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Analysing the anti-ageing activity of tea

Tea is one of the most consumed beverages in the world and it has been popular for over 4000 years. Its popularity is attributed to the sensory properties and potential health and anti-ageing benefits. Tea was first introduced into European countries from China by Portuguese and Dutch explorers.[1] A wide spectrum of biologically active substances present in this plant has resulted in wide application in cosmetology. At the present time, one of the most important trends in modern cosmetology is the application of active substances of natural origin. Raw materials of plant origin possess a wide spectrum of multidimensional activity and can impart many beneficial properties to the cosmetic product. The field of cosmetology is also interested in plants that have been used for many years in traditional medicine as well as hunting for completely new raw materials.

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Camellia sinensis.

Various kinds of teas are produced mainly from the same plant species, *Camellia sinensis*. However, the word 'tea' is very often applied also to other plants that can be used in preparation of hot beverages from leaves or flowers. Thus, the name 'tea' is used also very often used for rooibos tea (the beverage obtained from the South African plant *Aspalathus linearis*) or honey-bush tea (*Cyclopia intermedia*). Tea has been made from plants used by Man for many years for different purposes, including cosmetics. The leaves of *Camellia sinensis* are a very rich source of anti-radical substances which has resulted in a wide application of this plant in anti-ageing formulations.

Fermentation process

According to the manufacturing process four different kinds of tea are distinguished – black, oolong, green and white. The classification of the tea depends on the degree of fermentation: fully fermented black tea, partially fermented ollong tea, unfermented green tea and unfermented white tea manufactured from buds.

To produce the green tea, the leaves of *Camellia sinensis* are harvested and subjected to withering. After this process leaves are steamed or panfried and then rolled, shaped and dried. Steaming at 95˚C to 100˚C for 30-45 seconds inhibits enzymes which are responsible for fermentation, hence the green tea belongs to unfermented teas. This method is used mainly in Japan, while the Chinese method is based mainly on roasting.

The fermentation process does not require microbiological activities. The main difference between manufacturing of green and black tea is the additional step in the case of black tea: the leaves are bruised and crushed which induces the process of fermentation.[2] The substances responsible for this process are oxidising enzymes contained in tea leaves –mainly polyphenol oxidase. In the presence of polyphenol oxidase, catechins present in high levels in green tea are converted into theaflavins,

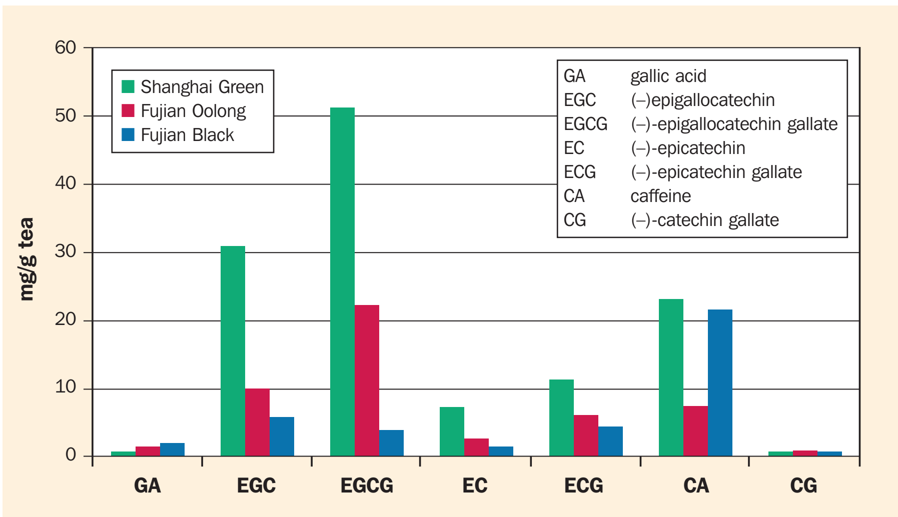


Figure 1: *Levels of individual catechins, gallic acid and caffeine in teas.*

thearubigins and other complex polyphenols which are characteristic of fermented teas.[3] The degree of fermentation is responsible for biological properties such as taste and the aroma of the tea. Carotenoids and unsaturated acids are recognised as the influential precursors for aroma. It is documented that enzymatic oxidation of linolenic and linoleic acids can result in the production of the unsaturated aliphatic compounds that are responsible for the tea aroma. A simple indicator of the fermentation degree can be changes in the colour of the tea leaves.

