

Flavonoids in today's cosmetology

Flavonoids are naturally occurring compounds, widely distributed in fruits, vegetables, seeds, nuts, flowers and beverages such as tea and red wine.

They are polyphenolic molecules, diverse in chemical structure and biochemical properties.

Flavonoids can occur in nature in the form of aglycone or glycoside – the general formula of these compounds is shown in Figure 1.

Having diverse functions, flavonoids have been extensively studied using biochemical, molecular and genetic approaches.¹ They have been shown to possess various biological properties, many of which can be related to their antioxidant, free radical scavenging and metal-chelating activities.^{2,3} The molecular mechanisms underlying effects are the consequences of the chemical heterogeneity and the wide range of pharmacodynamic properties.

Flavonoids have been recognised as possessing anti-inflammatory, antimutagenic, antiallergenic and antioxidant activities.⁴

It has been widely documented that the process of lipid peroxidation can be inhibited by these compounds at the beginning as well as at the termination state. They have been shown to have influence on a wide spectrum of enzymes – what is strictly related to their metal-chelating ability, and also on the microvessel system.^{5,6,7}

To sum up, flavonoids are compounds that display significant effects on all human organisms, including the skin.⁸



Green tea plant (*Camellia sinensis*).

The valuable features of flavonoids described already makes them priceless for the cosmetic industry. Over the last ten years, extracts containing these compounds have become an integral part of many cosmetic formulations.

Cosmetic application of plant extracts containing flavonoids

Herbal extracts have been applied in medicine, pharmacy and skin care since the ancient times. Extracts for cosmetic use must be aesthetic, acceptable in terms of odour and colour and, moreover, free from toxic chemicals.⁹

The quality and composition of the extract depends on the plant origin, season, climate, extraction method and many other factors. Extracts containing flavonoids are manufactured from flowers, roots, leaves, seeds and nuts of many different plants and appear to be a very valuable for the cosmetic market. Some of these extracts, their composition, characteristic features and cosmetic application are described below.

Green Tea (*Camellia sinensis*)

Tea is widely cultivated around the world. Black tea, green tea and Oolong tea are known as three major kinds of manufactured teas and green tea appears as the richest in flavonoid compounds.¹⁰

As previously mentioned, the composition of an extract depends on many factors and therefore green tea extracts available on the market can differ from each other.

Flavonoids and skin care

The skin is one of the most important organs of the body and creates a first line of organism defence against the external environment. Scientific research has confirmed a wide influence of flavonoid compounds on various levels of the skin.

The uppermost layer of the skin, the *stratum corneum*, is a structure very rich in lipids and other easily oxidisable compounds. In this layer flavonoids can play an efficient role as anti-oxidising agents and free radical scavengers. Their antioxidant properties enable them to influence deeper, epidermal skin layers, preventing UV radiation damage and inhibiting some enzyme functions. In the dermis, the deepest skin layer, flavonoids influence the permeability and fragility of the microvessel system.

Figure 1: Aglycone/glycoside.

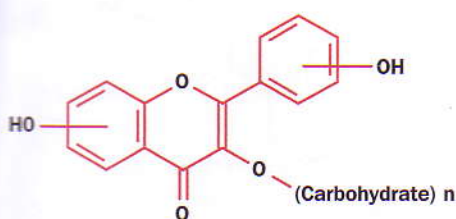


Figure 2: Carbon 2.

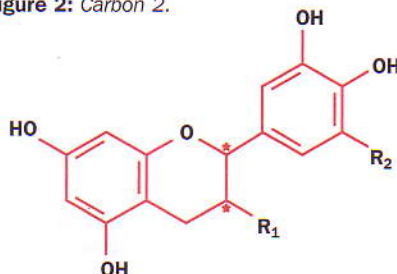
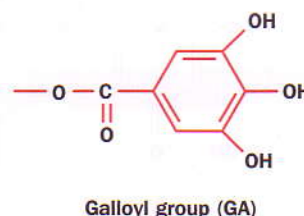


Figure 3: Carbon 3.



