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Antioxidants in sunscreens: which and what for?

Chaired by DR. ALFREDO BERZAL-HERRANZ;
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pharmaceuticals MDPI

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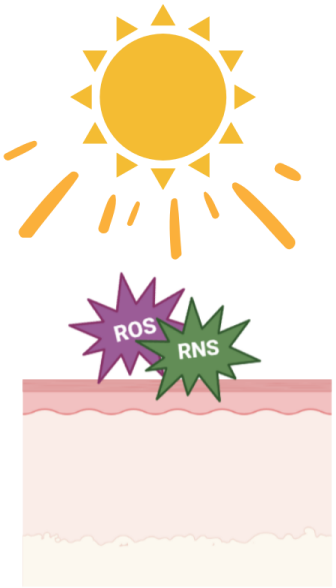
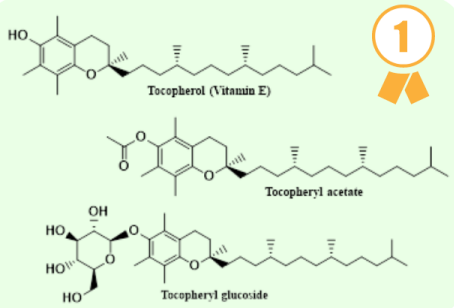
Antioxidants in sunscreens: which and what for?

Graphical Abstract



Photoaging
UV-induced skin damage

Photoprotection



Sunscreen + **Antioxidants**

Main goal

Top 5 antioxidant ingredients found in sunscreens

- Mechanisms of action
- Effectiveness

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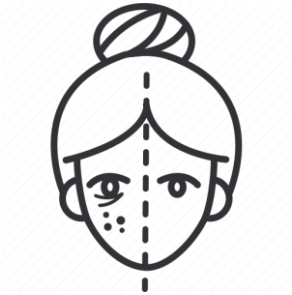
Abstract:
UV radiation promotes the generation of reactive oxygen (ROS) and nitrogen (RNS) species resulting in skin damage. Cosmetic industries have adopted the strategy to incorporate antioxidants in sunscreen formulations, aiming to prevent/minimize the UV-induced oxidative damage, boost photoprotection effectiveness and to mitigate skin photoaging. This work aims to characterize the frequency of the use of antioxidants in commercial sunscreens. Photoprotective formulations currently marketed in parapharmacies and pharmacies were analyzed concerning the composition described on the label. As a result, pure compounds with antioxidant activity were found. The majority of the sunscreen formulations contained antioxidants and the most frequently used were vitamin E and derivatives. A more thorough analysis of these antioxidants is also provided, unveiling the top of the antioxidant ingredients found in sunscreens and their mechanisms of action. A critical appraisal of the scientific evidence regarding their effectiveness is also performed. In conclusion, this work provides an up-to-date overview about the use of antioxidants in commercial sunscreens for a better understanding of the advantages associated to their use in photoprotective formulations.
Keywords: Antioxidants; Cosmetics; Sunscreens; Trends

Introduction



SKIN AGING

CHRONOLOGICAL AGING

EXTRINSIC AGING

UV

PHOTOAGING

UV-INDUCED SKIN DAMAGE

ROS

RNS

OXIDATIVE STRESS

- Cellular damage and senescence
- Activation of matrix metalloproteinases (MMPs)

Silva, S., et al., *Evolution of the use of antioxidants in anti-ageing cosmetics*. International Journal of Cosmetic Science, 2019. 41(4): p. 378-386.
Gromkowska-Kępka, K.J., et al., *The impact of ultraviolet radiation on skin photoaging - review of in vitro studies.* J Cosmet Dermatol, 2021. **20**(11): p. 3427-3431.

