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How to fight acute sun damage? Current strategies of the cosmetic market

Chaired by Dr. Alfredo Berzal-Herranz and Prof. Dr. Maria Emília Sousa

pharmaceuticals MDPI

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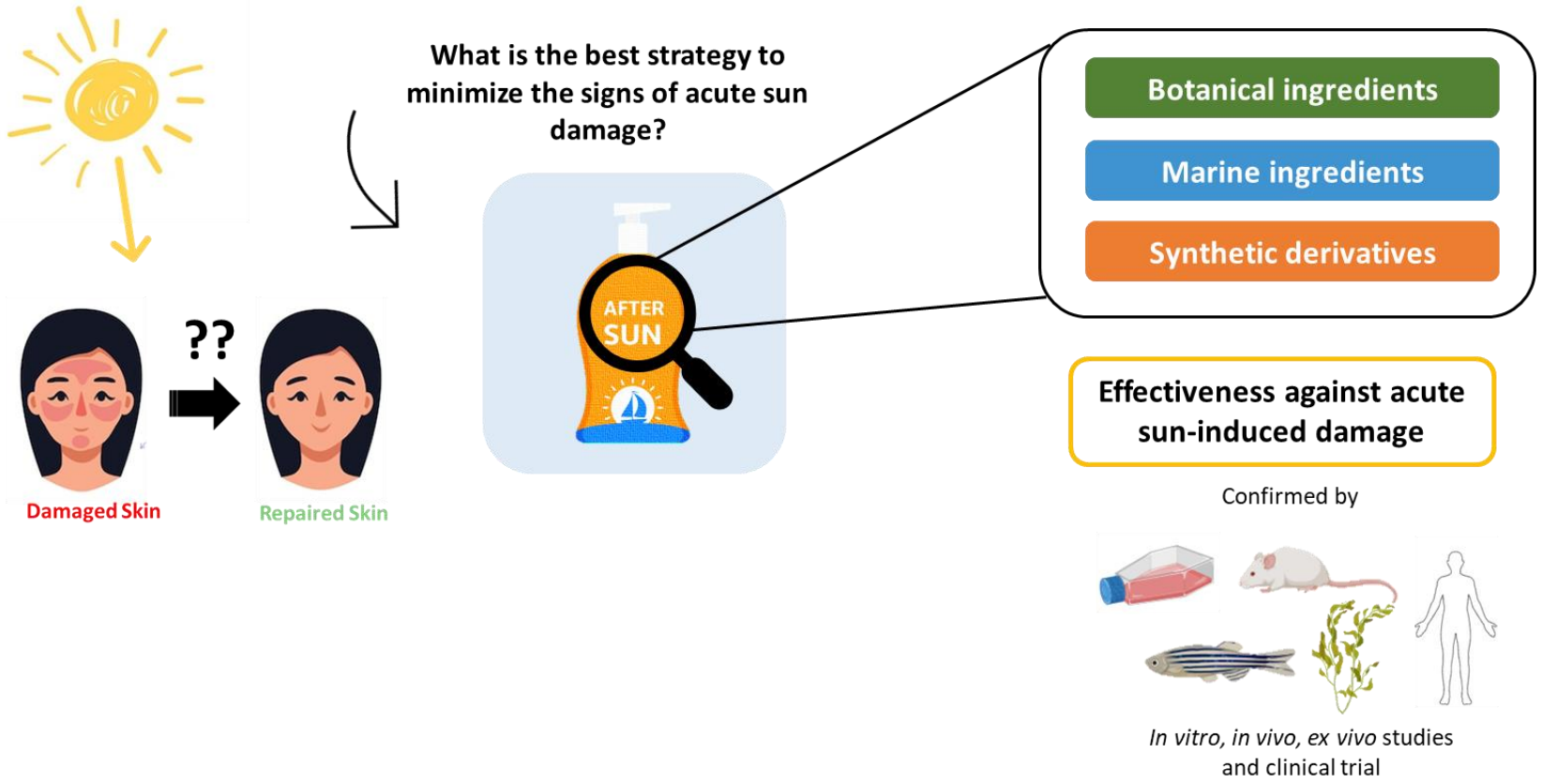
How to fight acute sun damage? Current strategies of the cosmetic market

