REVIEW

Ferulic Acid Use for Skin Applications: A Systematic Review

by JENNIFER ROUX, BS; LUKE HORTON, MD; ARASH BABADJOUNI, DO; COLIN M. KINCAID, MD; and NATASHA ATANASKOVA MESINKOVSKA, MD, PhD

Ms. Roux is with the University of California Irvine School of Medicine in Irvine, California. Drs. Horton, Babadjouni, Kincaid, and Mesinkovska are with the University of California Irvine, Department of Dermatology in Irvine, California. Dr. Babadjouni is also with Midwestern University, Arizona College of Osteopathic Medicine in Glendale, Arizona.

J Clin Aesthet Dermatol. 2025;18(4):38–42.

OBJECTIVE: Ferulic acid (FA) is gaining popularity in skincare products for its antioxidant and anti-inflammatory properties. However, its effectiveness and optimal use in humans require critical evaluation. This study aims to review the use of topical FA in skincare. **METHODS:** A search of PubMed and Cochrane using keywords related to skin effects and ferulic acid was conducted. Studies involving human subjects from January 1983 to June 2023 were included. **RESULTS:** Eighteen human studies have investigated the efficacy of FA in various cutaneous conditions, demonstrating effectiveness in enhancing one or more aspects such as skin erythema, pigmentation, hydration, elasticity, and texture. FA proved effective both alone and in combination with other active ingredients, and in subjects with and without dermatologic diagnoses. **LIMITATIONS:** The main limitations of this review include small sample sizes, limited diversity in study populations (Fitzpatrick skin types), a lack of robust randomized controlled trials, and varying compositions of formulations across studies which make it challenging to isolate FA's specific contributions. **CONCLUSION:** Existing literature supports the effectiveness of FA-containing formulations in reducing skin erythema, hyperpigmentation, and signs of aging in adults. Further studies are warranted to better understand and characterize FA's efficacy and mechanisms in treating skin conditions. **KEYWORDS:** Ferulic acid, skin, erythema, pigmentation, anti-aging, topical

The rising popularity of ferulic acid (FA) in skincare stems from its promising therapeutic potential. As a phenolic phytochemical present in plants, FA plays a crucial role in scavenging free radicals and chelating metals. Additionally, it modulates tyrosine kinase activity, signal transduction pathways, and interleukin production, particularly in inflammatory processes.[1,2] Preclinical research underscores the capacity of FA to mitigate UV radiation damage, promote wound healing, and alleviate various inflammatory skin conditions.[3] Given its wide availability, cost-effectiveness, and minimal side effects, FA has emerged as a highly coveted supplement in skincare routines.[2] This review provides a comprehensive evaluation of FA's benefits and potential drawbacks, marking a significant contribution to the current understanding of its dermatological applications.

METHODS

A primary literature search was conducted using the PubMed and Cochrane databases using search terms (skin OR skin effects OR skin pigmentation OR photoaging OR skin integrity) AND (ferulic acid) between January 1983 and June 2023. The resulting articles were screened by two independent reviewers and only clinically relevant randomized controlled trials (RCT), cohort studies, cross-sectional studies, case reports, observational studies, case series, and retrospective studies in human subjects were included. Review articles, non-English language articles, and animal studies were excluded.

RESULTS

The search identified 211 articles, of which 18 met the inclusion criteria, comprising a total of 443 patients (Figure 1). Detailed data including study designs, patient demographics, types of intervention, and outcomes was extracted and analyzed (Table 1). The studies evaluated FA's effect on skin erythema (n=13), pigmentation (n=9), hydration (n=7), elasticity (n=6), and texture (n=6).

