

Tea and Its Active Constituents in Cosmetics

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Tea plant itself and its extracts together with their centuries-old tradition of use play an important role on the cosmetics market. In general, cosmetics products containing tea extracts rich in polyphenols have a positive effect on the skin appearance and ameliorate skin damage, erythema and lipid peroxidation following UV exposure.

Keywords: tea plant ; skin care cosmetics ; dermatology ; *Camellia sinensis* (L.) Kuntze ; catechins ; Theaceae

1. Introduction

Cosmetics market continues to grow globally within the last decade. The growth of the upper middle class, an increasing number of senior citizens around the world and the expansion of online beauty spending and social networks, which certainly set new trends among the consumers, are all having an impact on an increasing interest in skin care products. Natural products as the cosmetics' ingredients are often associated with safety, marked activity and good quality. That is why a great interest in cosmetic products of natural origin can be observed ^[1].

Tea plant itself and its extracts together with their centuries-old tradition of use play an important role on the cosmetics market. In general, cosmetics products containing tea extracts rich in polyphenols have a positive effect on the skin appearance and ameliorate skin damage, erythema and lipid peroxidation following UV exposure ^[2]. An increasing number of cosmetics containing tea extracts, especially those produced using green tea infusions, but recently also black and white teas, encourage the authors to provide a review, that is focused on the application of tea in cosmetics. For the moment only a few review publications undertake the topic, however, the majority of them were published more than a decade ago. Due to this fact the authors found it necessary to prepare a more up-to-date manuscript that includes the information that have been spread in recent years, in the times of a constant and significant growth of the cosmetic industry ^{[2][3][4]}. Some of the above mentioned previously published references were also focused on the treatment of specific skin diseases only and represent rather dermatology than cosmetic applications ^{[5][6]}, or they described the activity of specific tea ingredients, e.g., caffeine ^[7] than the extracts per se.

2. The Chemical Composition of Tea Plant (*Camellia sinensis* (L.) Kuntze)

Tea plant is a rich source of bioactive components. According to the scientific literature it contains almost 4000 metabolites, among which the group of polyphenols constitutes a more than one-third share ^[8]. Tea infusions deliver approx. 2–3% flavonol glycosides (kaempferol, myricetin and quercetin), whereas their aglycones most often remain in the plant matrix upon water extraction due to their lower polarity. The flavanols present in tea infusions, also called catechins, constitute as much as 20–30% of tea's dry matter. They are responsible for its taste: bitterness and astringency ^[9]. The composition of tea varies depending on the fermentation process applied. Black tea contains (–)-epigallocatechin gallate (EGCG), (–)-gallocatechin gallate (GCG), (–)-gallocatechin (GC), (+)-catechin (C), (–)-epicatechin (EC), gallate (–)-epicatechin (ECG) and (–)-epigallocatechin (EGC) ^{[10][11][12]} in contrast to green tea that is rich in EGCG—present in the highest concentration, ECG, EC and EGC ^[13]. The differences in the composition of these two the most common types of tea is strictly related to the production process. To obtain green tea freshly harvested leaves of *Camellia sinensis* are treated with hot steam to prevent fermentation and are later subjected to drying. On the other hand, black tea is produced from the leaves, which are first dried, then rolled, ground and finally fermented. This is the fermentation process that induces the oxidation of polyphenols triggered by the influence of polyphenol oxidases ^[14]. This process results in the transformation of simple flavonoids (e.g., catechins) into more complex structures, like thearubigins (TR), theaflavins (TF) and theobrownins (TB) ^{[10][11][12]}.

Therefore, the catechins' concentration is inversely proportional to the degree of leaf processing ^[15]. Their highest content was noted in green tea, then in oolong tea and in the end-in black tea, which is due to a strong fermentation process that the latter type of tea is subjected to ^{[10][16][17]}. On the other hand black tea is a rich source of TR and TF ^[16] and oolong tea-of theasinensins and other condensed phenolic compounds ^[18]. TR, whose molecular weight is from 700 to 40,000

Da, gives the brew of black tea a taste and a reddish-black color [19]. In contrast, theaflavins are responsible for a golden yellow color of the infusion [9]. Catechins are certainly the best studied compounds of plant origin. However, still not much is known about the chemical structures and pharmacological properties of the catechins' conjugates, as they are difficult to identify and isolate from tea leaves. Some of the theaflavins have been, however, identified in tea extracts and include: 3-3'-theaflavin digalusate (TF3), theaflavin 3-gallate (TF2B), theaflavin 3-gallate (TF2A) and theaflavin (TF1) [20].