Graphical Abstract



Abstract: Sunlight exposure can cause skin damage, like sunburn, skin dryness, wrinkles hyperpigmentation and skin sensitivity reactions. The use of aftersun products is a strategy that minimizes the visible signs and symptoms of sun-damaged skin, once that photo-damaged skin is more susceptible to inflammaging and oxidative stress events, affecting the skin's repair mechanisms. Aiming to unveil the active ingredients able to counteract acute sun damage, this work focuses on the characterization of the aftersun products market. Aftersun formulations currently marketed in Portuguese pharmacies were analysed concerning the composition described on the product´s label. Natural-derived extracts and pure compounds, as well as synthetic compounds, with anti-photodamage activity were found. The majority of the aftersun formulations contained natural-derived ingredients (> 95%), from terrestrial (77%) and marine (4%) sources. An in-depth examination of these compounds is also disclosed, revealing the top of the most used natural and synthetic ingredients present in aftersun products, as well as their mechanism of action. A critical appraisal of the scientific data supporting their efficacy, together with some considerations concerning structure-activity relationship studies were carried out. The presence of terpenoid, guanidine, ester, amide, ureido moiety, carboxylic acid and alcohol functions were found in the cosmetic ingredients most used in aftersun products, allowing the correlation with their bioactivities. In summary, this work provides an overview of the use of actives in commercial aftersun products in order to better understand the benefits associated with their use in cosmetic formulations, concomitantly identifying opportunities for innovation.

Keywords: aftersun products; sun damage; scientific evidence; anti-photoaging effectiveness; structure-activity relationship.

Introduction

SKIN AGING

CHRONOLOGICAL AGING

EXTRINSIC AGING

UV-INDUCED SKIN DAMAGE

- Oxidative stress
- Inflammatory events
- Senescence
- Melanogenesis dysregulation

Mesa-Arango, A.C.; Flórez-Muñoz, S.V.; Sanclemente, G. Mechanisms of skin aging. Iatreia 2017, 30, 160-170.
Lee, H.J.; Kim, M. Skin Barrier Function and the Microbiome. Int J Mol Sci 2022, 23

Introduction

AFTERSUN PRODUCTS

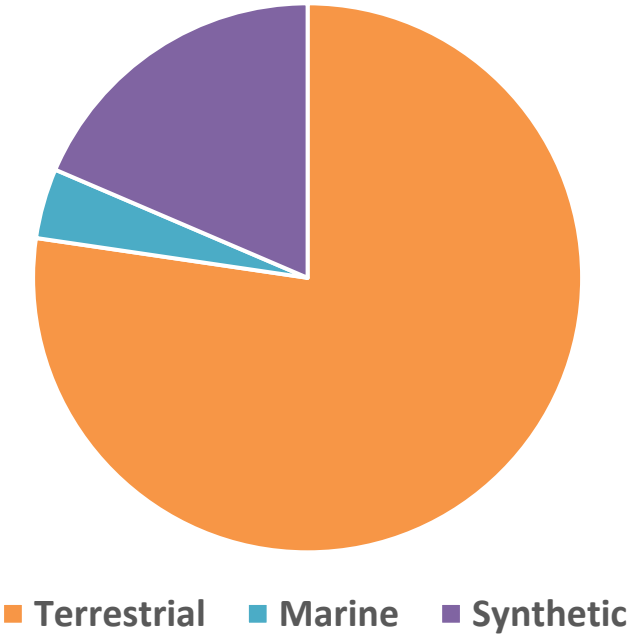
1. Minimize oxidative stress
2. Mitigate inflammatory events
3. Alleviate the swelling and redness
4. Refresh and sooth

Aim: Unveil the active ingredients able to counteract acute sun damage, through the characterization of the aftersun products market analysis to better understand their mechanism of action.