Erythema and photoprotection. For erythema and photoprotection, multiple studies explored FA's efficacy. Four randomized controlled trials (RCTs) examined topical antioxidant blends containing FA, L-ascorbic acid (AA), and dl-α tocopherol before UV exposure. These studies consistently demonstrated significant reductions in UV-induced erythema compared to vehicle controls across different minimal erythema doses (MEDs).[4–7] In one study, subjects (n=10; Fitzpatrick skin types (FST) II–III) applied a serum containing 10% L-ascorbic acid (AA), 2% phloretin, and 0.5% FA for four days before receiving UV irradiation (MED). Colorimetry analysis demonstrated erythema reduction in serum-treated areas in comparison to vehicle controls ($p<0.01$).[4] The other three RCTs used 15% AA, 1% dl-α tocopherol, and 0.5% FA serum, with similarly decreased UV-induced erythema in patients with FST II–IV ($p<0.05$).[5–7]

Two cohort studies utilizing FA via occlusive patches before or after UV irradiation also reported significant decreases in erythema indices compared to controls (n=18; FST II–III).[8,9] In another study, a formulation combining FA with two UV filters showed reduced erythema intensity compared to UV filters alone, as measured by laser doppler flowmetry (n=13; FST II-IV, $p<0.05$).[10] However, FA containing serum (0.5% FA, 15% AA, and 1% dl-α tocopherol) did not significantly reduce post-procedure erythema following Q-switched Nd:YAG (QSNY) laser treatment.[11,12] Similarly, there was no improvement in melasma patients with 20%

FUNDING: No funding was provided for this article.
DISCLOSURES: The authors declare no conflicts of interest relevant to the content of this article.
CORRESPONDENCE: Natasha Atanaskova Mesinkovska, MD, PhD; Email: natashadermatology@gmail.com

azelaic acid (AzA) and 2% FA serum after six months.[13]

Three cohort studies evaluated FA peels for treating photodamaged skin, demonstrating significant reductions in erythema immediately post-treatment and at one-month follow-up compared to baseline.[14–16] The effectiveness of 14% FA peels alone and with microneedle therapy on decreasing EI was demonstrated with mexameter measurements ($p<0.001$); the reduction was more pronounced with microneedling (n=16; FST II-III; $p<0.01$).[14,16] Both 14% FA peel and 14% FA + 12% AA peels reduce erythema (n=20; FST II-III; $p<0.001$); but adding AA did not show greater benefit.[15]

Pigmentation. Nine studies investigated the use of FA to reduce skin pigmentation. One RCT demonstrated the efficacy of topical 0.5% FA, 15% AA, and 1% dl-α tocopherol serum as an adjunct to QSNY laser treatment in melasma patients. Following full-face laser, daily FA treatment for two weeks reduced melanin index (MI) on spectrometry ($p<0.05$).[12] In an RCT by Mazurek et al[13] RCT, mexameter measurements showed that 20% AzA and 2% FA combination serum reduced mean pigment level by 35.5 units (scale 0–99) within hyperpigmented lesions after six months ($p<0.001$). In a single-blinded pilot study, daily use of 5% AA + 0.5% FA serum in women with facial hyperpigmentation (n=20; FST I-III) decreased pigment intensity after one month ($p=0.01$).[17] Mexameter results from the three cohort studies using 14% FA peel to treat photodamage demonstrated reduced melanin levels immediately and one month after the eight-peel series ($p<0.05$).[14–16] Neither microneedling nor the addition of AA conferred further benefits.[14,15]

In Huma et al's[11] RCT, melanin level in subjects without hyperpigmentation (n=13) was measured using mexameter before and after three months of treatment with ME. ME showed an eightfold decrease in baseline melanin content and a significant reduction in melanin when compared with placebo ($p<0.05$). A controlled single-blinded cohort (n=16; FST III-IV) found that daily treatment with encapsulated and free 5% FA creams reduced melanin content by 11.43 percent and 5.69 percent, respectively, at one month ($p<0.05$).[18] Another cohort study (n=30) used mexameter to evaluate the effects of 0.5% FA, 1.5% γ-oryzanol, and 1.5% phytic acid gel and cream. After 28 days of treatment, both gel and cream reduced melanin levels compared to baseline and no treatment ($p<0.05$).[19]

