1 INTRODUCTION

Extrinsic aging is a complex process modulated through environmental exposure from solar UVA (320-400 nm) and UVB (280-320 nm) radiation.\(^1\)\(^-\)\(^5\) UVA radiation penetrates skin more deeply and triggers the generation of hydroxyl and oxygen free radical intermediates, which can then react with macromolecules. The resultant damage has a major role in skin aging and wrinkling. The increase in reactive oxygen species also results in an increased chemiluminescence signal. UVB radiation does not penetrate as deeply, but is directly absorbed by DNA and protein in the skin.\(^6\)\(^-\)\(^7\) Botanical antioxidants are often included in topical preparations to help diminish UV-induced damage, but their efficacy is not widely established.\(^8\)\(^-\)\(^9\)

In vitro or ex vivo methods are often used to assess antioxidant activity, but these might not be representative of in-use conditions. Topical antioxidants can inhibit the transient increase in skin chemiluminescence and sunburn cell formation that occur in vivo following UVA and UVB exposure, respectively. For this reason, two separate in vivo studies were conducted to assess the nature-based facial oil’s ability to mitigate the effects of UVA and UVB challenge.

2 METHODS

2.1 UVA Study

The study was conducted at an independent research facility following ICH GCP guidelines. 22 healthy females aged 18-60 years with Fitzpatrick skin type I or II, based on measurement of the individual typological angle (ITA) by colorimetry to determine skin type I or II, based on measurement of the individual typological angle (ITA) by colorimetry to determine skin

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pigmentation, signed informed consent and were enrolled in the UVA study. Subjects were prohibited from applying cosmetic products to their backs, sunbathing, or swimming during their participation. After acclimation of 30 minutes, baseline readings of induced chemiluminescence of human skin (ICL-S) were taken from three designated areas on subjects’ backs using a proprietary apparatus.\textsuperscript{10,11} The ICL-S at each site was measured for 120 seconds following 120 seconds of controlled UVA irradiation (350 nm, ~1 J/cm\(^2\)).

Sites were randomized for treatment with the nature-based facial oil and an antioxidant standard, both dosed at 2 mg/cm\(^2\). The third site remained the untreated control. The treatments were applied by site personnel on weekdays and by subjects (or a partner) on weekends. Final ITA and ICL-S measurements were made after two weeks of daily use, at least 20 hours after the last treatment application.

2.2 | UVB Study

The UVB clinical study was conducted at an independent research facility (Dermatology Consulting Services, PLLC, High Point, NC) following ICH GCP guidelines. Ten healthy nonpregnant adult females age 30-70 years with Fitzpatrick skin type I were enrolled who signed an IRB-approved informed consent (Allendale Institutional Review Board, Old Lyme, CT). Subjects agreed to avoid sun exposure and swimming. Subjects self-applied a quarter-sized amount of the nature-based facial oil (Table 1) to one randomly assigned photoprotected upper outer buttock and nothing to the contralateral photo-protected upper outer buttock twice daily for 8 weeks. 8 weeks was required to build a stratum corneum reservoir of the antioxidant formulation. They maintained a daily compliance diary, and test article containers were weighed to monitor compliance.

Subjects returned to the research center after 4 weeks for a compliance check, and after 8 weeks for irradiation of both upper outer buttocks with 2MED of solar simulated radiation (150W xenon arc bulb, Solar Light, Philadelphia). Twenty-four hours later, dermaspectrophotometer (DSP) erythema readings were made, digital images were captured, and a 3 mm punch biopsy was taken from each site. Biopsy specimens were sent to a dermatopathology laboratory for H&E staining and apoptotic (sunburn) cell counting (Garron Solomon, MD, Tripoint Diagnostics, PLLC, Morrisville, NC).

### Table 1

| Ingredient listing for nature-based facial oil |
|------------------------------------------------|
| *Rosa canina* seed extract, *Simmondsia chinensis* (jojoba) seed oil, *Borago officinalis*, *Oenothera biennis* (evening primrose) seed extract, *Corylus avellana* (hazel) seed oil, *Triticum vulgare* (wheat) germ oil, Tocopherol, Fragrance, *Helianthus annuus* (sunflower) seed oil, Retinyl palmitate, Glycine soja (soybean) oil, Ascorbyl palmitate, \(\beta\)-Carotene, Canola oil, *Rosmarinus officinalis* (rosemary) leaf extract. |

Ingredients are listed in order of decreasing concentration in the formula.