Results and discussion

1. Overview of the use of natural and synthetic ingredients in aftersun products

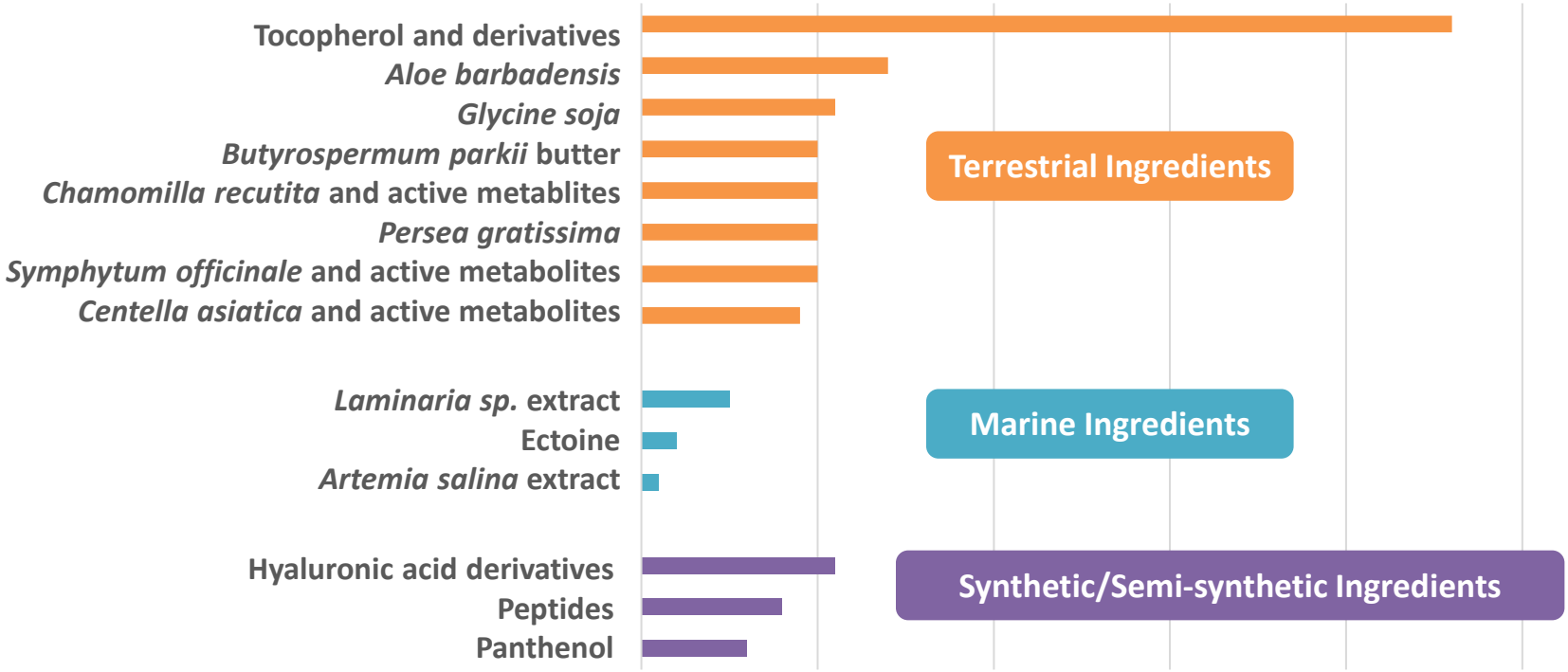
- Most aftersun products contain more than one active ingredient.
- More than 95% of the active ingredients are from natural sources.



Results and discussion

1. Overview of the use of natural and synthetic ingredients in aftersun products

Top of the most used terrestrial, marine, and synthetic/semi-synthetic ingredients

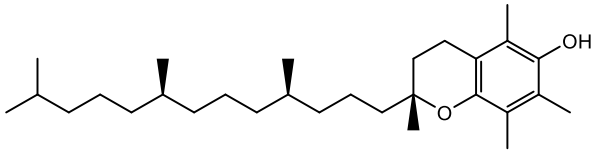


Results and discussion

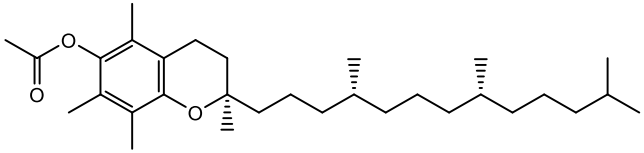
2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.1. Terrestrial ingredients

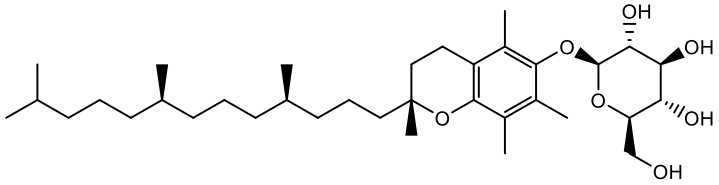
Tocopherol and its derivatives



Alpha-tocopherol



Tocopheryl acetate

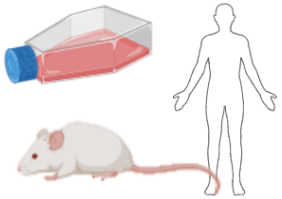


Tocopheryl glucoside

- Natural-derived lipophilic vitamin
- Derivatives with enhanced formulation stability
- Antioxidant activity

