17, 19–21]. It is extensively used in food and pharmaceuticals

Antioxidant properties of ferulic acid has a complicated antioxidant activity mechanism that is mostly dependent on the prevention of the synthesis of nitrogen or reactive oxygen species (ROS), as well as the "sweeping" or neutralisation of free radicals. Furthermore, this acid is in charge of chelating protonated metal ions as Fe (II) and Cu (II) [22, 23]. In addition to being a free radical scavenger, ferulic acid also increases the activity of scavenger enzymes and inhibits the enzymes that generate free radicals. Its chemical structure has a direct bearing on it [17, 24–40]. Its antioxidizing effects are mainly associated with binding transition metals like iron and copper, scavenging free radicals, and preventing lipid peroxidation. Ferulic acid's capacity to create stable phenoxy radicals through the interaction of the radical molecule with the antioxidant molecule is the mechanism behind its antioxidative activity. This makes it challenging to start a complicated chain of events that produces free radicals. This substance may also function as a hydrogen donor, providing the radicals with atoms directly. This is especially crucial for preventing undesirable autoxidation processes from affecting the lipids in cell membranes. Ferulic acids and similar chemicals have the ability to bind transition metals and act as a secondary antioxidant, like copper and iron [27]. By doing this, harmful hydroxyl radicals are prevented from forming, which stops cell membrane peroxidation [28].

Free radicals may also be formed through natural human physiological processes, such as cell respiration process. These xanthine oxidase and cyclooxygenase-2 are two examples [29]. It has been proposed that blocking this enzyme might stop the oxidative stress-related alterations, such as photophobia [30]. Research from the literature indicates that ferulic acid and its derivatives are very effective at lowering the activities of cyclooxygenase and xanthine oxidase. Ferulic acid is consequently thought to lessen the quantity of ROS generated by the enzyme-catalysed transition [31].

Other properties of ferulic acid are:

- Ferulic acid is also known as 4-hydroxy-3-methoxycinnamic acid, is phenolic compound with chemical formula $C_{10}H_{10}O_4$.
- It is usually found in the cell walls of plants such as grains, fruits, and vegetables, and particularly in seeds and leaves.
- *Antioxidant Properties:* ferulic acid exhibit strong antioxidant activity, which help in neutralising free radical and preventing oxidative damage to cell and tissues.
- *UV Protection:* it has been shown to provide photo protection against UV radiation. Making it a common ingredient in skin care products and sun screens.
- Ferulic acid has anti-inflammatory properties which alleviates inflammation related conditions.
- Havin cosmetic applications, anti-diabetic properties, neuroprotective effects and also having properties of wound healing.

**Uses of Ferulic Acid**

Because of its antioxidant qualities, ferulic acid is a common component in skincare products including serums and creams. Additionally beneficial for shielding skin against UV rays, delaying the ageing process, and encouraging a more youthful complexion. In order to strengthen hair follicles and stop hair breakage, it also included hair care products such shampoos and conditioners, which prevents the health of the hair as a whole. It is used as a food preservative to extend the shelf life of products by inhibiting oxidative deterioration and spoiling because of its inherent antioxidant capability. Because it has qualities that promote health, it is also employed in functional foods.

 