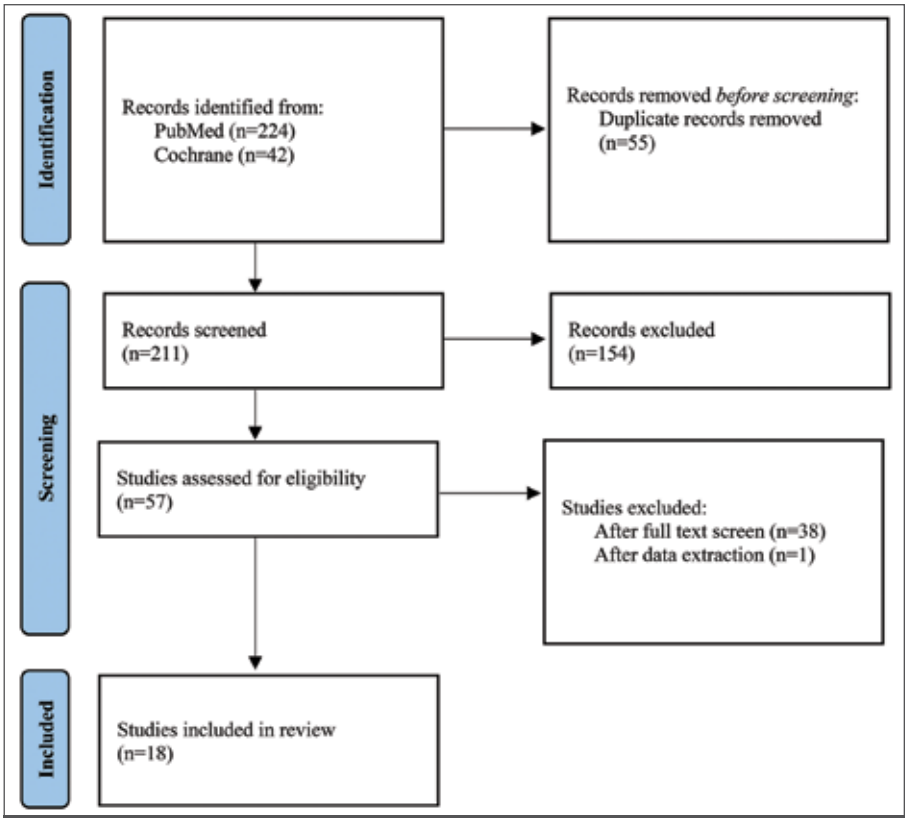

FIGURE 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram

Hydration. Seven studies evaluated the effect of FA on skin hydration. In the RCT using 20% AzA and 2% FA serum, corneometer results demonstrated a mean decrease in skin hydration of 15.1 U after six months of treatment compared to baseline ($p<0.001$).[13] In a pilot study by Milani et al,[17] there was a 19-percent decrease in transepidermal water loss after one month of treatment with 5% AA and 0.5% FA serum ($p=0.002$).[17] Manosroi et al[19] evaluated skin hydration before and after treatment with a gel and cream combination containing 0.5% FA, 1.5% γ-oryzanol, and 1.5% phytic acid. Results from corneometer measurements showed an eightfold and ninefold increase in skin hydration after gel and cream treatments, respectively, compared to baseline ($p<0.05$), and a significant increase compared to untreated control ($p<0.05$).[19]

FA peel treatments alone and in combination with microneedling were also found to significantly increase skin hydration immediately after completing eight peel sessions, with sustained improvements observed one month later ($p<0.001$).[14] Similarly, in another study comparing FA peel to FA+AA peel, both treatments demonstrated substantial increases in skin hydration immediately and one-month post-peel compared to baseline ($p<0.001$); the addition of AA did not provide additional benefit.[15]

Elasticity. Six studies evaluated the effects of FA on skin elasticity. In one RCT (n=82), application of microneedle patches containing FA (0.003mg) and hyaluronic acid (HA, 4.5mg) two times per week for six weeks resulted in increased skin elasticity for 78 percent of patients.[20] Another RCT by Huma et al[11] demonstrated a significant ninefold increase in skin elasticity after 12 weeks of treatment with a formulation containing FA compared to baseline and placebo ($p<0.05$), as measured by elastometer. In a cohort study evaluating encapsulated and free-form 5% FA creams, skin elasticity measurements with a cutometer increased by 11.29 percent and 7.81 percent from baseline, respectively.[18] In contrast, combination 0.5% FA, 1.5% γ-oryzanol, and 1.5% phytic acid gel and cream showed