Different types of tea are also rich sources of simple phenolic compounds (gallic acid—GA, *p*-coumaric acid and caffeic acid) and their derivatives: theogalline and chlorogenic acid [21][22][23][24]. Other compounds present in tea include purine alkaloids (theophylline, theobromine and caffeine (theine)), amino acids, theanine [25], carbohydrates, lipids (linoleic and linolenic acids), volatile compounds, pigments (carotenoids and chlorophylls), vitamins (A, C, E, K and B) and chlorophylls [26]. It also contains numerous mineral elements such as iron, zinc, sodium, magnesium, chromium, phosphorus, potassium, titanium, manganese, nickel, copper, aluminum, silver and bromine [23][27][28][29][30][31]. The structures of tea main catechins and theaflavins were presented in **Figure 1**.

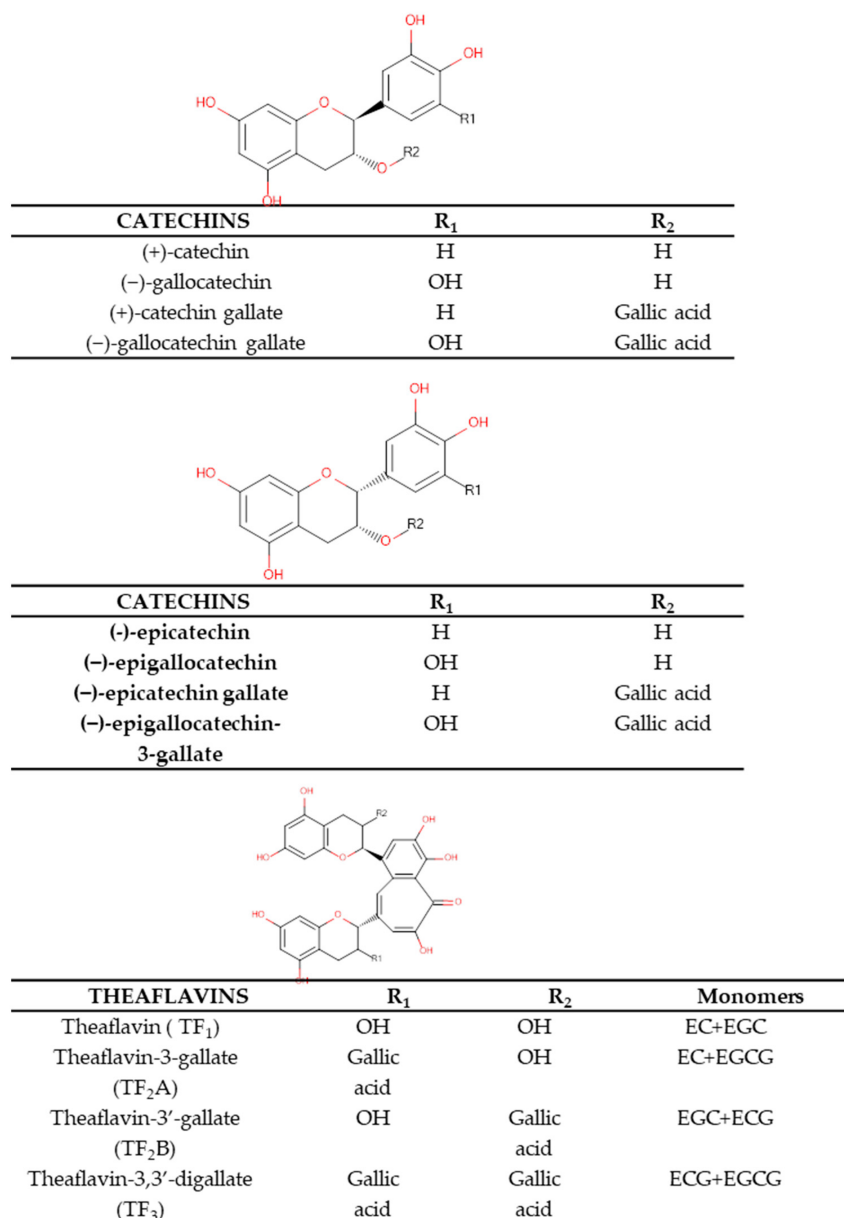


Figure 1. Chemical structures of the major secondary metabolites present in tea leaves.

3. The Application of Tea Extracts in Cosmetics

Tea extracts possess a wide spectrum of biological activities, which makes them precious components not only for pharmaceutical applications, but also for cosmetics industry. Among these activities antioxidant, photoprotective, anticellulite, slimming, improving skin, hair and microcirculation condition properties should be underlined (**Figure 2**). They will be further reviewed and discussed.