Green tea: its composition and cosmetic application

Chemical composition of the tea depends on the age of leaves, season, the climate in which the tea was growing as well as on the fermentation degree and variety of the tea shrub.[4,5]

The chemical composition of tea leaves has been widely investigated. The main group of chemical substances characteristic of tea are polyphenols.[6] The level of these substances in the leaves can reach 25%-35% of its dry weight.[7] A particularly characteristic group of polyphenols are catechins (flavan-3-ols) belonging to the group of flavanols. The most significant catechins are: (–)-epigallocatechin gallate (EGCG), (–)-epigallocatechin (EGC), (–)-epicatechin (EC), (–)-epicatechin gallate (ECG) and (+)-catechin.[8] The general formula and full content of catechins detected in tea leaves is shown in Table 1.

The tea leaves contain many different catechins but it is worth noting that the level of these substances is different in each kind of tea. The studies have proven that the highest level of (–)-epigallocatechin gallate (EGCG) and (–)-epigallocatechin (EGC) can be found in green tea.[9]

The studies introduced in the literature report relatively low concentrations of (–)-epigallocatechin, (–)-epigallocatechin gallate, (–)-epicatechin and (–)-epicatechin gallate in black tea. This is the reason for polyphenol oxidase activity that causes condensation of catechins into theaflavins, thearubigins and other substances. The concentration of caffeine is lowest in oolong tea.

The tea leaves also contain other flavonoids belonging to the group of flavonols – quercetin, myricetin and kaempferol – as well as glycosides of these compounds. It has been documented that the level of myricetin, quercetin and kaempferol is particularly high in green tea sencha.[10] The content of flavonols in different kinds of tea is shown in Figure 2.

As it has been presented in the diagram, the quantity of myricetin and kaempferol is the lowest in black Ceylon tea. It is worth noticing that contents of two green teas – sencha and zhejijang differ from each other.

Other substances, very characteristic for fully fermented teas are theaflavins, thearubigins, theaflavinic acid and proanthocyanidin polymers formed by oxidation of polyphenols during processing.[11] The structure of theaflavin is shown on the following page.

The tea also contains many diverse amino acids but one of them – theanine – is very specific to the tea plant, accounting for 50% of all amino acids. Other common amino acids are arginine and aminobutyric acid. Tea also contains purine alkaloids such as caffeine and theobromine as well as phenolic acids – gallic, caffeic and *p*-cumaric acid.[11]

Chlorophyll, carotenoids and lipids are not major constituents of the tea plant but they play an important role in the plant biochemistry.[12] It is worth mentioning that tea leaves contain many different minerals.[13] The comparison of mineral levels in black, Oolong and green teas is shown in Table 2.

Analysing Table 2 one can notice that the highest content of sodium, magnesium

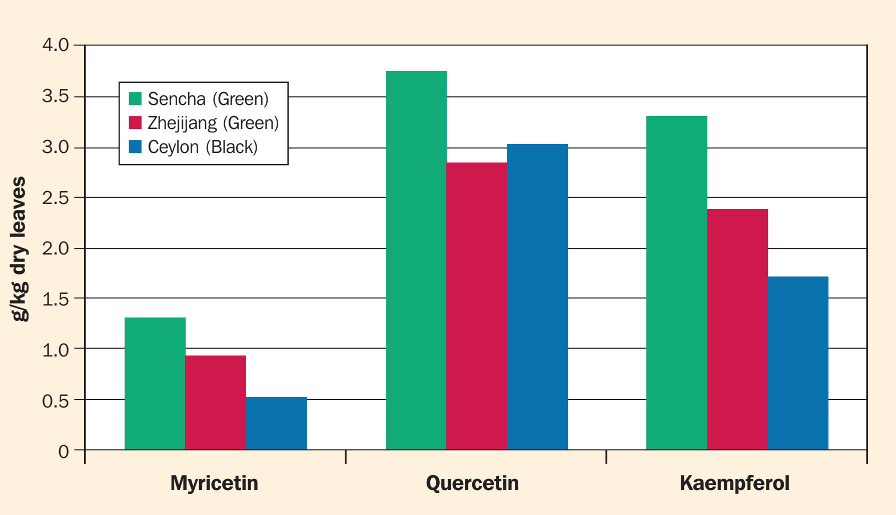
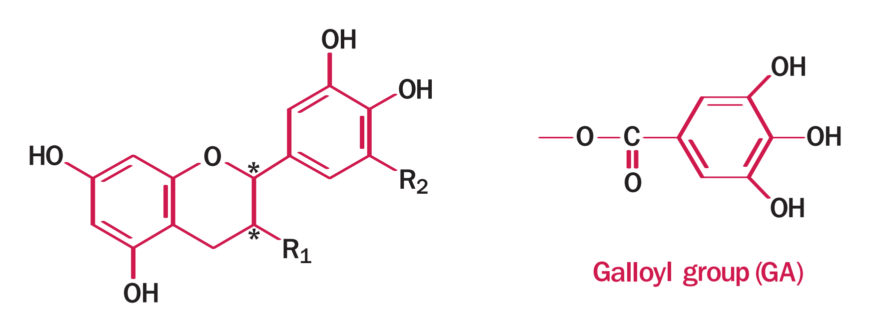