Generally, fresh green tea leaves can contain about 20% to 35% of polyphenols (dry weight). The composition of the green tea plant varies according to the age of leaves, the season and the climate.¹¹ The major components of green tea extract are catechins, and the formula of catechin and derived compounds of different configuration on carbon 2 and 3 is illustrated in Figures 2 and 3 and in Table 1.

During the fermentation process of green tea, oligomerisation of catechins can be observed.

The most abundant polyphenol in green tea is an (-) epigallocatechin gallate (EGCG).

Catechins discovered in green tea have been shown to display a variety of physiological functions. It has been well established that they are able to inhibit mutagenicity induced by many chemicals (including those in cigarette smoke condensate). It is commonly known that their anticarcinogenicity is based on an ability to inhibit some enzyme activity. It has been determined that they block certain carcinogens from binding to DNA, as well as acting as a free radical trap. It is also to be noted that their antioxidant properties and prevention of lipids from oxidation are of particular interest from the cosmetological point of view.¹²

The green tea catechins display very high superoxide and hydrogen peroxide radical scavenging activities. The antioxidant potency of particular green tea

Table 1.

Catechin name	Configuration	R ₁	R ₂
(+)-epicatechin	2S, 3R	OH	H
(+)-catechin	2R, 3S	OH	H
(-)-epicatechin	2R, 3R	OH	H
(-)-catechin	2S, 3R	OH	H
(-)-epigallocatechin	2R, 3R	OH	OH
(-)-gallocatechin	2S, 3R	OH	OH
(-)-epicatechin gallate	2R, 3R	GA	H
(-)-catechin gallate	2S, 3R	GA	H
(-)-epigallocatechin gallate	2R, 3R	GA	OH
(-)-gallocatechin gallate	2S, 3R	GA	OH

extract components is different for each chemical species and reaches the highest value for (-) epigallocatechin gallate and (-) epigallocatechin. It is lower for (-) epicatechin gallate, while an (-) epicatechin displays only little antioxidant potency. These particular properties can be related to the lipoxygenase inhibition activity of catechins. Scientific studies in this area have shown that reactive oxygen species are produced on the lipoxygenase pathways in the metabolism of arachidonic acid. It is known that (-) epigallocatechin gallate, (-) epigallocatechin, and (-) epicatechin gallate display high lipoxygenase inhibition ability, while there is only little effect observed for (-) epicatechin.

The structure-activity relationships play a very important role in the scavenging

processes and it is generally known that catechins possessing multiple hydroxyl groups exhibit better antioxidant activity than these possessing only one hydroxyl group in the structure. Catechins having hydroxyl groups in ortho configuration can take part in chelation of metal ions that enables them to influence enzyme activity.

According to the exceptional properties described above, green tea extracts have found a wide application in the cosmetic field. Having these attributes in view, producers of cosmetics widely employ green tea extracts in many different cosmetic formulations such as lotions and creams. The presence of these compounds improves the appearance of the skin, and the compounds are widely used in anti-acne

Figure 4: Peonidin.



Figure 5: Ginkgetin.

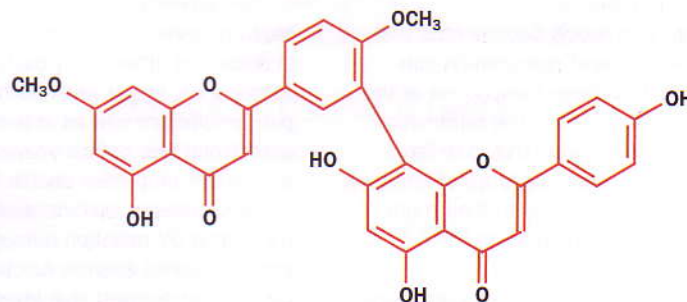


Figure 6: Isoginkgetin.