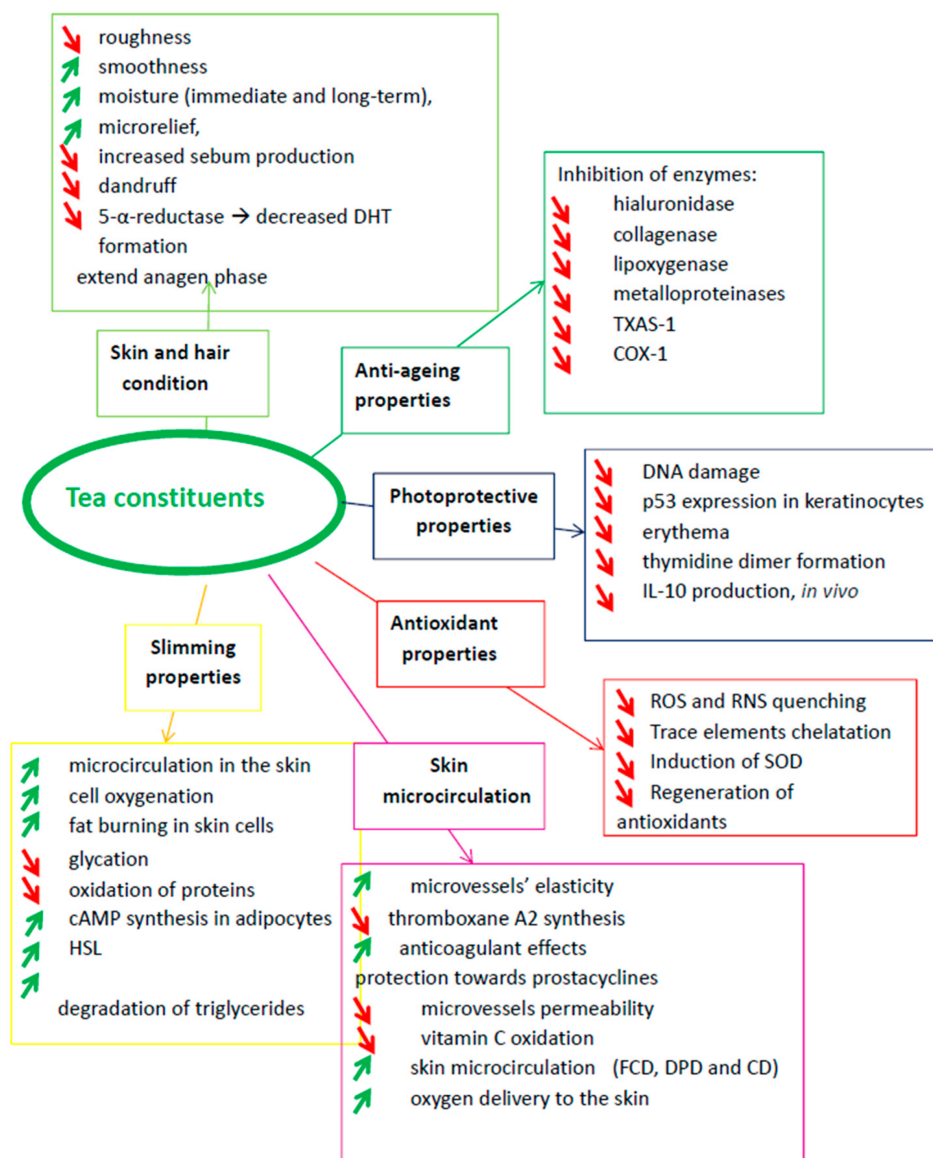




Figure 2. The major cosmetic properties of catechins (—stimulation, —inhibition).

4. Skin Penetration of Tea Active Constituents

The efficacy of cosmetic formulation is strictly correlated with the skin permeability of its active ingredients. One of the most important penetration-conditioning factors is the polarity of components. According to Yanagida and co-investigators [32] the partition coefficients ($K(\text{non-polar/polar})$) of green tea polyphenols can be placed in the following order: ECG (6.25) > EGCG (2.94) > EC(2.38) > C(2.33) > EGC(0.93). From all simple catechins present in tea extract EGC is considered as the most hydrophilic molecule, while ECG is characterized by the smallest polarity [32]. A study performed by Dal Belo and co-investigators [33] revealed that, after topical application of a green tea extract containing cream, EGCG was significantly retained within the skin, mostly in the stratum corneum, followed by the epidermis and dermis. This suggests a non-polar character of EGCG, as non-polar compounds tend to stay within the stratum corneum layer, and not penetrate into deeper parts of the skin, like the epidermis and dermis [34]. This is in agreement with a previous finding of Yanagida and co-workers, which also suggests a non-polar character of EGCG [32]. Zillich and co-investigators reported that both the size of the molecule as well as the hydrophobicity are the most crucial parameters regarding the ability of green tea catechins to penetrate the skin [6]. Definitely more experiments, especially in vivo and human studies, are needed to expand the knowledge on the bioavailability of tea polyphenols from cosmetic preparations.