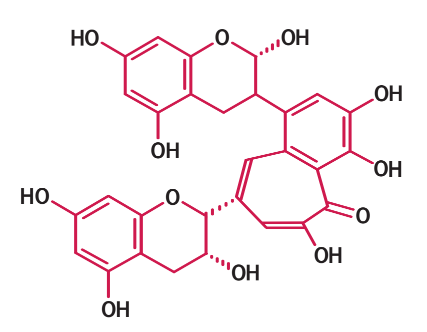
Figure 2: *Levels of flavonols in different teas (dry leaves).*



The chemical structure of polyphenols.

Table 1: Catechins present in tea leaves.

Catechin's 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



The chemical structure of theaflavin.

and zinc can be observed in black tea. Red, oolong tea contains high levels of potassium and calcium. The highest quantity of iron is seen in green tea.

Other important constituents of the tea plant are vitamins presented in Table 3.

It is worth noting that different green teas – gyokuro and sencha – do not display the same profile of vitamin quantity. Sencha contains more than twice the amount of vitamin C compared to gyokuro but the highest level of vitamin A can be found in gyokuro. Black tea seems to be the poorest in terms of vitamins except for quite a high quantity of niacin.[14]

Generally, it can be also observed that green tea contains more chlorophyll and organic acids but black tea possesses more products of polyphenolic oxidation such as theaflavins and thearubigins. The comparison of poyphenols present in green and black tea is shown in Table 4.

As it has been shown above the green tea contains much more catechins than the black. Black tea is very rich in theaflavins and thearubigins that are formed in the oxidation process of catechins.

High content of catechins and gallic acid, displaying strong radical scavenging activity makes green tea a priceless ingredient for the cosmetic industry. Free radicals occurring in the environment can trigger chain reactions, which cause damage to biological structures, including skin. Mechanisms of free radical scavenging by EGC are shown in Figure 3.

The antioxidant activity of green tea catechins is the result of their molecular structure – the presence of at least five hydroxyl groups in the molecule assures strong antioxidant activity to the polyphenolic substance. The critical factor is the presence of two hydroxyl groups in the ring B, situated in ortho position. It has been documented that antiradical activity of esters of gallic acid and catechins is higher than activity of catechins, tocopherol and other gallates.[15] The antioxidant activity of green tea catechins has been studied *in vitro* in erythrocytes by Ramarathnam and Osawa.[16] The inhibiting effect of catechin on the oxidation process of polyunsaturated fatty acids contained in erythrocytes has been determined.

According to Figure 4 the highest antioxidant activities display EGCG and ECG. It has also been documented that the activity of a natural mixture of green tea catechins is higher than the activity of each substance determined separately.[16]

The antiradical activity of green tea catechins was studied by the determination of catechin concentration that can decrease the level of free radicals by 50%.[17]

Table 5 shows that the most effective substance against O_2^- and HO^* free radicals is (–)-epicatechin. (–)-Epicatechin gallate effectively decreases the concentration of O_2^- but seems to be insufficient against HO^* radical.

It is known that polyphenols can hamper the lipid oxidation process by chelation of metals that catalyse free radical reactions and by influencing activity of enzymes. It has been proven that green tea polyphenols can also influence the absorption of UVB radiation by the skin. One of substances contained in green tea, (–)-epigallocatechin gallate, can inhibit the activity of enzyme that decomposes urocanic acid, which is the natural

Table 2: MInerals in different kinds of tea (expressed in ppm).

Kind of tea	Fe	Na	K	Mg	Ca	Zn
Black Syrian tea	11250	32142	286688	34415	22451	730.5
Oolong Chinese tea	6751.5	11377	359131	27844	23980	523.9
Green Chinese tea	13040	1800	262000	30800	13750	630

Table 3: The levels of vitamins in different kinds of tea.