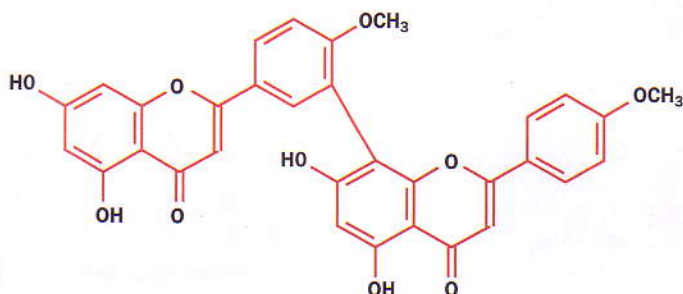
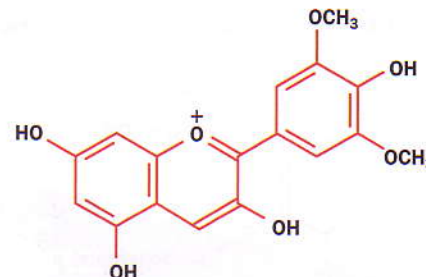


Figure 7: Malvidin.



products, lotions and formulations developed for greasy skin. Because of the antioxidant activity of green tea catechins, extracts are found in a wide range of applications for day and night anti-ageing formulations. The magnificent properties of green tea enable a wide application in hair care cosmetics to be achieved as well. The producers of cosmetics recommend an application of this extract in the amount of 0.1% to 1%.

A cosmetic formulation containing green tea extract is shown in Table 2.¹³

Grape leaves and seeds (*Vitis vinifera*)

The grape plant originates in Asia Minor and is widely grown. Flavonoids from grape leaves and seeds have been described fully in the literature.¹⁴ Polyphenols of this plant are represented mainly by anthocyanins and proanthocyanidins that are catechin oligomers.

Peonidin, cyanidin, delphinidin and petunidin appear to be the most common flavonoid aglycones in the anthocyanin structure. Other flavonoid compounds widely found in grape extracts are kaempferol, quercetin, rutin and myricetin as well as catechin, epicatechin and gallicocatechin. The structure of the most characteristic aglycone for this extract peonidin is shown in Figure 4.

It has been documented that both anthocyanins and proanthocyanidins of grape origin display a wide spectrum of biochemical properties. They possess a haemostatic effect that leads to a decrease in platelet reactivity and are known to secure very high protection against cardiovascular diseases. Proanthocyanidins are proven to play a natural antioxidant role that is of particular interest from the cosmetological point of view. Compounds such as catechin



Ginkgo biloba (*Ginkgo biloba*).

Table 2: Hand lotion formulation.

Green tea extract	0.1%
Hydrogenated lecithin	0.3%
Etoxylated phytosterol	0.7%
Cyclomethicone	2.0%
Glycerol	10.0%
Methyl parahydroxybenzoate	0.3%
Distilled water	q.s. for 100%

Table 3: Body care cream.

Glyceryl stearate	2.0%
Etoxylated sorbitan monostearate	1.0%
Cetyl alcohol	0.5%
Stearic acid	1.4%
Triethanolamina	0.7%
Carbomer	0.4%
Karite fat	12.0%
Synthetic perhydrosqualen	12.0%
Ginkgo extract	1.0%
Distilled water	q.s. for 100%

oligomers are known to work as very reactive free radical scavengers, more efficient than the monomeric (+) catechin and (-) epicatechin forms.

Researchers suggest that the scavenging capacity of proanthocyanidins increases with the number of hydroxyl groups in the B ring. These compounds are also known to prevent the lipid peroxidation process. Due to their strong chelating properties for free iron, which is a catalyst that exacerbates the peroxidative damage through decomposition of performed lipid hydroperoxides, they are able to protect preformed peroxidised lipids from further decomposition. Proanthocyanidins are known to inhibit some enzyme activity (elastase, collagenase and hyaluronidase) that makes them valuable for the cosmetic market. It is also proven that proanthocyanidins of grape origin display a co-interaction with chemical UV filters, suggesting potential use as co-ingredients in sunscreen products, to increase their efficacy.