3 | RESULTS

3.1 | Subject accountability

All enrolled subjects completed the studies without adverse events. There was a technical issue with the ICL-S measurement made on the facial oil-treated site for one subject in the UVA study, and the sunburn response for one subject in the UVB study was considered inadequate for erythema measurement. This data not included in the analysis.

3.2 | Effect of nature-based facial oil following UVA irradiation (ICL-S study)

All subjects enrolled in the study possessed minimally pigmented skin, that is, an ITA value greater than or equal to the minimum target value of 41. ITA values showed no significant change over the...
course of the study ($P = .90$) and therefore did not influence ICL-S measurements.

The ICR values measured on subject back treatment areas were not significantly different at baseline ($P > .57$). Measured ICR changes for the three treatments are summarized in Figure 1. Pretreating skin with the nature-based facial oil for two weeks prior to UVA challenge reduced the ICR value from baseline, indicating skin antioxidant activity. The ICR reduction for the oil was significantly greater than the change measured on untreated skin ($P = .03$). As expected, pretreatment with the antioxidant control produced the greatest reduction in ICR.

3.3 | Effect of nature-based facial oil following UVB irradiation

The DSP-assessed erythema results are summarized in Figure 2. The erythema measured on the oil-treated buttock treated was lower than on the untreated buttock in 8 of 9 subjects included in the analysis. Overall, pretreatment with the nature-based facial oil significantly ($P < .01$) reduced UVB-induced erythema compared to untreated skin. Figure 3 shows representative H&E biopsy sections with fewer sunburn cells in specimens taken from sites pretreated with the oil compared to untreated skin in 6 of 10 subjects.

4 | DISCUSSION

Exposure to UV radiation has a cumulative, damaging effect on skin leading to premature aging, which can be mitigated with antioxidants. Plants are an abundant source of metabolites protecting from ROS in the environment by neutralizing endogenous free radicals and protecting from oxidative stress.12

These studies examined the antioxidant activity of a nature-based facial oil based on botanical oils (Table 1). *Rosa canina* oil is very high in linoleic acid, an essential fatty acid that is necessary for skin barrier health, and antioxidants.13-15 Borage, evening primrose, and sunflower seed oils also contain high concentrations of this omega-6 essential fatty acid.16-18 Jojoba seed oil contains unique fatty alcohol esters that provide high oxidative stability.19,20 Hazel seed, wheat germ, and soybean are antioxidant oils selected for their viscosity to enhance product aesthetic properties.21-24 Tocopherol, retinyl palmitate, ascorbyl palmitate, and β-carotene provide antioxidant protection for the botanical oils. Finally, rosemary leaf extract functions as a naturally occurring preservative.25

As UVA and UVB radiation affect the skin differently, separate in vivo models were used to assess the nature-based facial oil’s antioxidant potential. UVA exposure transiently increases skin chemiluminescence due to increased oxidative stress. This study revealed pretreatment with the nature-based facial oil significantly reduced chemiluminescence following UVA exposure indicating reduced oxidative stress.

Skin damage following UVB exposure is more direct, occurring when DNA and skin proteins absorb the radiation. Therefore, UVB protection was studied in a model that used erythema and sunburn cell formation as endpoints. After 8 weeks of pretreatment with the nature-based facial oil, erythema following UVB challenge was significantly reduced corresponding to fewer sunburn cells in 66.67% of subjects.

![FIGURE 2](image1.png)

**FIGURE 2** DSP Erythema Values on Treated and Untreated Buttock Skin. Pretreatment with the nature-based facial oil significantly reduced UVB-induced erythema compared to untreated skin.

![FIGURE 3](image2.png)

**FIGURE 3** Sunburn Cells on Treated (A) and Untreated (B) Buttock Skin. Pretreatment with the nature-based facial oil significantly reduced sunburn cell counts compared to untreated skin [Color figure can be viewed at wileyonlinelibrary.com]
5 CONCLUSION

Topical treatment with a nature-based facial botanical oil provided antioxidant protection against UVA/UVB-induced oxidative stress.

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CONFLICT OF INTEREST

Dr Draelos is an investigator for Burt’s Bees. Dr Levy is a consultant for Burt’s Bees. Dr Gunt is an employee of Burt’s Bees. All subjects involved in the human research portion of this study completed consent and followed all GCP guidelines. The study and consent were approved by the Allendale Institutional Review Board, Old Lyme, CT, USA.

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