Introduction

SUNSCREENS

UV FILTERS

ANTIOXIDANTS

1.Prevent Oxidative Stress

2. Stabilize UV Filters

3. Boost Photoprotection

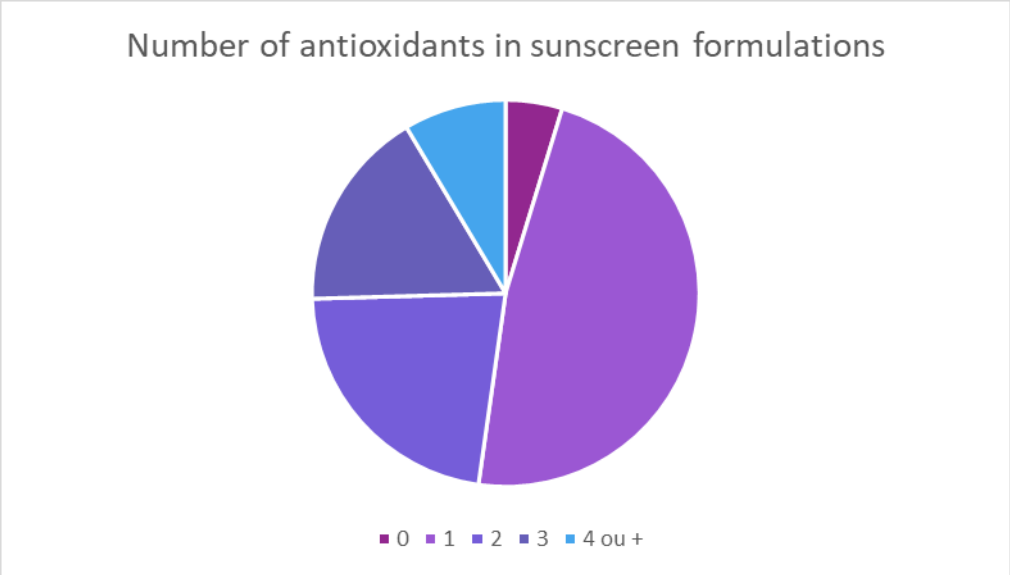
Aim: Up-to-date overview of the most commonly used antioxidant compounds in commercial sunscreens and better understanding of their photoprotection effectiveness

Krutmann, J., et al., *Daily photoprotection to prevent photoaging.* Photodermatology Photoimmunology and Photomedicine, 2021. **37**(6): p. 482-489.
Dunaway, S., et al., *Natural Antioxidants: Multiple Mechanisms to Protect Skin From Solar Radiation.* Front Pharmacol, 2018. **9**: p. 392.
Chen, L., J.Y. Hu, and S.Q. Wang, *The role of antioxidants in photoprotection: A critical review.* Journal of the American Academy of Dermatology, 2012. **67**(5): p. 1013-1024.
Lorigo, M. and E. Cairrao, *Antioxidants as stabilizers of UV filters: an example for the UV-B filter octylmethoxycinnamate.* Biomedical Dermatology, 2019. **3**(1): p. 11

Results and discussion

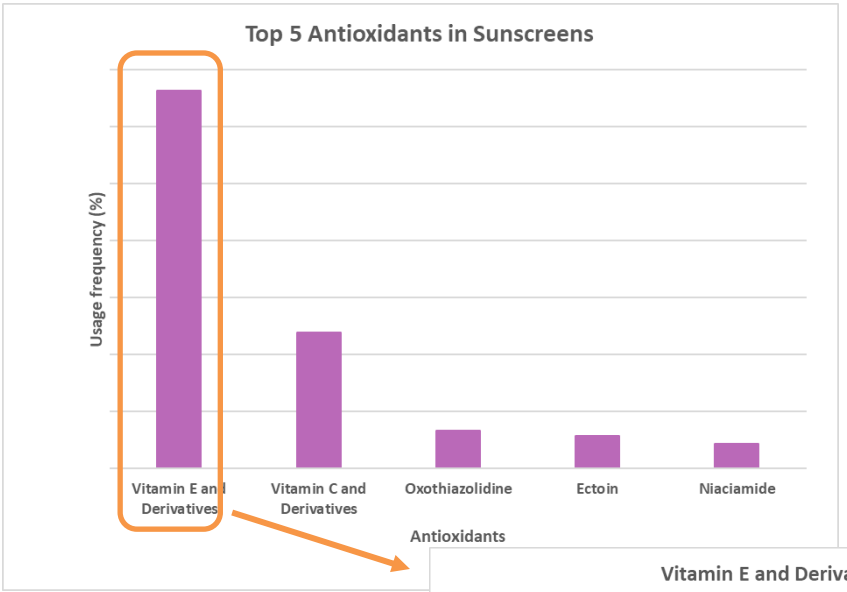
2.1. Overview of the use of antioxidants in sunscreens