TABLE 1. Summary of the studies included in this review

STUDY	STUDY DESIGN	PATIENTS (N)	PATIENT CHARACTERISTICS	FA TYPE, DOSE, DURATION	MAIN FINDINGS
Oresajoet al[4]	Randomized, vehicle-control	10	F/M, age 18–60 years, FST II–III	Serum 10% AA, 0.5% FA and 2% phloretin, daily x 4 days	Protected against UV-induced erythema ($p<0.01$).
Murray et al[5]	Randomized, vehicle-control	9	F/M, age 18–65 years, FST II–III	Serum 15% AA, 1% dl-α tocopherol and 0.5% FA, daily x 4 days	Protected against UV-induced erythema ($p<0.01$).
Addor et al[6]	Randomized, double-blind, vehicle-control	10	F/M, age 18–60 years	Serum 15% AA, 1% dl-α tocopherol and 0.5% FA, daily x 4 days	Protected against UV-induced erythema ($p<0.05$).
Wu et al[7]	Randomized, vehicle-control	12	F, age 18–60 years, FST III–IV	Serum 15% AA, 1% dl-α tocopherol and 0.5% FA, daily x 4 days	Protected against UV-induced erythema ($p<0.05$).
Mancuso et al[8]	Prospective, controlled	12	F/M, age 26–36 years, FST II–III	Multiple emulsion 0.2% FA, HTC	Pre- and post-treatment attenuated UV-induced erythema ($p<0.05$).
Saija et al[9]	Prospective, controlled	6	F/M, age 22–40 years, FST II–III	Solution FA 200µl, HTC	Protected against UV-induced erythema ($p<0.01$).
Sauce et al[10]	Randomized, controlled	13	F/M, age 18–70 years, FST II–IV	Emulsion 5% ethyl-hexyl triazone, 10% bemotrizinol and 1% FA, occlusive patch x 2 hours	Mitigated erythema induced by methyl nicotinate ($p<0.05$).
Huma et al[11]	Randomized, single-blind, placebo-control	13	F, age 20–40 years	Multiple emulsion 5% niacinamide and 0.5% FA, daily x 12 weeks	Improved erythema, melanin, hydration, and elasticity ($p<0.05$).
Kim et al[12]	Randomized, single-blind, split-face control	18	F with hyper-pigmentation, age 26–53 years, FST II–IV	Serum 15% AA, 1% dl-α tocopherol and 0.5% FA, twice daily x 2 weeks following laser resurfacing	Improved texture and pigmentation ($p<0.05$). No difference in erythema.
Mazurek et al[13]	Randomized, controlled	60	F with hyper-pigmentation, age 35–55 years, FST I–III	Serum 20% azelaic acid, 10% mandelic acid, 5% phytic acid, and 2% FA, twice daily x 6 months	Improved hydration and pigmentation ($p<0.001$). No difference in erythema.
Zduńska-Pęciak et al[14]	Split-face control	16	F with photoaging, age 45–60, FST II–III	Peel 14% FA vs 14% FA + microneedle x 8 sessions	Improved hydration, elasticity, erythema, and pigmentation ($p<0.05$). Elasticity further improved with microneedle.
Zduńska-Pęciak et al[15]	Split-face control	20	F with photoaging, age 39–61, FST II–III	Peel 14% FA vs 14% FA + 12% AA x 8 sessions	Improved hydration, elasticity, erythema, and pigmentation ($p<0.0001$). No further improvement with addition of AA.
Zduńska-Pęciak et al[16]	Split-face control	20	F with photoaging, age 45–60, FST II–III	Peel 14% FA x 8 sessions	Improved hydration, texture, erythema, and pigmentation ($p<0.05$).
Milani et al[17]	Single-blind, controlled	20	F with hyper-pigmentation, age 35–45 years, FST I–III	Serum 5% AA, 1% dl-α tocopherol, 0.5% FA, twice daily x 28 days	Improved hydration and dark spots ($p<0.05$).
Pueknang et al[18]	Randomized, single-blind	16	F/M, age 20–60 years, FST III–IV	Encapsulated and free cream 5% FA, twice daily x 4 weeks	Improved elasticity, brightness, and texture ($p<0.05$).
Manosroi et al[19]	Single-blind, placebo-control	30	F, age 25–40 years	Cream and gel 1.5% γ-oryzanol, 1.5% phytic acid and 0.5% FA, twice daily x 28 days	Improved hydration, pigmentation, roughness, and elasticity ($p<0.05$).
Zvezdin et al[20]	Randomized, single-blind, controlled	82	F, age 30–50 years	Microneedle patch 4.5mg hyaluronic acid and 0.003mg FA x 6 treatments	Improved skin roughness and wrinkles ($p<0.05$).
Chauhan et al[21]	Randomized, single-blind	60	F, with photoaging, age 25–36 years, FST III–IV	Peel 12% FA vs 12% FA + 30% lactic acid x 6 sessions	Improved texture ($p<0.001$). Greatest improvement with FA + lactic acid ($p<0.001$).