## Ferulic Acid as an Antioxidant Against Negative UV Influence

Impact Particularly vulnerable to UV-induced oxidative damage are fibroblasts and keratinocytes. Lipid peroxidation, amino acid nitration, and even DNA changes are some of the ways that ROS harm cells and ultimately cause cell death. Comparing ferulic acid to different skin structures and skin cells, it demonstrates protective antioxidant characteristics. Human endothelial cells and keratinocytes treated to ferulic acid prior to irradiation are significantly less vulnerable to UVA-induced free radical damage, as demonstrated by Pluemsamran and collaborators [32]. It is thought that fibroblasts experience higher oxidative stress from UVA exposure than do keratinocytes, which are exposed to UVA just superficially. Ferulic acid administered before to UVA radiation exposure greatly reduced its detrimental effects, according to the human fibroblast test. It controls the expression of UV-induced changes in the cell cycle and DNA damage prevention. genes involved in DNA repair. Hahn and associates [33] have demonstrated that fibroblasts treated with ferulic acid following UVA irradiation produce intracellular ROS generation that is almost two times lower. Similar outcomes have been noted in UVB-exposed fibroblasts, such as defence against free radical damage. In their study, Ambothi and Nagarajan [34] showed how ferulic acid, administered to cells 30 minutes before UVB exposure, can be protective. Cytotoxicity, lipid peroxidation, DNA modification, antioxidant enzyme decline, and decreased ROS generation have all been found in comparison to cells not exposed to antioxidants. Given that UVB-induced ROS are one of the major causes of skin cancer growth, ferulic acid has been shown to be a promising anticancer agent since it is known to diminish their levels [20]. In an additional investigation using human fibroblasts, ferulic acid demonstrated its efficacy in shielding heat shock proteins from the deteriorating effects of hydrogen peroxide. Because of this, the experiment using cells treated before UV irradiation demonstrated noticeably higher cell survival and less ROS-induced damage. Comparing it to the ferulic acid experiment, it has been demonstrated to be closely associated with noticeably higher amounts of defensive heat shock proteins [35]. UVB radiation-induced MMP-2 and MMP-9 activation results in photo saturation and the start of photocancerogenesis processes [36]. Ferulic acid can effectively stop these processes when applied shortly after UVB radiation exposure, as demonstrated by Staniforth et al. [37]. Research done using mice shown a 37- and 83%-fold drop in MMP-2 and MMP-9 activity, respectively, in comparison to the group not treated to antioxidants [37]. In comparison to individuals treated without antioxidant, ferulic acid given before to radiation produces less cytotoxicity, less activation of MMP-1 matrix metalloproteinases, and the formation of ROS. Additionally, in the probe containing ferulic acid, the levels of endogenous antioxidants, glutathione and catalase, decreased less and recovered more quickly. In addition to its ability to scavenge free radicals, the antioxidant under test demonstrated efficacy in safeguarding the intracellular antioxidant system [32]. Ferulic acid has proven to be highly effective in preventing $H_2O_2$-induced damage in human embryonic kidney cells, according to research by Bian and colleagues [38]. Application of ferulic acid increased the levels of antioxidant enzymes (superoxide dismutase and catalase) and cell viability prior to exposure to $H_2O_2$. It has been shown that the body's negative oxidative stress-related effects, including the breakdown of collagen, can be avoided by using natural antioxidants such ferulic acid [24].

In their investigation on human fibroblasts, Kawaguchi et al. [39] shown that free oxygen radicals are the primary source of elastosis, or the accumulation of trophoblastic aggregates in the skin reticular layer. Tropoelastin mRNA expression was shown to significantly increase in the cells exposed to ROS. The fibroblasts' reduction of this process was given catalase treatments, also known as free radical scavengers. Based on this, the authors propose that ferulic acid and other antioxidants might be used to stop the undesirable elastosis phenomena [39, 40].

## Angiogenesis Effect

Based on current understanding, ferulic acid is thought to influence the function of the primary players in angiogenesis, such as vascular endothelial growth factor (VEGF), hypoxia-inducible factor 1 (HIF-1), and platelet-derived growth factor (PDGF). Using human umbilical vein endothelial cells, Lin and colleagues' study [41] demonstrated that ferulic acid increases the quantity of hypoxia-induced HIF-1, which causes hypoxia-responsive reactions, and improves the production of VEGF and PDGF.

 

Based on data from both in vivo and in vitro experiments, the authors think ferulic acid is a useful agent that stimulates the growth of new blood vessels [41, 42].