Caffeine, a very important tea active constituent, is more often used as a hydrophilic model substance in skin penetration experiments. An in vitro study performed by Van de Sandt and co-workers [35] revealed that the maximal absorption rates of caffeine through the human skin were found to be $2.24 \pm 1.43 \mu\text{g}/\text{cm}^2/\text{h}$. The authors have also proved that the maximal absorption of this alkaloid was reached 100 min after percutaneous application in the human skin [36]. Touitou and co-investigators studied caffeine skin delivery by carrier design [37]. Using quantitative skin autoradiography they have confirmed the highest concentration of caffeine (280 $\mu\text{g}/\text{g}$ tissue) after 24 h in the epidermis, while the lowest amount of this alkaloid (50 $\mu\text{g}/\text{g}$ tissue) was detected in the dermis. However, the caffeine's ability to penetrate from different cosmetic

preparations through the skin barrier differs and is significantly correlated with the type of emulsion applied on the skin [38]. It occurs that its permeation mostly depends on the quantity of the formulation applied, rather than on the concentration of caffeine in the cosmetic formulation [39]. It was also proved that the composition of the cosmetic significantly affects caffeine absorption through the skin—water-in-oil nanoemulsion formulations were much more effective in comparison to aqueous solutions of caffeine, which was proved in Franz diffusion cells using rat skin as permeation membrane [40]. An effective way to transfer caffeine through the skin barrier was based on the application of microspheres in aqueous suspension (diameter of the microspheres: 2.8 µm, caffeine loading: 2.3 mg/g of particles). Such a formulation improved caffeine transfer across the skin, as microspheres easily penetrated the skin barrier and gathered in the receptor compartment, providing continuous alkaloid release [41][42]. Taking all into consideration it should be remembered that not only the quality of the tea extract or the concentration of caffeine, but first of all the composition of the cosmetic formulation is significant for the effectiveness of topical applications containing this alkaloid.

5. Skincare Products Containing Tea Extracts

Tea extracts are important components of many cosmetics, including creams, moisturizing lotions, tonics, shower gels, hair products as well as cosmetic facial masks. That frequent use of *Camellia sinensis* extracts is due to its multidirectional effect. From all types of tea extracts, those obtained from green tea are the most widely used. These are proposed not only for young and problematic skin types, as they inhibit excessive sebum production, but can also be used by people with sensitive and allergic skin [11][43]. However, on the market also cosmetic products containing black and white tea can be found and their popularity is increasing. Due to a many producers and cosmetic forms a large number of different products can be found and their exact number is hard to estimate, also because almost every year new products appear on the market. **Table 1** presents an example of 30 different cosmetics containing green, black and white extracts, including a type of a cosmetic form and manufacturer's recommendations.

Table 1. Selected examples of cosmetic products containing tea.

Tea Extract	Cosmetic Product	Cosmetic's Effects (Manufacturer's Declaration)	Production Area
Green tea	Peeling mask	- Improved skin regeneration based on the antioxidant, anti-inflammatory and toning properties of green tea	Poland
Green tea	Face mask	- Strong soothing, anti-inflammatory and regenerative properties - antioxidant activity - Protection against harmful environmental influences	Poland
Green tea	Face mask	- Eliminated excess sebum - Proper skin hydration	USA
Green tea	Shampoo	- Hair care for normal and slightly damaged hair - Antioxidant properties - Soothing action towards sensitive scalp (slightly moisturized and refreshed)	Poland
Green tea (Fuji)	Shampoo	- Hair care for normal hair - Refreshed and purified hair and scalp	UK