FA: ferulic acid; AA: L-ascorbic acid; FST: Fitzpatrick Skin Type; HTC: hill top chamber; F: Female; M: Male

increased skin elasticity at Day 14 but not at Day 28.[19]

Two cohort studies examined the effects of FA peel treatments on skin elasticity using cutometer measurements. The first study with 16 participants reported a 20-percent increase immediately after the final peel and a 30-percent increase one month later ($p<0.05$).[14] The second study involving 20 participants showed a 23-percent increase immediately post-treatment and a 35-percent increase one month later ($p<0.001$).[16] Overall, these studies collectively suggest that FA, whether applied topically in creams or through peel treatments, can enhance skin elasticity.

Texture. Six studies examined the effectiveness of ferulic acid (FA) in improving skin texture using various interventions. In a randomized controlled trial (RCT), daily application of a combination serum containing 0.5% FA, 15% L-ascorbic acid (AA), and 1% dl-α tocopherol post QSNY laser treatment, resulted in a significant improvement in skin texture compared to untreated skin (Mann-Whitney U test, $p<0.05$).[12]

Profilometric evaluation of microneedle patches infused with FA and hyaluronic acid (HA), demonstrated significant reductions in skin roughness index ($65.32 \pm 2.99\%$) and mean skin waviness ($66.84 \pm 1.6\%$) compared with untreated controls ($p<0.05$).[20]

In a cohort study of 60 female subjects with photoaging (Fitzpatrick skin types III–V), treatment with a 12% FA peel and a combination of 12% FA with 30% lactic acid (LA) showed significant improvements in Allergen Skin Roughness Score (ASRS) compared to baseline ($p<0.001$).[21] The combination with LA produced a greater net improvement in ASRS compared to FA alone ($p<0.001$).

Zdunska et al[16] used a special LED UV-A light video camera (videoscan) to assess skin topography after a series of eight FA peels, reporting significant reductions in epidermal scale immediately and one month after treatment compared to untreated controls ($p=0.027$). Pueknang et al[18] evaluated skin texture using videoscan after applying encapsulated and free forms of 5% FA creams for 28 days, demonstrating increase in skin smoothness by 22.89 percent and 22.5 percent, decrease in roughness by 14.45 percent and 17.10 percent, scaliness by 20.56 percent and 14.47 percent, and wrinkles by 22.47 percent and 26.33 percent respectively, compared to baseline ($p<0.05$). Similarly, Manosroi et al[19] reported a threefold reduction in mean skin roughness following 28-day treatment with encapsulated and free FA creams compared to baseline, as assessed by videoscan ($p<0.05$).

