Avocado Peel Extracts in Topical Formulations

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The avocado fruit, a derivative of the avocado tree of botanical name *Persea americana* Mill.. Avocado peel is a cheap and promising option for the retrieval of phenolic compounds, and it was reported that this by-product possesses higher total phenolic content, radical scavenging capacity, and antioxidant activity compared to the pulp. These results highlight the possibility of obtaining sustainable cosmetics, reducing significantly the negative impacts on the environment by the incorporation of extracts sourced from the avocado peel, an interesting source of phenolic compounds, abundant and low-cost by-product.

by-products avocado peels Cosmetics

1. Introduction

Personal appearance is a requirement of great importance in all segments, leading the current population to valorise more their appearance and to look for the correct tools to create the allusion of the perfect appearance imposed by society. There is a close connection between a person's health and the use of cosmetics to beautify the skin and appear younger. Therefore, healthy-looking skin means skin that does not evidence exposure to degenerative effects, which contributes to a person being recognised as "beautiful" [1][2].

One of the most common ways to achieve beautiful and healthy skin is through the application of cosmetics. Skin is the largest organ in the human body, and it is constantly exposed to outer environmental conditions, such as pollution, and ultraviolet (UV) radiation, that can lead to extrinsic aging processes [3]. These processes are related to the emergence of wrinkles, skin dryness, loss of elasticity, and a rough-textured appearance due to the reduction of collagen, and hyaluronic acid, as well as the oxidation of certain molecules important to maintain a healthy skin appearance [4][5][6]. Therefore, it is essential to find ways to fight against them.

Skin hydration products are cosmetics whose purpose is to restore and maintain the levels of skin hydration, making it look prettier, healthier, and soft. Moisturising creams are the most common skin hydration products, with components such as humectants–compounds that have a lot of affinity with water and, therefore, attract it–and emollients –hydrophobic compounds that promote the formation of a lipid layer on the skin, preventing dehydration by occlusion [7]. Moisturising creams can be oil-in-water (O/W) or water-in-oil (W/O) emulsions, depending on which liquid is dispersed in the other. An O/W cream has water as a continuous phase, with some droplets of oil inside, whereas a W/O cream is the opposite, where the continuous phase is the oil. **Figure 1** shows the difference between an O/W and W/O emulsion.

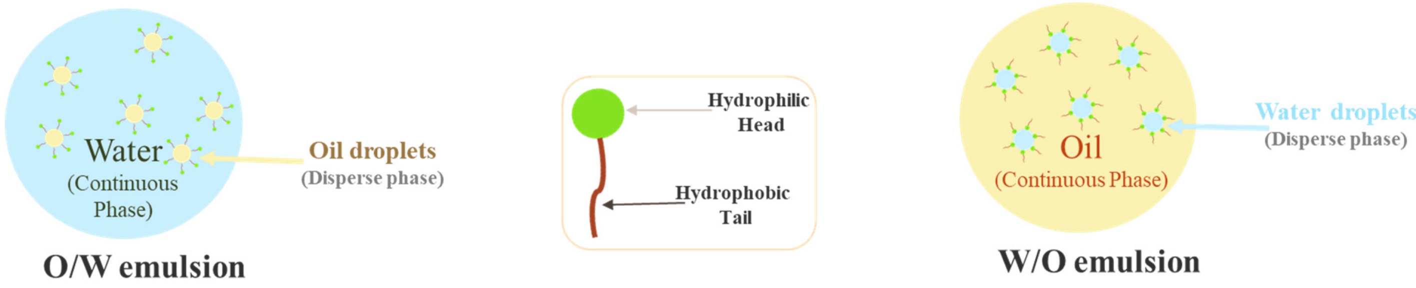

Figure 1. Oil in water (O/W) emulsion, and water in oil (W/O) emulsion.

Moisturising creams are usually composed of the following ingredients: solvent (that dilutes and disperses other ingredients), emollients, humectants, emulsifiers (responsible for the stabilisation of the emulsion), thickening agents, and neutralisers [8]. **Figure 2** shows the main ingredients present in cosmetics, as well as their function in the formulations, and some examples of the compounds commonly used.