- More than 95% of the sunscreens analysed contained at least one antioxidant
- Only 21 sunscreens did not possess antioxidants in their composition

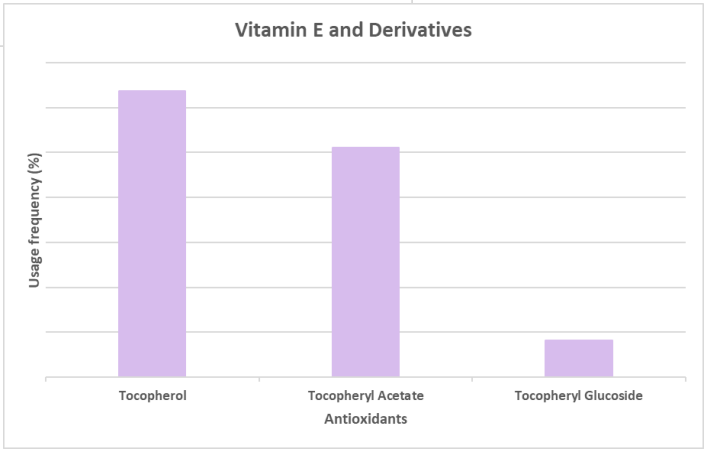


Results and discussion

2.1. Overview of the use of antioxidants in sunscreens



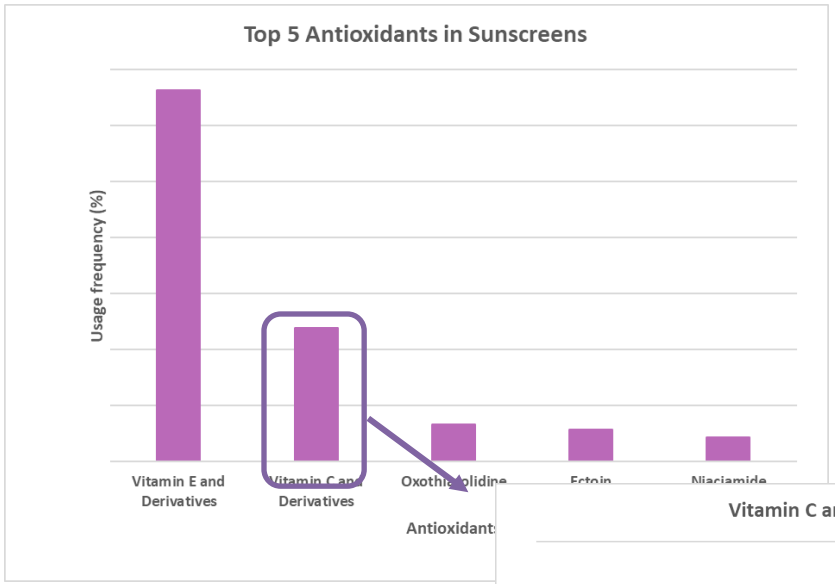
- Vitamin E and derivatives were the antioxidants with highest usage frequency (> 50%)