With a high quantity of quercetin and rutin, the grape leaf extract displays an influence on the microvascular system of the dermis as well. These compounds are known to be helpful in capillary fragility and varicose vein treatment.

Over the last 20 years, grape leaf extract has become a very common ingredient of skin tone-up lotions, antiseptics, refreshing and soothing products as well as anti-ageing and anti-wrinkle formulations.

Ginkgo biloba (*Ginkgo biloba*)

The Ginkgo tree is a plant of Asian origin. With a high level of rutin, this plant is widely used as a capillary fragility preventing agent as well as a compound that decreases blood pressure. The presence of quercetin and kaempferol secures a very high antioxidant activity. It is to be noted that Ginkgo extract contains many other substances, from which the most characteristic appear to be ginkgolides. The final result obtained by an application of Ginkgo extract is a complex effect, depending on the activity of substances accompanying flavonoids.¹⁵

In 1941, Japanese scientists discovered a very characteristic species named ginkgetin. Ginkgetin, called also amentoflavone 7,4'- dimethyl ether, turned out to be a compound based on the linkage of two flavone nuclei that created a biflavonoid molecule, composed of two dimethyl ethers of apigenin. The formula of ginkgetin is shown in Figure 5.

The second characteristic compound of the Ginkgo extract is isoginkgetin, that is known also as amentoflavone 4', 4''- dimethyl ether, and the structure is shown in Figure 6.

These flavonoids are directly responsible for the very good antioxidant properties of the *Ginkgo biloba* extract.

With its features, *Ginkgo biloba* extract is used widely in cosmetic formulations, especially in anti-wrinkle products as well as in cosmetics developed for skin with microvascular problems.

Considering its high level of the free radical scavengers, the Ginkgo extract is widely applied in anti-ageing and sun care cosmetics. In view of its high percentage of quercetin and rutin, this extract is a very common ingredient in anti-varix ointments.

The formulation shown in Table 3 is for a body care cream containing *Ginkgo biloba* extract.

Arnica (*Arnica montana*)

Arnica montana, called also marigold of the Alps, is a mountain plant widely found in the German and French Alps.

Arnica flowers contain a wide spectrum of flavonoids – the most significant roles are played by quercetin, isoquercetin, rutin, kaempferol-3-O-glucoside and apigenin-7-O-glucoside.

Due to the presence of the compounds

Table 4.

Flavonoid	R
Kaempferol	OH
Trifolin	O-gal
Panasenoside	O-glu-gal

Figure 8: Apigenin.

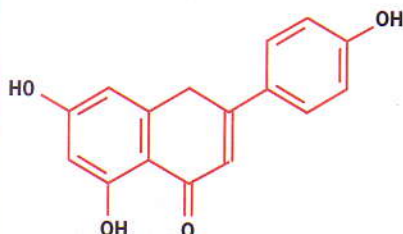


Figure 9: Luteolin.



Figure 10: Ginseng.



mentioned above, their antioxidant properties and the healing effect of the extract, *Arnica montana* has found a wide application in cosmetic and pharmaceutical sectors, especially in products for skin with microvascular problems and in cosmetics developed for swollen legs. It is used in skin care products, mainly in day and night moisturising creams and anti-ageing cosmetics, as well as in hair care products having anti-dandruff properties.

Horsetail (*Equisetum arvense*)

The origin of the name of the plant comes from its horse tail appearance. The plant contains an enormous amount of silica and potassium. Flavonoids that can be found in horsetail are isoquercitrine and some kaempferol glycosides.

The horsetail extract is manufactured from leaves of the plant and plays the role of a very good hair stimulant. The extract tones up the scalp and possesses strong antiseptic properties. It has been documented that it stimulates synthesis of elastin and collagen and influences some activity of enzymes. In view of these properties, as well as moisturising, anti-radical, and anti-irritant features, the horsetail extract has found an application in skin care cosmetics. With its sebaceous secretion reducing properties, it is widely used in cosmetics developed for greasy skin.