DISCUSSION

The current studies consistently support the efficacy of FA and FA-containing formulations in enhancing various skin parameters. Topical FA has demonstrated effectiveness in reducing skin erythema, particularly when combined with ascorbic acid (AA) and dl-α tocopherol before UV exposure. This combination significantly protects against UV-induced erythema and correlates with reductions in sunburn formation, thymine dimer formation, p53 protein expression, Langerhans cell depletion, and keratinocyte apoptosis in human subjects.[4–7] However, FA did not reduce erythema in patients recovering from QSNY laser treatment.[12]

FA has also shown efficacy in reducing melanin levels and improving the appearance of hyperpigmentation. A serum containing FA, AA, and dl-α tocopherol reduced melanin content in melasma lesions after two weeks of twice-daily treatment.[12] Mechanisms for skin brightening include direct inhibition of melanocytic processes and indirect stabilization of AA.[17–21]

Due to its anti-inflammatory and antioxidant properties, FA is considered beneficial for anti-aging effects. *In vitro* studies with human keratinocytes and dermal fibroblasts treated with FA demonstrated reduced reactive oxygen species (ROS) generation, which contributes to skin aging.[22] Animal models and clinical trials consistently support FA's anti-aging activity by inhibiting free radical chain reactions, scavenging free radicals, inhibiting matrix metalloproteinase enzyme activity, and promoting the production of skin components like procollagen and hyaluronic acid.[23–25]

For optimal results, a topical regimen of 0.5 to 1% FA applied once or twice daily for 1 to 3 months is recommended. Additionally, peels containing 12 to 14% FA have shown therapeutic benefits for improving an array of skin parameters.[14–16] Techniques such as microneedle therapy and combining FA with other active ingredients have been used to further enhance its efficacy.

Limitations. We acknowledge the limitations of this review, mainly the small sample sizes of available studies, limited diversity in study populations (Fitzpatrick skin types), and the lack of robust randomized controlled trials (RCTs). While positive outcomes have been reported with FA-containing formulations, the varying compositions of these formulations across studies make it challenging to isolate FA's specific contributions.

CONCLUSION

While the existing literature supports the photoprotective and anti-aging effects of topical FA, larger-scale and more targeted studies are needed to better define its efficacy across different dermatologic applications and skin types. Daily use of topical 0.5 to 1% FA for at least 1 to 3 months appears to achieve therapeutic benefits, such as improved skin erythema, hyperpigmentation, hydration, elasticity, texture, and density. Future research should also explore optimal delivery vehicles for FA and conduct comparative studies to further elucidate its therapeutic potential.

REFERENCES

1. Li D, Rui YX, Guo SD, et al. Ferulic acid: a review of its pharmacology, pharmacokinetics and derivatives. *Life Sci.* 2021;284:119921.
2. Babbar R, Dhiman S, Grover R, et al. A comprehensive review on therapeutic applications of ferulic acid and its novel analogues: a brief literature. *Mini Rev Med Chem*. 2021;21(12):1578–1593.
3. Zhou Z, Shi T, Hou J, et al. Ferulic acid alleviates atopic dermatitis-like symptoms in mice via its potent anti-inflammatory effect. *Immunopharmacol Immunotoxicol*. 2020;42(2):156–164.
4. Oresajo C, Stephens T, Hino PD, et al. Protective effects of a topical antioxidant mixture containing vitamin C, ferulic acid, and phloretin against ultraviolet-induced photodamage in human skin. *J Cosmet Dermatol*. 2008;7(4):290–297.
5. Murray JC, Burch JA, Streilein RD, et al. A topical antioxidant solution containing vitamins C and E stabilized by ferulic acid provides protection for human skin against damage caused by ultraviolet irradiation. *J Am Acad Dermatol*. 2008;59(3):418–425.
6. Addor F, Goncalves JE, Szrajbman M, et al. A double blind, randomized, comparative study of a facial serum containing 15% L-ascorbic acid, 1% alpha-tocopherol and 0.5% ferulic