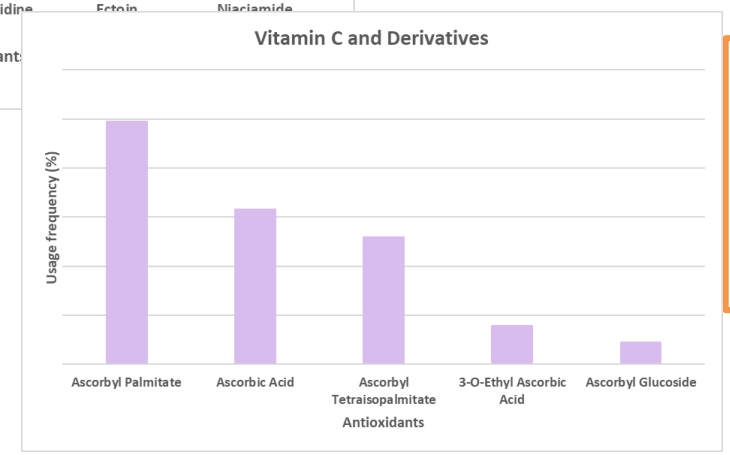
- Tocopherol and Tocopheryl acetate are present in more than half of the 444 sunscreens

Results and discussion

2.1. Overview of the use of antioxidants in sunscreens



- Vitamin C and derivatives were found with percentagem up to 10% of the total number of antioxidants present in sunscreens

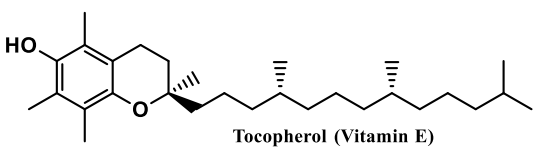


- Ascobyl Palmitate was the most used vitamin C derivative

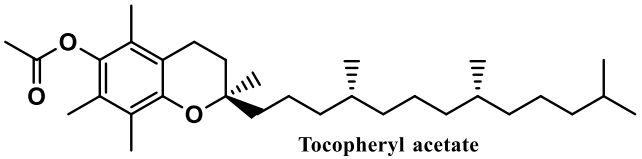
Results and discussion

2.2. Scientific Evidence Supporting the photoprotection effectiveness of the Top 5 Antioxidants used in Sunscreens

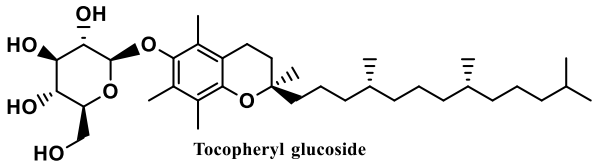
Vitamin E and derivatives



Tocopherol (Vitamin E)



Tocopheryl acetate



Tocopheryl glucoside

Characterization

Natural-occurring lipophilic vitamin

Derivatives release tocopherol *in situ*

Biological activity

Antioxidant activity

Protective effects against UV-induced skin damage

↓

In vitro epidermal keratinocyte and dermal fibroblast cell lines and *in vivo* studies

Mechanism

- **Limiting the UVR-induced cellular apoptosis**
- **Reduction of erythema**

Jiang, Q. Natural forms of vitamin E: metabolism, antioxidant, and anti-inflammatory activities and their role in disease prevention and therapy. Free Radic Biol Med 2014, 72, 76-90

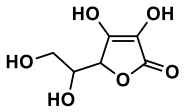
Jacques, C. et al. Sustained effect of two antioxidants for immediate and long-term sun protection in a sunscreen emulsion based on their different penetrating properties. Int J Cosmet Sci (2021), **43**, 391-404

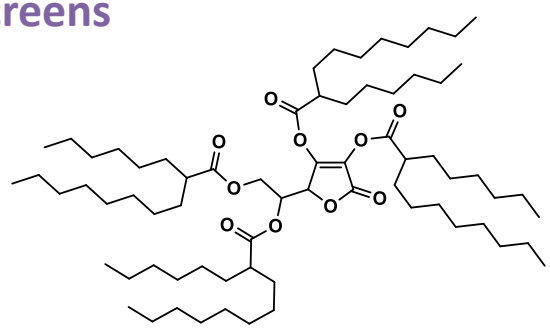
Camillo L, et al. Alpha-Tocopherol Protects Human Dermal Fibroblasts by Modulating Nitric Oxide Release, Mitochondrial Function, Redox Status, and Inflammation. Skin Pharmacol Physiol. 2022;35(1):1-12.