Mallow (*Malva sylvestris*)

Malva sylvestris is a plant that can be easily found in Europe and Asia. The very characteristic flavonoid of this plant is malvidin 3,5-di-O-glucoside and other flavonoids based on the aglycon named malvidin that belongs to a group of anthocyanins. The structure of malvidin is shown in Figure 7.

Apart from malvidine's derivatives, some more common flavonoids are abundant in the mallow flowers as well. Presence of quercetin, myricetin, rutin and kaempferol secures good anti-irritant and anti-oxidant properties.

Extracts obtained from flowers and leaves of *Malva sylvestris* are applied in cosmetic formulations as emollient,

moisturising, anti-irritant, anti-ageing and softening agents. There is wide application in anti-wrinkle day and night creams, in after-sun lotions, and in all kinds of formulations developed for dry skin.

Roman chamomile (*Anthemis nobilis*)

The plant is also called chamomile or medicinal chamomile. *Anthemis nobilis* blossom contains a large number of flavonoid compounds such as apigenin, apigenin-7-glucoside, luteolin and quercetin. Formulas of apigenin and luteolin are shown in Figures 8 and 9.

Chamomile extract, manufactured from the flower part of the plant, displays a disinfecting, anti-inflammatory and anti-dandruff role that makes it very valuable in shampoos and other hair care products. The *Anthemis nobilis* extract is very common in soaps, bath products, tonics and in under-eye emulsions. In view of the magnificent anti-oxidant properties of flavonoids mentioned above, it is widely used in sun protection products and in after-sun emulsions.

Matricaria (*Matricaria chamomilla*)

Matricaria chamomilla is named also as wild chamomile or German chamomile. Flavonoids of this plant are very similar to the compounds abundant in Roman chamomile – apigenin appears to be a compound of the highest level. There

has been a recent surge of interest in *Matricaria chamomilla* because of the presence of bisabolol and chamazulene – compounds that secure an anti-inflammatory effect with the extract. In view of the presence of these compounds, the activity of flavonoids appears to be just assisting.

Extracts produced from *Matricaria* are, for various reasons, very widely applied in hair care cosmetics as well as in cleansing products, creams, soaps and, in view of the bisabolol presence, in baby care products.

Calendula (*Calendula officinalis*)

Calendula officinalis is widely cultivated in many regions around the world. Extracts applied in cosmetics are produced from flowers of the plant. The most common flavonoids of *Calendula* are rutin and quercetin that guarantee good free radical scavenger properties. The isorhamnetin-3-glucoside, that appears to be a very characteristic chemical of this plant, ensures an anti-inflammatory and soothing effect.

The *Calendula officinalis* extract has found an application in almost all kinds of cosmetics. It is widely used in sun care cosmetics, after-sun products, anti-acne formulations, lotions, anti-dandruff shampoos, and emulsions developed for irritated, chapped and grazed skin.

Linden (*Tilia platyphyllos*)

Tilia platyphyllos is a tree seen widely across Europe, and is especially easily found in oak forests. The presence of commonly known flavonoids such as quercetin and rutin secures the moisturising, softening and anti-oxidising properties of the linden extract.

Apart from the flavonoid compound mentioned, the very common structures are catecholic tannins as well as phloroglucinol that are responsible for the scavenging properties of the extract.

The linden tree extract is manufactured from the sapwood and causes softening of the skin, reduces acne, attenuates wrinkles and displays magnificent properties in cases of burns. In view of these beneficial features, the linden



Ginseng (*Panax ginseng*).

Table 5: Summary of characteristic features of extracts which contain flavonoids and which are mentioned in this article.