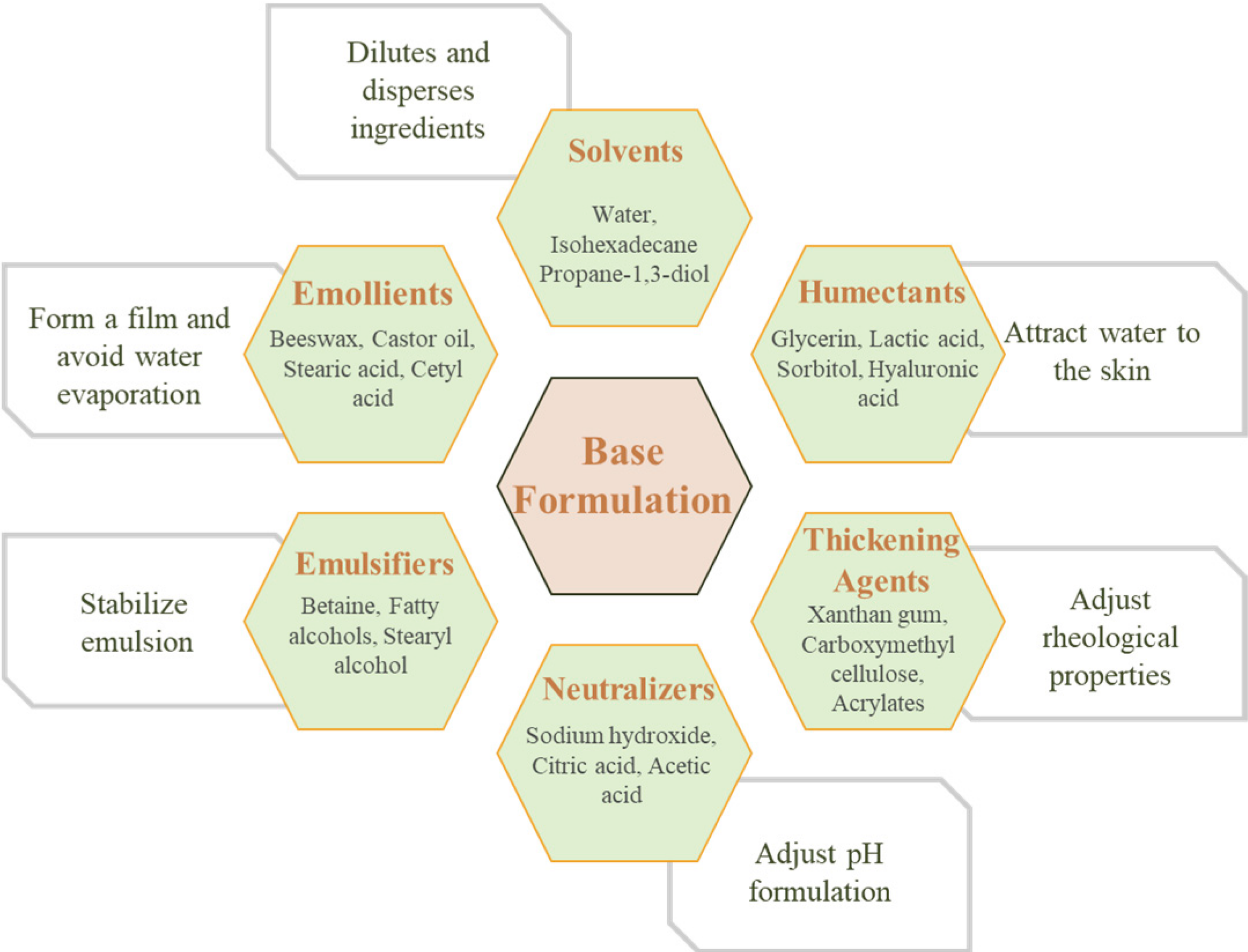

Figure 2. Base ingredients present in cosmetic formulations, some examples, and their function on the formulation.

Furthermore, in addition to the ingredients present in **Figure 2**, moisturising creams also have ingredients that act as formulation stabilisers, such as antimicrobial agents (used to prevent the growth of microorganisms, promoting product safety), chelating agents (which help to avoid the establishment of salt deposits, such as magnesium and calcium deposits), and antioxidants (preventing the oxidation of the product by delaying radical-chain reactions, and by avoiding this phenomenon they also avert the development of unpleasant smells) [9][10].

