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Determination of Antioxidant Activity in Tea Extracts, and Their Total Antioxidant Content

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Abstract

Antioxidant activity of different types of tea (green, oolong, black, pu-erh) were measured using different modern methods. Several types of commercially available teas, from various manufacturers were tested for antioxidant content using the amperometric method, the data is displayed here. Data gathered about antioxidant content of these different tea samples can be used to estimate quality and type of tea. The data collected using this method is also important when trying to account for the normal daily consumable antioxidant of healthy people and also patients using clinical antioxidant therapy.

Keywords: Tea, antioxidant activity, amperometric method, antioxidants, tea polyphenols.

1. Introduction

In the last decade, determination of antioxidant activity and the total content of antioxidants in foods, beverages, dietary supplements and herbal extracts has been in wide demand. This relates to the fact that antioxidants can prevent free radicals, primarily highly reactive oxygen and nitrogen species, from damaging human health.

The steady increase of free radicals in cells creates the conditions for so-called oxidative stress, wherein free radicals oxidize blood vessel walls, protein molecules, DNA, and lipids. These radicals are particularly active in interacting with membrane lipids that contain unsaturated bonds, and thus alter the properties of cell membranes. The most active free radicals break bonds in DNA molecules and damage the cells' genetic apparatus regulating their growth, which can result in cancerous cells. Recently a large number of diseases have been associated with oxidative stress. Oxidative stress also plays a key role in aging.

Harmful effects of free radicals and oxidative stress can be reduced by regular consumption of foods and beverages which exhibit antioxidant activity.

The primary natural antioxidants include flavonoids, oxiaromatic acids, vitamins C and E, carotenoids, and other compounds.

In recent years bioflavonoids have become more popular since they possess anticarcinogenic, antisclerotic, antiallergenic properties, and their antioxidant activity is several tens of times greater than α-tocopherol, vitamin C, and β-carotene. A combination of natural bioflavonoids contained in vegetables, berries, fruits, grains, seeds, nuts, etc. is especially effective. Bioflavonoids are synthesized by plants to protect them from oxidative processes, and during long-term evolution they formed their optimal combinations.

Plant-based bioflavonoids effectively protect the human body from oxidative stress; a conclusion base on substantial epidemiological evidence.

Tea is one of the richest sources of antioxidants and the three major forms of antioxidant tea are green tea, oolong tea, and black tea. These teas are differed in producton methods and chemical composition [1, 2].

The major antioxidants in tea are catechins, then theaflavins, thearubigins, oxyaromatic acids, flavonols, such as kaempferol, myricetin, quercetin; flavones, such as apigenin; derivatives of gallic acid, such as tannins, etc. The most powerful antioxidant tea is green tea which is characterized by the presence of large amount of flavan-3-ols known as catechins. (-) Epigallocatechin-3-gallate (EGCG) is most abundant catechin in green tea and may occure up to 50% of the catechins by weight. Oolonng tea is partially oxidized or fermented tea (25-60%) and black tea is fully oxidized. The result of catechins oxidation is the formation of catechins dimers, known as theaflavins. These compounds are responsible for the color and taste and also a key factor in the antioxidant activity.

The known in vitro antioxidant properties of catechins and other polyphenolic compounds in tea have led to interest in the potential health benefits of tea consumption [3]. The evaluation of their efficacy as antioxidants in vivo is more complex [4]. Numerous epidemiologic studies have addressed the relationships between tea consumption and the incidence of cardiovascular diseases [5-9]. The antioxidant activity of green tea polyphenols and, more recently, the pro-oxidant effects of these compounds, have been suggested as potential mechanisms for cancer prevention [10-12]. The mechanism of action of tea on human health can be characterized not only by potent antioxidant activity (like reduction of LDL oxidation, lipid per oxidation, and DNA oxidation [13,14]) but also anti-inflammatory (skin disorders, arthritis) and thermogenesis (fat oxidation and energy expenditure) activities as well [15].

In [2] has been shown that although tea polyphenols have generally been regarded as antioxidants, the emerging evidence for the pro-oxidant effects of these compounds is interesting and raises many potential questions. Studies using higher doses of EGCG also show that pro-ixidant effects may play a role in the potential toxic effects of EGCG that have been reported in vivo [16]. Most case reports involved the use of non-traditional dosage forms (e.g., pills, or capsules) but there has been a report of green tea beverage causing hepatoxicology [17]. The existing differences in sensitivity to potential green tea toxicity are unclear and probably related to individual differences in metabolism and bioavailability of green tea polyphenols [2].