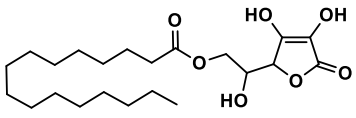
Results and discussion

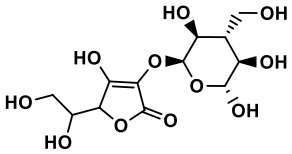
2.2. Scientific Evidence Supporting the photoprotection effectiveness of the Top 5 Antioxidants used in Sunscreens

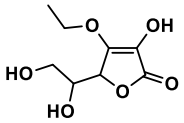
Vitamin C and derivatives


Ascorbic acid


Ascorbyl tetraisopalmitate


Ascorbyl palmitate


Ascorbyl glucoside


3-*O*-ethyl ascorbic acid

Characterization

- **Botanical-derived vitamin**
- **Derivatives release ascorbic acid *in situ***

Biological activity

- **Antioxidant activity**
- **Regeneration of oxidized vitamin E**

- **Protective effects against UV-induced skin damage**

↓

In vitro epidermal keratinocyte and dermal fibroblast cell lines and *in vivo* studies

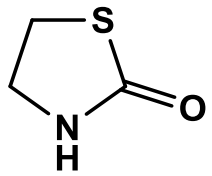
Mechanism

- **Reduction of lipid peroxidation radicals**
- **Reduction of erythema and sunburn cell formation**

Farris, P.K. Topical vitamin C: a useful agent for treating photoaging and other dermatologic conditions. *Dermatol Surg* **2005**, *31*, 814-817; discussion 818, doi:10.1111/j.1524-4725.2005.31725.
Enescu, C.D.; Bedford, L.M.; Potts, G.; Fahs, F. A review of topical vitamin C derivatives and their efficacy. J. Cosmet. Dermatol. 2022, 21, 2349-2359, doi:10.1111/jocd.14465.

Results and discussion

2.2. Scientific Evidence Supporting the Photoprotection Effectiveness of the Top 5 Antioxidants used in Sunscreens



Oxothiazolidine

Characterization

Heterocyclic compound

Release taurine *in situ*

Biological activity

Antioxidant activity

Protective effects against UV-induced skin damage

In vitro epidermal keratinocyte and dermal fibroblasts cell lines and *ex vivo* human skin explants studies

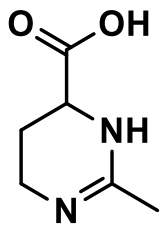
Mechanism

- **Limiting the UVR-induced cellular apoptosis**
- **Prevention of imunossupression**
- **Stop lipid peroxidation chain reaction**

Jacques, C. et al. Sustained effect of two antioxidants for immediate and long-term sun protection in a sunscreen emulsion based on their different penetrating properties. Int J Cosmet Sci (2021), **43**, 391-404
Warskulate et al. The Osmolyte Strategy of Normal Human Keratinocytes in Maintaining Cell Homeostasis. J Invest Dermatol(2004) **123**, 516-521.

Results and discussion

2.2. Scientific Evidence Supporting the Photoprotection Effectiveness of the Top 5 Antioxidants used in Sunscreens



Ectoine

Characterization

Amino acid derivative

Natural origin (produced by marine organisms)

Biological activity

Antioxidant activity

Moisturizing effect

Protective effects against UV-induced skin damage

↓

In vitro epidermal keratinocyte and dermal fibroblast cell line studies

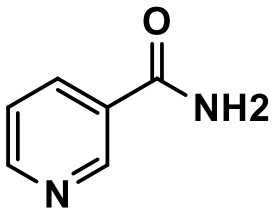
Mechanism

- **Quenching action for singlet oxygen**
- **Increase of skin enzymatic and non-enzymantic antioxidants**

Cheng, W.et al.,. Protective Effect of Ectoin on UVA/H2O2-Induced Oxidative Damage in Human Skin Fibroblast Cells. Applied Sciences (2022) **12**
Schroter, M.A. Et al. Ectoine protects DNA from damage by ionizing radiation. Sci Rep (2017) **7**, 15272