The cosmetic industry has been changing drastically over the past few years. Consumers express concern regarding skin aging, skin imperfections, and skin diseases, such as skin cancer and acne. These requirements have driven the investigation and innovation in this industry, and, as a response, new products are developed with the intention to help achieve pretty and healthy skin. Therefore, biologically-active ingredients–such as vitamins, enzymes, essential oils, antioxidants, and extracts of natural origin–were introduced in cosmetics. These ingredients establish new functions in cosmetics since they evidence antioxidant, antimicrobial, and antiaging properties, among others, and they are viewed as key constituents in skin protection [11][12][13].

Nowadays, consumers look for cosmetics mainly composed of natural ingredients and with fewer negative effects on the environment. Hereupon, researchers started to study the possibility of using the waste produced from food and plant processing to attain bioactive ingredients, mainly antioxidants, that prevent the oxidation of the product and help to reduce the oxidative damage of cellular components, and antimicrobial agents, ingredients that have antibacterial, antifungal, and antiviral properties [14][15][16]. This strategy has helped to develop greener and value-added cosmetics, as well as to reduce and recycle waste, diminishing their environmental, social, and economic impact. Moreover, this approach has in consideration all the important steps of the life cycle of the products, which follows the ideals behind the principle of circular economy [17][18].

Natural antioxidants and preservatives include different substances and extracts and can be achieved from a wide variety of plants, fruits, and grains, for example, green tea, grapeseed, blueberry, chestnut, and avocado. Polyphenols, flavonoids, and flavonols are some of the main natural antioxidants that can be found in plant extracts (including carotenoids and essential oils) [19][20]. This way, there is a possibility of natural antioxidants and preservatives, obtained from food and plant waste, being incorporated in cosmetics, and replacing the use of synthetic ones. Furthermore, the use of natural ingredients is also better perceived from the consumer’s point of view.

The avocado fruit, a derivative of the avocado tree of botanical name *Persea americana Mill*., is a tropical and subtropical pear-shaped climacteric berry native to Mexico and Central America. Avocado production has grown massively over the past years, making it a major agro-industrial commodity, with global productions reaching seven million tons in 2019, with Mexico being the largest avocado producer, and accounting for approximately 30% of all its production [21][22]. The majority of commercialised avocados are destined for the food industry, typically consumed as fresh fruit, as a sandwich filling, in a salad, or as sweetened desert. Processing of the pulp usually takes place to produce guacamole or avocado oil, with the avocado oil being used in the cosmetic industry, as well for the production of skin and hair care products, such as soaps and shampoos. After processing, the remnants of the fruit, namely seeds and peel that constitute approximately 33% of the fruit, are managed as solid waste, and because of their potential negative impacts on the environment, efforts are being made to promote the utilisation of these by-products [23][24][25].

Avocado peel is a cheap and promising option for the retrieval of phenolic compounds, and it was reported that this by-product possesses higher total phenolic content, radical scavenging capacity, and antioxidant activity compared to the pulp [26][27][28]. The majority of the phenolics present in avocado peels are flavonoids (such as catechins, procyanidins, and quercetins), and derivates of chlorogenic acid (such as caffeoylquinic acids, and coumaroylquinic acids) [29]. However, the phenolic profile of the peel varies greatly with the degree of ripeness of the avocado, as well as the country of origin and growth conditions that the fruit was subjected to [30].

Studies were conducted in order to characterise and evaluate the antioxidant and antimicrobial capabilities of avocado peel extracts. A study verified that different solvent extracts from the peels of two avocado varieties had a high number of phenolic compounds with elevated in vitro antioxidant potential, as well as moderate antimicrobial activity, especially towards Gram-positive bacteria. This entry also confirmed the antioxidant potential of avocado extracts in a real food product [31]. Another study revealed that, in general, avocado peel ethanol extracts of different avocado varieties displayed a wide range of high-level antimicrobial activity against Gram-positive and Gram-negative bacteria [32]. Herewith, the researchers suggested that avocado extracts may be used as natural additives in food products in order to extend their shelf life. In another study, the production of a tea based on avocado peels was evaluated and it was verified that phenolic and flavonoid compounds were present in the tea and that this exhibited a notable antioxidant capacity [33]. Overall, the mentioned studies indicate how the avocado peel can be used as an ingredient in cosmetic products. Up until the date of the publication of this manuscript, to the best of the researchers' knowledge, no study has been published that analyses the potential of avocado peel extract for cosmetic applications.