Effectiveness against acute sun-induced damage

- Mitigate oxidative stress and lipid peroxidation
- Improve wrinkles and skin hydration



In vitro and *in vivo* studies

Thiele, J.J., Hsieh, S. N., Ekanayake-Mudiyanselage, S. Vitamin E: critical reviews of its current use in cosmetic and clinical dermatology. *American Society for Dermatologic Surgery* **2005**, *31*, 805-813

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.1. Terrestrial ingredients

Aloe barbadensis

- From Aloe family, *A. barbadensis* is cultivated in tropical and semi-tropical climates
- Skin regeneration and moisturizing properties
- Antioxidant and anti-inflammatory activities

Effectiveness against acute sun-induced damage

- Downregulate MMPs expression
- Reduce UV-induced erythema

In vitro and *in vivo* studies

Rodrigues, D.; Viotto, A.C.; Checchia, R.; Gomide, A.; Severino, D.; Itri, R.; Baptista, M.S.; Martins, W.K. Mechanism of Aloe Vera extract protection against UVA: shelter of lysosomal membrane avoids photodamage. Photochem Photobiol Sci 2016, 15, 334-350.

MMPs: metalloproteinases

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

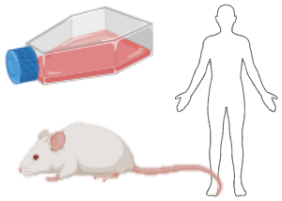
2.1. Terrestrial ingredients

Gycine soja

- From Fabaceae family, *G.soja* is native from southeastern countries
- Emollient and moisturizing characteristics
- Antioxidant and anti-inflammatory activities

Effectiveness against acute sun-induced damage

- Suppress UVB-induced MMPs expression
- Reduce UV-induced erythema



In vitro, in vivo, and *ex vivo* studies

Wallo, W., Nebus J., ; Leyden, J.J. Efficacy of a soy moisturizer in photoaging: a double-blind, vehicle-controlled, 12-week study. Journal of Drugs in Dermatology 2007, 6, 917-922.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

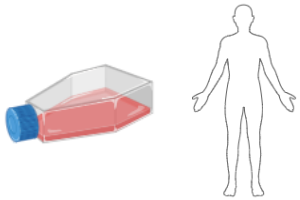
2.1. Terrestrial ingredients

Butyrospermum parkii

- Also known as Sheatree is native from African countries
- Ameliorate and soften skin texture
- Antioxidant and anti-inflammatory activities

Effectiveness against acute sun-induced damage

- Inhibit protease enzymes
- Ameliorate skin texture



In vitro and clinical trial studies

Maanikuu, P.M.I., Perker, K. Medicinal and Nutritional Benefits From the Shea Tree- (Vitellaria Paradoxa). Journal of Biology, Agriculture and Healthcare 2017, 7, 51-57.

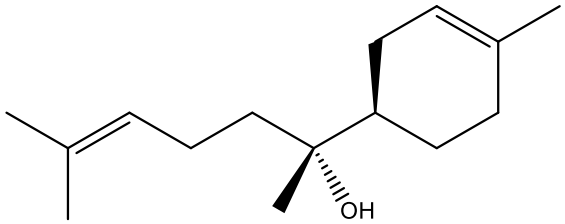
Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.1. Terrestrial ingredients

Chamomilla recutita and α-bisabolol

- Mostly used for therapeutic, food and cosmetic applications
- Appeasing sensation and wound healing properties
- Antioxidant and anti-Inflammatory activities

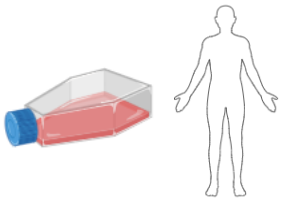


α-bisabolol

Effectiveness against acute sun-induced damage

-Decrease pro-inflammatory mediators and melanogenesis-related factors expression

- Calm and relieving skin sensation



In vitro and clinical trials studies

Eddin, L.B.; Jha, N.K.; Goyal, S.N.; Agrawal, Y.O.; Subramanya, S.B.; Bastaki, S.M.A.; Ojha, S. Health Benefits, Pharmacological Effects, Molecular Mechanisms, and Therapeutic Potential of alpha-Bisabolol. Nutrients 2022, 14.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

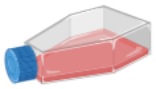
2.1. Terrestrial ingredients

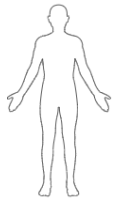
Persea gratissima

- From Lauraceae family, *P. gratissima* oil is considered one of the most expensive vegetable oils
- Mantain skin firmness and reinforce skin´s barrier
- Anti-inflammatory activity