acid protecting against acute photodamage in Brazilian patients. *J Am Acad Dermatol*. 2017;76(6):AB14.
7. Wu Y, Zheng X, Xu XG, et al. Protective effects of a topical antioxidant complex containing vitamins C and E and ferulic acid against ultraviolet irradiation-induced photodamage in Chinese women. *J Drugs Dermatol*. 2013;12(4):464–468.
8. Mancuso A, Cristiano MC, Pandolfo R, et al. Improvement of ferulic acid antioxidant activity by multiple emulsions: in vitroand in vivo evaluation. *Nanomaterials (Basel)*. 2021;11(2):425.
9. Saija A, Tomaino A, Trombetta D, et al. In vitro and in vivo evaluation of caffeic and ferulic acids as topical photoprotective agents. *Int J Pharm*. 2000;199(1):39–47.
10. Sauce R, Pinto CASO, Velasco MVR, et al. Ex vivo penetration analysis and anti-inflammatory efficacy of the association of ferulic acid and UV filters. *Eur J Pharm Sci*. 2021;156:105578.
11. Huma S, Khan HMS, Ijaz S, Sarfraz M, Zaka HS, Ahmad A. Development of niacinamide/ferulic acid-loaded multiple emulsion and its in vitro/in vivo investigation as a cosmeceutical product. *Biomed Res Int*. 2022;2022:1725053.
12. Kim J, Kim J, Lee YI, et al. Effect of a topical antioxidant serum containing vitamin C, vitamin E, and ferulic acid after Q-switched 1064-nm Nd:YAG laser for treatment of environment-induced skin pigmentation. *J Cosmet Dermatol*. 2020;19(10):2576–2582
13. Mazurek K, Pierzchała E. Comparison of efficacy of products containing azelaic acid in melasma treatment. *J Cosmet Dermatol*. 2016;15(3):269–282.
14. Kamila MZ, Helena R. The effectiveness of ferulic acid and microneedling in reducing signs of photoaging: a split-face comparative study. *Dermatol Ther*. 2020;33(6):e14000.
15. Zduńska-Pęciak K, Kołodziejczak A, Rotsztejn H. Two superior antioxidants: ferulic acid and ascorbic acid in reducing signs of photoaging-a split-face comparative study. *Dermatol Ther*. 2022;35(2):e15254.
16. Zduńska-Pęciak K, Dębowska R, Kołodziejczak A, et al. Ferulic acid - a novel topical agent in reducing signs of photoaging. *Dermatol Ther*. 2022;35(7):e15543.
17. Milani M, Hashtroody B, Piacentini M, et al. Skin protective effects of an antipollution, antioxidant serum containing Deschampsia antartica extract, ferulic acid and vitamin c: a controlled single-blind, prospective trial in women living in urbanized, high air pollution area. *Clin Cosmet Investig Dermatol*. 2019;12:393–399.
18. Pueknang J, Saewan N. Stability and anti-aging of encapsulated ferulic acid in phosphorylated rice starch. *Molecules*. 2022;27(11):3463.
19. Manosroi A, Chutoprapat R, Abe M, et al. Anti-aging efficacy of topical formulations containing niosomes entrapped with rice bran bioactive compounds. *Pharm Biol*. 2012;50(2):208–224.
20. Zvezdin V, Kasatkina T, Kasatkin I, et al. Microneedle patch based on dissolving, detachable microneedle technology for improved skin quality of the periorbital region. Part 2: Clinical evaluation. *Int J Cosmet Sci*. 2020;42(5):429–435.
21. Chauhan A, Singh S. Comparative Analysis of efficacy of lactic acid with ferulic peel (combination peel) vs ferulic peel alone as a monotherapy for photoaging. *Aesthetic Plast Surg*. 2021;45(1):281–288.
22. Zhang J, Guan Y, He L, et al. Influence of a combination of triptolide and ferulic acid on the activities of CYP450 enzymes and oxidative stress in HaCaT cells. *Exp Ther Med*. 2020;20(6):157.
23. Hahn HJ, Kim KB, Bae S, et al. Pretreatment of ferulic acid protects human dermal fibroblasts against ultraviolet A irradiation. *Ann Dermatol*. 2016;28(6):740–748.
24. Staniforth V, Huang WC, Aravindaram K, et al. Ferulic acid, a phenolic phytochemical, inhibits UVB-induced matrix metalloproteinases in mouse skin via posttranslational mechanisms. *J Nutr Biochem*. 2012;23(5):443–451.
25. Ghaisas MM, Kshirsagar SB, Sahane RS. Evaluation of wound healing activity of ferulic acid in diabetic rats. *Int Wound J*. 2014;11(5):523–532. JCAD