	Gyokuro (green)	Sencha (green)	Oolong (red)	Black
A [IU]	12000	7200	8300	500
B1 [mg]	0.30	0.35	0.13	0.10
B2 [mg]	1.16	1.40	0.86	0.80
Niacin [mg]	6.0	4.0	5.7	10.0
C [mg]	110	250	8	0

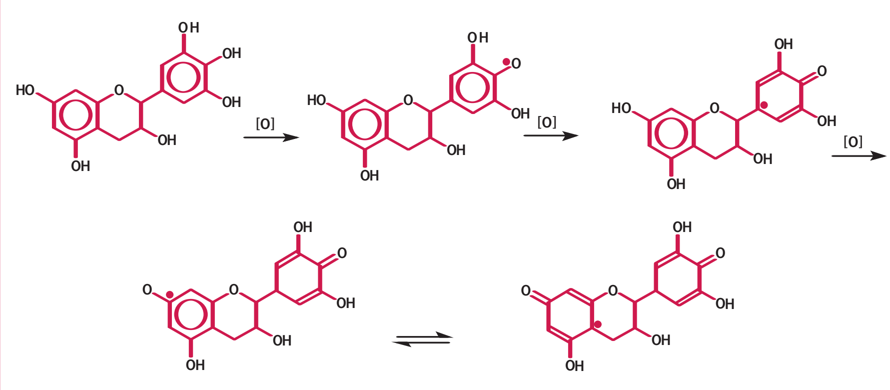


Figure 3: *The mechanism of free radical scavenging by EGC.*

Table 4: Phenolic components of green and black teas (% dry solids).

Constituent	Green tea	Black tea
Catechins	30-40	5-10
Epigallocatechin gallate	10-15	4-5
Epicatechin gallate	3-10	3-4
Epigallocatechin	3-10	1-2
Epicatechin	1-5	1-2
Flavonols	5-10	6-8
Phenolic acids	3-5	10-12
Theaflavins		3-6
Thearubigens		10-30

protection of the skin against UVB.[18]

Another feature of the green tea extract that can be useful from a cosmetological point of view is its astringent activity. The tea contains tannins that are polyphenolic compounds which are able to create strong hydrogen bonds with proteins and other compounds containing nitrogen and oxygen. This group of substances can contain hydrolysing tannins (e.g. gallic acid and its derivatives) and condensed tannins (e.g. olygomeric proanthocyanidins). The presence of these compounds assures astringent activity to the green tea.

It is widely known that green tea polyphenols can influence the microvessel system and microcirculation.[19,20] The mechanism of this activity is multidirectional. By inhibition of thromboxane synthesis, polyphenols display antiagregation activity.[21] The antiradical activity of these substances allows them to protect prostacyclines. It had also been documented that green tea polyphenols, influencing the activity of receptors can cause an increase in microvessel elasticity. Scientists have proven that tea polyphenols can protect vitamin C from oxidation and it is known that vitamin C is necessary for collagen synthesis, which is a very important compound for skin condition.

All of the features reported above make green tea plant and its extracts very important raw materials for the cosmetic industry.

Conclusion

The growing interest in tea applications is caused by its various, very often beneficial influences on the human body. According to the manufacturing process the green tea is the richest kind of tea in catechins. It has been documented that compounds contained in this plant display beneficial influence on human skin, hence the wide application of green tea as a raw material in cosmetology.

Green tea displays anti-ageing, antioxidant and astringent activity as well as influencing the microvessel system. All of these features make it an ideal ingredient in anti-ageing formulations and products influencing the microvessel system. Scientists will continue to work on the evaluation of new methods that could increase our knowledge on green tea and enable us to find new applications for it. PC

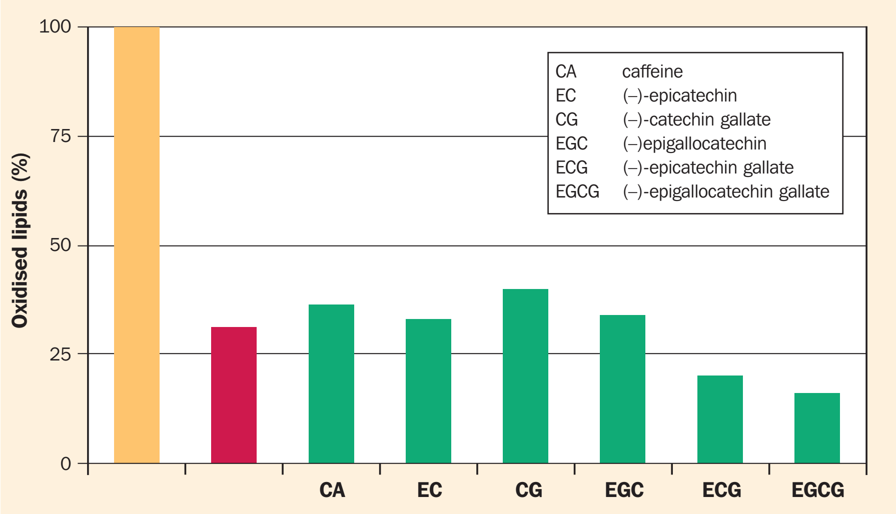


Figure 4: *The antioxidant activity of different green tea catechins comparing to the lack of the antioxidant (■) and vitamin E (■).*

Table 5: Concentration of catechins that can decrease levels of free radicals by 50%.