Effectiveness against acute sun-induced damage

- Inhibit protease enzymes and activate DNA repair
- Increase skin firmness and elasticity





In vitro and *ex vivo* studies

Rosenblat, G.; Meretski, S.; Segal, J.; Tarshis, M.; Schroeder, A.; Zanin-Zhorov, A.; Lion, G.; Ingber, A.; Hochberg, M. Polyhydroxylated fatty alcohols derived from avocado suppress inflammatory response and provide non-sunscreen protection against UV-induced damage in skin cells. Arch Dermatol Res 2011, 303, 239-246.

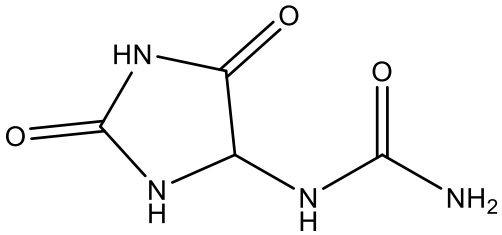
Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.1. Terrestrial ingredients

Symphytum officinale and allantoin

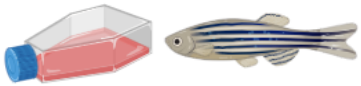
- Often used as medicinal herb to heal small skin injuries
- Moisturizing properties and wound healing effect
- Antioxidant and anti-Inflammatory activities



allantoin

Effectiveness against acute sun-induced damage

- Decrease pro-inflammatory mediators expression and mitigate oxidative stress
- Reduce UV-induced skin erythema



In vitro and in vivo studies

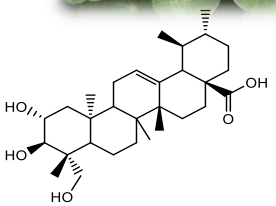
Araújo L. U., R.P.G., Barbosa L. C., Saúde-Guimarães D. A., Grabe-Guimarães A., Mosqueira V. C. , Carneiro C. M. , Silva-Barcellos N. M. . In vivo wound healing effects of Symphytum officinale L. leaves extract in different topical formulations. Pharmazie 2012, 67, 355-360.

Results and discussion

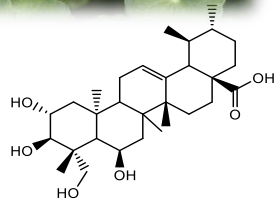
2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.1. Terrestrial ingredients

Centella asiatica and its actives



Asiatic acid



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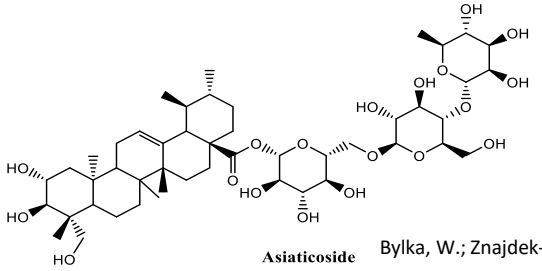
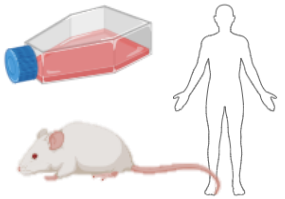


Asiaticoside

- Found in humid areas and tropical regions
- Applications in chinese traditional medicine
- Anti-inflammatory activity and wound healing properties

Effectiveness against acute sun-induced damage

- Inhibit MMP-9 expression and suppress lipid peroxidation and oxidative stress
- Reduce wrinkle development



In vitro, in vivo and clinical trial studies

Bylka, W.; Znajdek-Awizen, P.; Studzinska-Sroka, E.; Brzezinska, M. Centella asiatica in cosmetology. Postepy Dermatol Alergol 2013, 30, 46-49.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

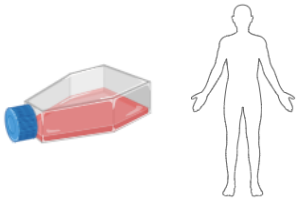
2.2. Marine ingredients

Laminaria sp.