English name	Latin name	Plant material used in extract	Characteristic flavonoids	Most common cosmetic applications
Green tea	<i>Camellia sinensis</i>	Leaves	Catechins, rutin	Anti-ageing cosmetics, hair care
Grapes	<i>Vitis vinifera</i>	Seeds, leaves	Anthocyanins, proanthocyanidins	Skin care, heavy legs treatment
Ginkgo biloba	<i>Ginkgo biloba</i>	Leaves	Ginkgetin, isoginkgetin	Anti-ageing cosmetics, greasy skin treatment
Horsetail	<i>Equisetum arvense</i>	Leaves	Isoquercitrine, kaempferol glycosides	Hair care cosmetics
Arnica	<i>Arnica montana</i>	Flowers	Quercetin, apigenin-7-glucoside	Anti-dandruff shampoos, moisturising creams
Mallow	<i>Malva sylvestris</i>	Flowers	Malvidin and its derivatives	Under-eye cosmetics, after-sun lotions
Roman chamomile	<i>Anthemis nobilis</i>	Flowers	Apigenin-7-glucoside, luteolin	Hair care, soothing cosmetics
Matricaria	<i>Matricaria chamomilla</i>	Flowers	Apigenin-7-glucoside, luteolin	Hair care, baby care products
Calendula	<i>Calendula officinalis</i>	Flowers	Isorhamnetin-3-glucoside, rutin	Anti-dandruff shampoos, sun care
Linden	<i>Tilia platyphyllos</i>	Sapwood	Quercetin, rutin	Hair care, anti-acne cosmetics
Ginseng	<i>Panax ginseng</i>	Roots	Ginseng saponins	Anti-wrinkle products, after-sun cosmetics
Cornflower	<i>Cenaurea cyanus</i>	Flowers	Rutin, anthocyanosides	Hair products, sun care cosmetics
Cypress	<i>Cupressus sempervirens</i>	Fruits	Catechin tannins	Products to counter heavy legs

extract is commonly applied in gels, emulsions, beauty masks, lotions, sun care and hair care products.

Ginseng (*Panax ginseng*)

The Ginseng plant originates from the north-east regions of China.¹⁶ The main components of the plant are ginseng saponins that secure moisturising and regenerating effects, and quercetin and rutin that have anti-oxidising properties. The most characteristic flavonoids of the extract are based on the structure shown in Figure 10 and Table 4 and named kaempferol, trifolin and panasenoxide.

It has been widely documented that ginseng can activate the skin metabolism, reduce keratinisation, moisturise and soften, alleviate wrinkling as well as activate dermal blood circulation. The cell proliferation resulting from the increased metabolism leads to the anti-ageing effect that is very valuable for cosmetics.

The ginseng extract is produced from the root part of the plant and is commonly applied in anti-ageing, anti-wrinkle and after-sun products. Many cosmetics developed for preventing hair loss and dandruff, for promoting scalp circulation, and for creating a glossy finish on hair, contain a Ginseng extract.

Cornflower (*Cenaurea cyanus*)

The flavonoids found in cornflower blossom extract are mainly rutin and anthocyanosides. Due to its properties, the cornflower extract displays strong anti-inflammatory properties and can be used as an astringent and free radical scavenging agent.

The extract manufactured from *Cenaurea cyanus* has found a particular application in hair care products and in sun care formulations.

Cypress (*Cupressus sempervirens*)

Cupressus sempervirens extract, which has found a wide application in the cosmetic market, is manufactured from cypress fruits. Due to the procyanidol presence, it provides anti-bacterial and antiseptic properties. Its astringent and vasoconstrictive features are strictly related to the presence of catechin tannins.¹⁷

It has been shown that cypress works as an astringent by tightening up blood vessels, and this makes it very useful in formulations to counter "heavy legs".

Summary

Flavonoids are compounds widespread in the plant kingdom and they have unique cosmetic properties. As a result of their magnificent influence on different skin layers, extracts containing flavonoid compounds are of particular interest in the cosmetic industry. Flavonoids have to be treated as integral parts of extracts and it is to be noted that their activity depends also on the presence of other components and should not be investigated separately. It has been proven that flavonoids are able to penetrate different skin layers. The permeation ability of flavonoids depends on many different factors and the penetration rate can be decreased or increased by the presence of other substances in the system.¹⁸

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