Substance	O_2^-	$HO^\cdot$
(–)-epicatechin	1.8	1.0
(–)-epicatechin gallate	2.6	45.0
(+)-catechin	7.6	1.1
(–)-epigallocatechin gallate	9.4	11.0
(–)-epigallocatechin	9.5	8.6

References

1 Hollman PCH, Hertog MGL, Katan MB. Analysis and health effects of flavonoids. *Food Chem* 1996; **57** (1): 43-6.

2 Santana-Rios G, Orner GA, Amantana A, Provost C, Wu SY, Dashwood RH. Potent antimutagenic activity of white tea in comparison with green tea in the *Salmonella* assay. *Mutat Res* 2001; **495** (1-2): 61-74.

3 Sugimura T. Overview of carcinogenic heterocyclic amines. *Mutat Res* 1997; **376** (1-2), 211-9.

4 Tomlins K, Mashingaidze A. Influence of withering, including leaf handling, on the manufacturing and quality of black teas – a review. *Food Chem* 1997; **60** (4): 573-80.

5 Togari N, Kobayashi A, Aishima T. Pattern recognition applied to gas chromatographic profiles of volatile components in three tea categories. *Food Res Int* 1995; **28** (5): 495-502.

6 Dufresne C, Farnworth E. Tea, Kombucha, and health: a review. *Food Res Int* 2000; 33 (6): 409-21.

7 Antony J, Shankaranaryana M. Polyphenols of green tea. *Int Food Ingred* 1997; **5**: 47-50.

8 Hara Y, Luo S-J *et al*. Chemical composition of tea, *Food Rev Int* 1995; **11**: 435-56.

9 Zuo Y, Chen H, Deng Y. Simultaneous determination of catechins, caffeine and gallic acids in green, Oolong, black and pu-erh teas using HPLC with a photodiode array detector. *Talanta* 2002; **57** (2): 307-16.

10 Wang H, Helliwell K. Determination of flavonols in green and black tea leaves and green tea infusions by high-performance liquid chromatography. *Food Res Int* 2001; **34**: 223-7.

11 Liebert M, Licht U, Bohm V. Antioxidant properties and total phenolics content of green and black tea under different brewing conditions, *Z Lebensm Unters Forsch A* 1999; **208**: 217-20.

12 Hara Y, Luo S *et al*. Biochemistry of processing black tea. *Food Rev Int* 1995; **11**: 457-71.

13 Ferrara L, Montesano D, Senatore A. The distribution of minerals and flavonoids in the tea plant (*Camellia sinensis*). Farmaco 2001; **56** (5-7): 397-401.

14 Horie H, Kohata K. Analysis of tea components by high-performance liquid chromatography and high-performance capillary electrophoresis. *J Chromatogr A* 2000; 881 (1-2): 425-38.

15 Wang H, Provan G, Helliwell K. Tea flavonoids, their functions, utilization and analysis. *Trends Food Sci Technol* 2000; **11**: 152-60.

16 Ramarathnam N, Osawa T. *Trends Food Sci Technol* 1995; **6**: 324-31.

17 Guo Q, Zhao B, Li M, Shen S, Xin W. Studies on protective mechanisms of four components of green tea polyphenols against lipid peroxidation in synaptosomes. *Biochim Biophys Acta* 1996; **1304** (3): 210-22.

18 Kuroda, Hara Y. Antimutagenic and anticarcinogenic activity of tea polyphenols. *Mutat Res* 1990; **436** (1): 69-97.

19 Gábor M. Pharmacologic effects of flavonoids on blood vessels. *Angiologica* 1972; **9** (3-6): 355-74.

20 Thring TS, Hili P, Naughton DP. Antioxidant and potential anti-inflammatory activity of extracts and formulations of white tea, rose, and witch hazel on primary human dermal fibroblast cells. *J Inflamm (Lond)* 2011; **8** (1): 27

21 Göker H, Tunçbilek M, Leoncini G *et al*. Synthesis and inhibitory activities on platelet aggregation of some flavonoid analogues. *Arzneimittelforschung* 1995; **45** (2): 150-5.