- Food and cosmetic applications in oriental countries
- Moisturizing properties
- Antioxidant and anti-inflammatory activities

Effectiveness against acute sun-induced damage

- Mitigate oxidative stress and avert senescence in fibroblasts
- Increase of skin hydration and collagen fibers



In vitro and *in vivo* studies

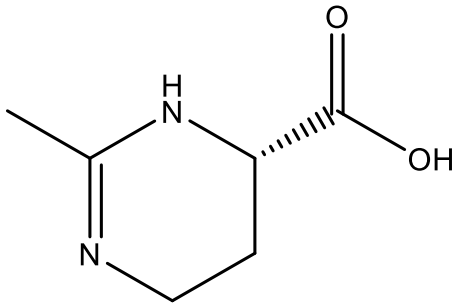
Lopez-Hortas, L.; Florez-Fernandez, N.; Torres, M.D.; Ferreira-Anta, T.; Casas, M.P.; Balboa, E.M.; Falque, E.; Dominguez, H. Applying Seaweed Compounds in Cosmetics, Cosmeceuticals and Nutricosmetics. Mar Drugs 2021, 19.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.2. Marine ingredients

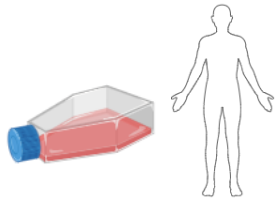
Ectoine



- Algae- and bacteria-derived bioactive metabolite
- Moisturizing properties
- Antioxidant and anti-inflammatory activities

Effectiveness against acute sun-induced damage

- Prevent alterations in mitochondrial DNA and minimize cellular DNA damage
- Long-lasting moisturizing effect



In vitro and clinical trial studies

Buenger, J.; Driller, H. Ectoin: an effective natural substance to prevent UVA-induced premature photoaging. Skin Pharmacol Physiol 2004, 17, 232-237.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

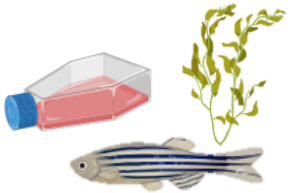
2.2. Marine ingredients

Artemia salina

- Obtained from zooplankton
- Skin regeneration properties
- Anti-inflammatory activity

Effectiveness against acute sun-induced damage

- Enhance skin defence by reducing sunburn cells
- Improve skin hydration



In vitro and *in vivo* studies

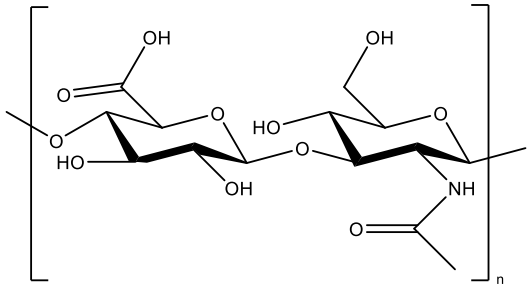
Bauza, E.F., C.D.; Domloge, N. Hsp70 induction by Artemia extract exhibits anti-inflammatory effect and down-regulates IL-1 and IL-8 synthesis in human hacat cells. *J. Investig. Dermatol.* **2002**, *117*, 415.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.3. Synthetic and semi-synthetic ingredients

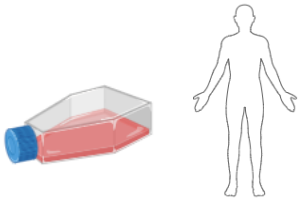
Hyaluronic acid derivatives



- Sodium hyaluronate and hydrolysed hyaluronic acid
- Wound healing and strong moisturinzing properties
- Derivatives with improved skin permeation

Effectiveness against acute sun-induced damage

- Activate skin repair mechanisms
- Long-lasting moisturizing effect



In vitro, in vivo and *ex vivo* studies

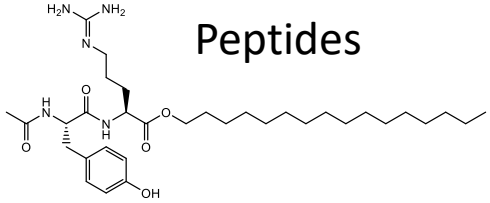
Gold, M.H.; Biron, J.A.; Wilson, A.; Nelson, D.B. Efficacy and tolerability of a hyaluronic acid-based serum and a peptide-rich cream for the face and neck in subjects with photodamaged skin. *J Cosmet Dermatol* **2022**, *21*, 3458-3463.