Tea Extract	Cosmetic Product	Cosmetic's Effects (Manufacturer's Declaration)	Production Area
Green tea (Matcha)	Shampoo	<ul style="list-style-type: none"> - Reduction of dandruff and greasy hair - Clarified and toned scalp - Intensive shine 	UK
Green tea	Shampoo	<ul style="list-style-type: none"> - Antioxidant in hair care (protection of hair against free radicals) - Hydrated and moisturized scalp 	Malaysia
Green tea	Hair conditioner	<ul style="list-style-type: none"> - Hair care for all hair types - Protection against moisture loss - Strong antioxidant and hair growth stimulant properties - Smooth and soft hair 	UK
Green tea	Hair conditioner	<ul style="list-style-type: none"> - Strengthens hair - Antioxidant properties towards hair 	Japan
Green tea	Hand and Body Lotion	<ul style="list-style-type: none"> - Nourishing cream for feet, hands and body - Makes the skin smooth and hydrated 	USA
Green tea	Body lotion	<ul style="list-style-type: none"> - A fresh fragrance - Refreshing body and mind - Improved mood 	USA
Green tea	Balancing lotion	<ul style="list-style-type: none"> - Superior hydration and nourishment of the skin - Softened and smoothed, cleansed skin leaving 	USA
Green tea	Refreshing body lotion	<ul style="list-style-type: none"> - Hydrated skin - Skin fragrance for a long time 	USA
Green tea	Body cream	<ul style="list-style-type: none"> - Nourished and moisturized skin - Smoothed skin - Soft and flexible skin - Skin care for all skin types 	USA
Green tea (Fuji)	Hand cream	<ul style="list-style-type: none"> - Nourished hands' skin - Softer and smoother hands 	UK

Tea Extract	Cosmetic Product	Cosmetic's Effects (Manufacturer's Declaration)	Production Area
Green tea (Matcha)	Hand cream	<ul style="list-style-type: none"> - Skin care for all skin types - Nourished and moisturized skin of the hands 	UK
Green tea	Eye cream	<ul style="list-style-type: none"> - Removed six types of wrinkles under the eyes - Improved production of hyaluronic acid by epidermal cells - Restored moisture in the skin to fill fine lines in dry skin 	Japan
Black tea	Face mask	<ul style="list-style-type: none"> - Nourished and smoothed skin - Antioxidant properties towards the skin 	USA
Black tea	Instant perfecting mask	<p>Black tea complex:</p> <ul style="list-style-type: none"> - Protection against harmful effects of the environment - Reduction of the skin roughness, improved glow and elasticity - Softened, smoothed and soothed the skin 	EU
Black tea (Darjeeling tea)	Antiwrinkle cream	<ul style="list-style-type: none"> - Protection against any harmful environmental factors - Moisturized and revitalized skin 	South Korea
Black tea	Shampoo	<ul style="list-style-type: none"> - Everyday shampoo for all types of hair - Removed build-up and excess oils 	UK
Black tea	Lotion	<ul style="list-style-type: none"> - Hydration and the look of firm, radiant skin - Provided SPF 20 UVA/UVB sun protection - Protection against UV and free radicals-induced damage <p>Recommended for:</p> <ul style="list-style-type: none"> - Dryness - Dullness/uneven texture - Loss of firmness/elasticity 	EU
Black tea	Body cream	<ul style="list-style-type: none"> - Antioxidant benefits towards the skin - Smoothed and moisturized the skin 	USA

Tea Extract	Cosmetic Product	Cosmetic's Effects (Manufacturer's Declaration)	Production Area
Black tea	Firming corset cream	Black tea complex:	EU
		- Firms and redefines the contours	
		- Prevents loss of elasticity and smoothness	
		- Makes the skin look healthier and younger	
		- Protects the skin against free radicals	
Black tea	Eye concentrate	Black tea complex:	EU
		- Firmed and redefined eye contour	
		- Increased elasticity and smoothness	
		- Healthier and more youthful appearance	
Black tea	Hand cream	- Hand skin care for all skin types	UK
		- Regenerated and smoothed the skin	
White tea	Body cream	- Softened and hydrated skin	USA
White tea	Shower gel	- Refreshed and softened fragrant skin	USA
White tea	Toilet water	- Fragrant skin	USA
White tea	Hand cream	- Alleviated rough patches and calluses	USA

According to Możdżeń and co-workers, who analyzed the plant species, which are used to produce cosmetic masks offered on the Polish market, *Camellia sinensis* is the most commonly used, followed by *Matricaria chamomilla* L. and *Vitis vinifera* L. [44].

After applying cosmetics containing tea extract, the skin appears more tense and refreshed, which is the result of astringent activity of polyphenols and tannins and their interaction with keratin present in the stratum corneum. This process also leads to a reduction in skin redness, irritation and reduction of swelling. The facial masks, containing mainly green tea extracts, have a disinfecting, antioxidant and toning effect. They also soothe inflammation, accelerate the healing of wounds and skin eruptions, and also close skin pores by which they reduce their visibility [44].

Tea infusions are also used as compresses, which are applied after insect bites [45] or to soothe the itching and burning around the eyes.

The latter effect results from the vasoconstriction induced by the metabolites of tea plant and is shown up as a noticeable reduction of swelling around the eyes, which is often observed during inflammation [11][45].

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