Results and discussion

2.2. Scientific Evidence Supporting the Photoprotection Effectiveness of the Top 5 Antioxidants used in Sunscreens



Niacinamide

Characterization

Active form of vitamin B3

Amide of the carboxylic acid of niacin

Biological activity

Anti-inflammatory activity

Antioxidant activity

Protective effects against UV-induced skin damage

In vitro epidermal keratinocyte, dermal fibroblast and melanocyte cell lines and *in vivo* studies

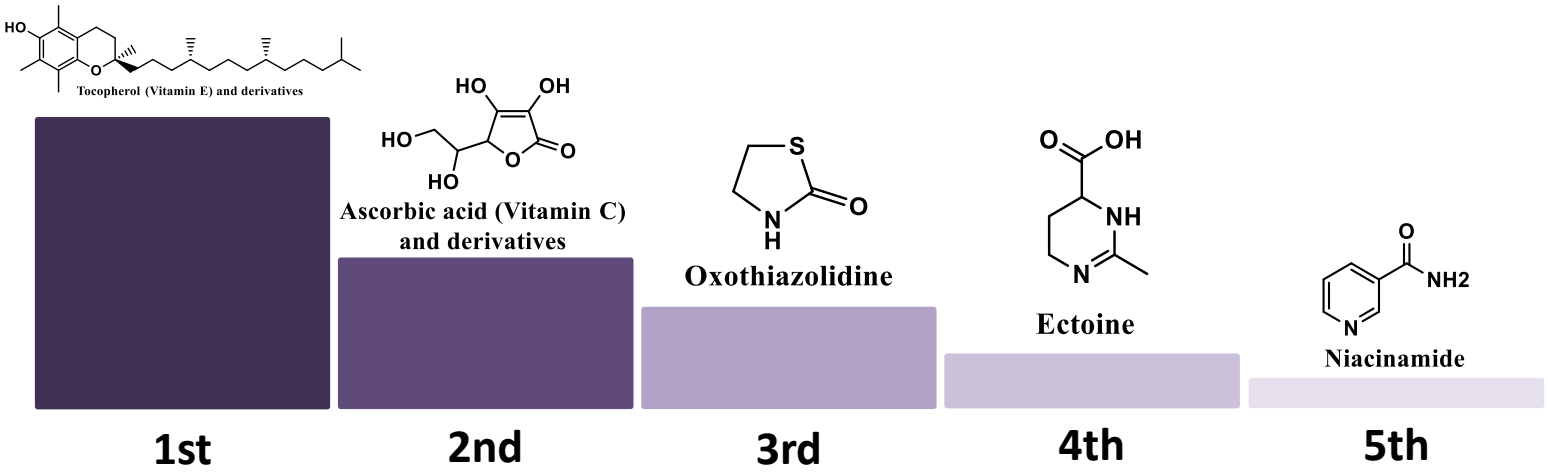
Mechanism

- **Prevention of immunosuppression**
- **Increase of skin enzymatic and non-enzymantic antioxidants**

Snaidr, V.A. Et al., Nicotinamide for photoprotection and skin cancer chemoprevention: A review of efficacy and safety. Exp Dermatol (2019) **28** S1, 15-22
Namazi, M.R. Nicotinamide in dermatology: a capsule summary. Int. J. Dermatol. (2007), **46**, 1229-1231.
Thompson, B.C. et al. Nicotinamide enhances repair of ultraviolet radiation-induced DNA damage in primary melanocytes. Exp Dermatol (2014) **23,** 509-511
Tan, C.Y.R; et al. Nicotinamide Prevents UVB- and Oxidative StressInduced Photoaging in Human Primary Keratinocytes. J Invest Dermatol (2022), **142**, 1670-1681 e1612

Conclusions

Pool of 444 sunscreen formulations currenty marketed



Protective effects against UV-induced skin damage and oxidative stress

Acknowledgments

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