**Regeneration or Wound Healing Effect**

Ferulic acid has been shown in an experiment using diabetic rats to speed up wound regeneration and healing. After four days, the percentage of rats receiving ferulic acid ointment showed wound contractions at 27%, compared to the group that did not get it. After four days, only 14% of the total was given. Rats given ferulic acid treatment recovered almost entirely (96%) after 16 days. After 16 days, 83% of the wounds in the control group that used an ointment standardised to treat difficult-to-heal lesions with 1% soframycin had healed. In comparison to the control group, the ferulic acid group also saw a quicker initiation of granulomas and a faster rate of epithelialization [43]. In a related investigation, Ghaisas and colleagues [44] noted an association with enhanced epithelialization and quicker wound shrinkage enhanced production of hydroxyproline and hydroxylysine, two important amino acids involved in wound healing and the building blocks of collagen, in the skin of diabetic rats treated with ferulic acid. Furthermore, it has been demonstrated that applying ferulic acid ointment to the wound during healing inhibits lipid peroxidation and raises glutathione, catalase, and superoxide dismutase. According to the authors, this phenomenon also considerably quickens the wound's healing process [44].

**The Use of Ferulic Acid in Cosmetology and Aesthetic Dermatology**

One of the key concerns in modern aesthetic medicine and cosmetology is the prevention of skin ageing processes. defence against environmental influences such air pollution, UV exposure, and free radical scavenging has a significant impact. Ferulic acid is one of the substances with demonstrated antioxidative efficaciousness. Its first application was as a stabiliser of other well-known antioxidants like vitamin C and vitamin E in cosmetics. However, research indicates that this chemical is utilised as an active component in addition to being an extra compound antioxidant quality that bolster the body's own antioxidant defence mechanisms. As a result, ferulic acid, which is utilised in antiaging cosmetic compositions, has a protective effect for the primary skin structures (keratinocytes, fibroblasts, collagen, and elastin). It is also used in anti-blemish cosmetic compositions because of its capacity to inhibit tyrosinase, the primary enzyme involved in melanogenesis.

Because it inhibits tyrosinase activity, an enzyme involved in melanogenesis, and melanocytic proliferation, ferulic acid is utilised in skin-lightening preparations [45, 46]. UV (290–320 nm) is absorbed by ferulic acid, according to Staniforth et al. [37]. Ferulic acid can be used with other substances that also have a brightness effect to enhance the lightening impact, but by other procedures like niacinamide, which prevents melanosomes from moving from melanocytes to keratinocytes. Ferulic acid was shown to have improved benefits when lipohydroxycarbons, a keratolytic agent, was added, according to Saint-Leger et al. [47].

Ferulic acid is frequently used in skin care formulas as a photoprotective and skin photoaging process delayer. Because it maintains a high local concentration and a low cutaneous concentration, its use as a topical antioxidant has grown in importance as a method of delivery metabolism [48]. Furthermore, both dissociated and non-dissociated local ferulic acid permeate deeply into the skin at neutral and acidic pH [48]. The penetration of soluble ferulic and caffeic acids in saturated aqueous solutions (pH 3 and pH 7.2) via a human skin incision in Franz cells et al [49]. It was discovered that these acids may pass through the stratum corneum at any pH. Ferulic acid's somewhat greater penetration capability was observed, and this was explained by the known higher that acid's lipophilicity. Studies on phenolic antioxidants have demonstrated that ferulic acid enhances the photoprotective qualities of α-tocopherol and L-ascorbic acid by improving their chemical stability.

Ferulic acid finds application in the manufacturing of moisturising, protecting, and antioxidant creams and lotions, as well as in face masks. For this kind of cosmetic product, an acid content of 0.5 to 1% is advised. Medical cosmetology and aesthetics salons also employ ferulic acid. It is most frequently used in conjunction with hyaluronic acid and vitamins C at a concentration of 12%. Chemical peels, microneedling and non-needle mesotherapy, and grooming treatments all involve the use of fermentic acid. Ferulic acid is indicated for the treatment of acne, seborrhoeic skin, hyperpigmentation (melasma), and ageing and photoaging of the skin, overall the formulation of ferulic acid used in skin care application [50].

## CONCLUSION

Thus far, research has demonstrated the potent antioxidant qualities of ferulic acid, which are linked to both its prevention of melanogenesis and its protective function for cellular structures. It is mostly used to prevent photostage in cosmetic preparations, where its use is growing. It also aids in the reduction of fine lines and pre-existing discolouration. Ferulic acid is a substance that is being utilised in cosmetics more and more due to its good skin penetration, compatibility with a wide range of formulae, and ability to stabilise other components.

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