2. Extraction and Characterisation of the Avocado Peel Extract

The results of the extraction yields and antioxidant and antibacterial assays for the three extraction times evaluated are displayed in **Table 1**.

Table 1. Extraction yield, antioxidant, and antimicrobial capacity results for each extraction time.

		Extraction Time	
	1.5 h	3 h	4 h
	Yield (%)		
	19.49 ± 0.56	22.88 ± 1.06	22.24 ± 1.80
	Antioxidant Assay		
DPPH Inhibition (%)	93.92 ± 1.29	92.89 ± 0.77	91.18 ± 0.48
IC_{50} ($\mu g_{sample} \cdot mL_{DPPH}^{-1}$)	37.30 ± 1.00	38.23 ± 2.33	38.79 ± 0.70

Antibacterial Assay–Inhibition halos (mm)			
E. coli	<5.0	<5.0	<5.0
S. aureus	13.0 ± 0.0	12.7 ± 0.9	10.0 ± 0.8
S. epidermidis	14.0 ± 0.8	12.7 ± 0.5	9.3 ± 0.5

DPPH—2,2-diphenyl-1-picrylhydrazyl; IC50—the necessary concentration of extract to inhibit 50% of DPPH. The results are expressed as means ± standard deviations of n = 3 independent measurements.

From the results expressed in **Table 1**, it was verified that the extraction time that allowed the highest yield was the 3 h extraction. A statistical analysis of variance (ANOVA) of the yield results demonstrates that the difference in the extraction yields from 3 to 4 h is not very substantial ($p > 0.05$). Thereby, it is possible to conclude that, in a compromise between time and yield, the 3 h extraction allows for better results. The yields of this entry were greater than the yield values obtained in another study, for an ethanol Soxhlet extraction of avocado peels of the Hass variety, probably due to the difference in particle sizes and extraction time [34].

The DPPH inhibition percentages were very similar for the three extraction times ($p > 0.05$) but with a decrease in antioxidant capacity with increasing extraction times. The same behaviour was verified for the IC_{50} ($p > 0.05$). The 1.5 h extraction time was the one with the lowest IC_{50} value and highest DPPH inhibition percentage, hence, the one with the highest antioxidant capacity. Longer exposure times to high temperatures may have caused the loss of thermosensitive phenolic compounds, which would explain the reduction in antioxidant capacity with longer extraction times [35].

The results in **Table 1** show that the ethanolic APE of the Hass variety developed a considerable inhibition halo diameter against the strains *Staphylococcus aureus* and *Staphylococcus epidermidis* after 24 h of incubation, whilst for the *Escherichia coli* strain, almost no halo was observed. A literature study showed that for an ethanolic extract from avocado peels of the Hass variety, the antibacterial activity for *S. epidermidis* was not verified below a 0.5 $g{\cdot}L^{-1}$ concentration, while in the present study, the concentration of 250 $g{\cdot}L^{-1}$ was able to inhibit bacterial growth, suggesting that *S. epidermidis* inhibition is possible with higher extract concentrations [32]. In contrast, for *E. coli*, a higher extract concentration did not result in bacterial inhibition. The literature reports show that APE exhibits antibacterial activity against *E. coli*, but with different extraction solvents, which can explain the difference in results [36][37]. The phenolic compounds procyanidin A and B (derivatives of epicatechin) are the main ones responsible for the antibacterial activity in avocado peels [38]. Longer extraction times also compromised the APE antibacterial capacity evidenced by the decrease in the inhibition halo diameter values with increased extraction times for both *Staphylococcus* species. The ANOVA demonstrates a significant difference between the inhibition halo diameters of the three extraction times ($p < 0.05$) for both *S. aureus* and *S. epidermidis*.

In view of these results, the 3 h APE displayed a satisfactory compromise between the yield and antioxidant and antimicrobial capacities and, therefore, was the selected extract to be incorporated in the W/O and O/W formulations.

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