Results and discussion

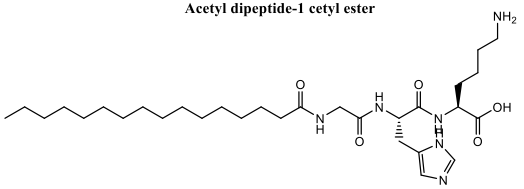
2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.3. Synthetic/ Semi-synthetic ingredients

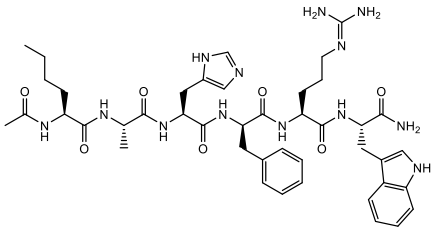
Peptides



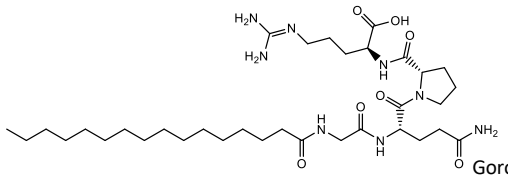
Acetyl dipeptide-1 cetyl ester



Palmitoyl tripeptide-1



Acetyl hexapeptide-1

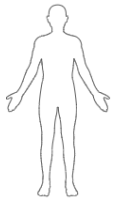


Palmitoyl tetrapeptide-7

- Mainly classified as "*messenger peptides*"
- Appeasing sensation and wound healing properties
- Signalling molecules able to activate fibbers production

Effectiveness against acute sun-induced damage

- Decrease of pro-inflammatory interuleukins and reduce hyperpigmentation
- Smooth wrinkles and improve skin texture



Clinical trial studies

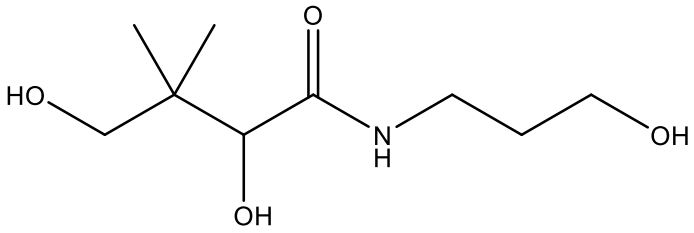
Gorouhi, F.; Maibach, H.I. Topical Peptides and Proteins for Aging Skin. In *Textbook of Aging Skin*, Farage, M.A., Miller, K.W., Maibach, H.I., Eds.; Springer Berlin Heidelberg: Berlin, Heidelberg, 2016; pp. 1-33.

Results and discussion

2. Scientific evidence about the efficacy the active ingredients found in aftersun products

2.3. Synthetic/ Semi-synthetic ingredients

Panthenol



- Easily converted into pantothenic acid
- Wound healing and moisturizing properties
- Anti-inflammatory activity

Effectiveness against acute sun-induced damage

- Reduce pro-inflammatory cytokine expression
- Reduce UV-induced erythema

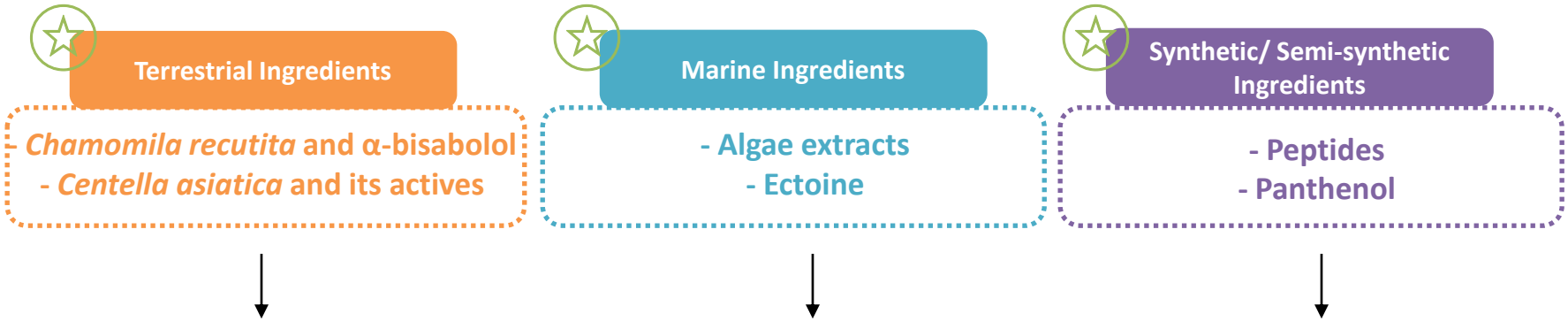
In vitro and *in vivo* studies

Chadwick, M.R. Panthothenic acid for skin: Benefits and how to use Available online: https://www.byrdie.com/panthenol-for-skin-the-complete-guide-4770218 (accessed on 07/07/2023).

Results and discussion

3. Some considerations about structure-activity relationships of the ingredients

- **Natural extracts from terrestrial sources are rich in polyphenols and flavonoids, while marine extracts contain alginates, polyssacharides, and polyphenols.**



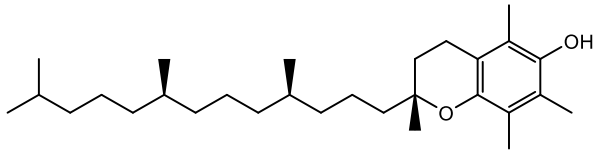
These most promising ingredients are highlighted due to their vast biological activities and ability to reduce clinical signs of sun-damaged skin

☆ The most promising ingredients

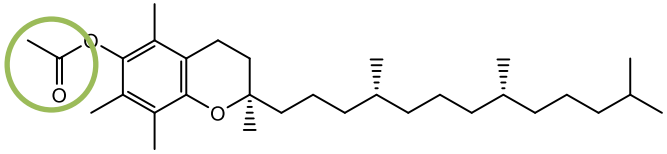
Results and discussion

3. Some considerations about structure-activity relationships of the ingredients

Modifications in the parent compound could facilitate crucial parameters during formulation process

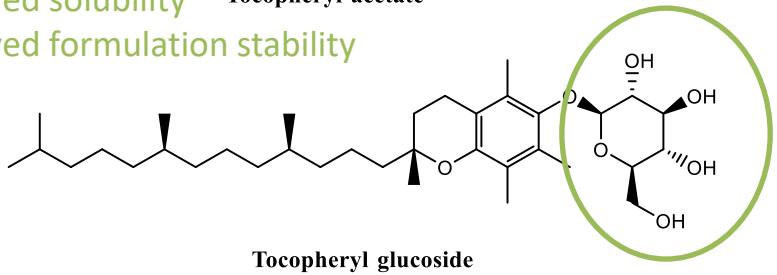


Alpha-tocopherol



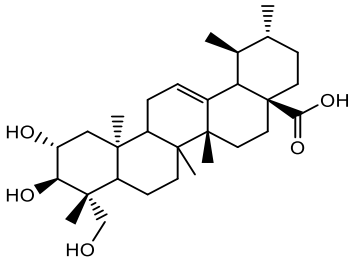
Tocopheryl acetate

Improved solubility
Improved formulation stability

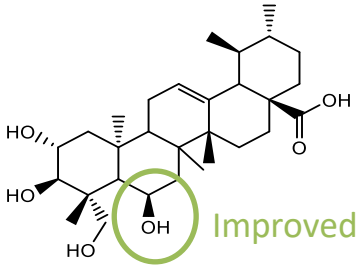


Tocopheryl glucoside

Improved solubility

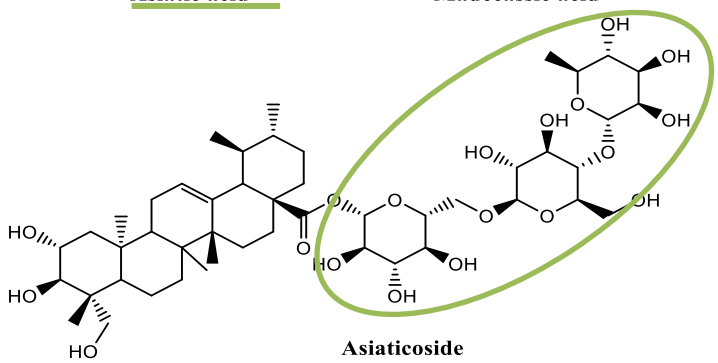


Asiatic acid



Madecassic acid

Improved solubility



Asiaticoside

Improved solubility
Improved formulation stability

Conclusions

Terrestrial Ingredients

Marine Ingredients

Synthetic Ingredients

Effectiveness against acute sun-induced damage

Confirmed by

In vitro, in vivo, ex vivo studies and clinical trial

1) Biological mechanism-oriented (antioxidant, anti-inflammatory,…)

2) Clinical effects-oriented (moisturizing, refreshing, decrease of wrinkles,..)

Highlighting…

Terrestrial Ingredients

Chamomila recutita and α-bisabolol
- *Centella asiatica* and its actives

Marine Ingredients

- Algae extracts
- Ectoine

Synthetic and Semi-synthetic Ingredients

- Peptides
- Panthenol

Acknowledgments

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