Antioxidant activity in tea is measured by well-known methods, such as ORAC, FRAP, ABTS, etc. [18-22].

The Oxygen Radical Absorption Capacity method (ORAC) is based on the measurement of fluorescence quenching in fluorescein when it is exposed to the stable radicals and antioxidants being studied [22].

The Ferric Reducing/Antioxidant Power (FRAP) assay is based on the recovery of an Fe (III)-tripyridyltriazine complex in Fe (II) at low pH, exhibiting an intense color [19,20].

The total content of antioxidants can be determined by an amperometric method and high performance liquid chromatography.

2. Determination of Antioxidant Activity

Antioxidant activity of green tea, as measured by different methods, is usually higher than the antioxidant activity of black tea or oolong tea [18, 22-25].

However, it was determined that the theaflavins in black tea and catechins in green tea are equally effective antioxidants [26, 27].

The antioxidant activity of certain types of tea, i.e., green tea [28, 29], black tea [30] and oolong tea [31-33] have also been investigated.

The major hypothesis of the beneficial health effects of tea is associated with its antioxidant properties [34]. In addition to the capturing (quenching) of free radicals, the tea catechins can chelate metal ions such as iron and copper, preventing their participation in Fenton and Haber-Weiss reactions [35].

Antioxidant capacity of various teas and tea polyphenols has been investigated in many studies [36-43]. Using the oxygen radical absorption capacity method (ORAC), green and black teas were found to have a higher antioxidant activity with respect to peroxyl radicals than vegetables (garlic, kale, spinach, and Brussels sprouts) [22].

The total antioxidant activity of green tea was shown by FRAP to be higher than that of black tea [19]. Epicatechin and catechin were classified by the trolox equivalent antioxidant capacity (TEAC) method as the best among 24 plant flavonoids [44].

Coulometric evaluation of the antioxidant capacity of several tea extracts was performed using electrogenerated bromine [45].

In this case, the integral antioxidant capacity (AOC) of tea was assessed in kilocoulombs (kC) per 100g of tea. At the same time, the total flavonoid content was determined in terms of rutin and was expressed in mg/100g of tea.

The bromine AOC in black teas ranged from 7.4 to 19.3 kC/100g. The total flavonoid content was within the range of 29±1.3 to 72±9.5.

The total content of phenols as well as the portion of catechins in them was determined in black and green teas by the Folin-Ciocalteu method [40]. The content of all polyphenols in black teas ranged from 80.5 to 134.9 mg/g of dry tea weight relative to gallic acid. The greatest amount of total polyphenols were found in Ceylon black tea. The percentage of all catechins in the total content of polyphenols in black tea was determined to range from 10.1 to 37.3%. The largest percent of catechins was detected in black Darjeeling tea.

The total content polyphenols in green tea was within the range of 65.8 to 106.2 mg/g, and the portion of catechins varied from 50.4 to 98.0%. The largest percent of catechins was identified in Japanese green tea (Bandia).

In one of the studies the total antioxidant capacity of 27 different types of tea (green, black, oolong, and Pu-erh) was determined using FRAP assay [19]. Five grams of dry tea powder was brewed in 150 ml of boiling distilled water. The antioxidant capacity ranged from 132 μmol/g for Pu-erh tea and up to 1,144 μmol/g for one grade of green tea. The average values are given in Table 1.

Table 1. The Total Antioxidant Capacity of Different Teas Using FRAP Assay [19].

No.	Type of Tea	Number of Experiments	Value in μmol/g (Dry Powder)
1	Green	13	571
2	Oolong Tea	5	373
3	Black	8	365
4	Pu-erh	1	132

These measurements show that antioxidant activity of green tea is higher than that of black tea.

The values for antioxidant activity varied by 2-3 times—the authors attribute this to the tea grades as well as cultivation, production, and storage conditions.

The antioxidant capacity of brewed teas changed only slightly during storage for 48 hours at 4 ℃.

The antioxidant activity of catechins depends on the number of hydroxyl groups, that is epigallocatechin gallate (8 hydroxyl groups), epicatechin gallate (7), gallocatechin (6), and epicatechin (5) [46].

Table 2. Total Content of Antioxidants (CCA) in Black Tea (Quercetin Used as Reference)

No.	Name	Manufacturer/Country	CCA mg/g
1	Darjeeling Premium	Mlesna Tea Naturally, Sri Lanka	186.6
2	Darjeeling Tea No.1	India, Darjeeling	150.0
3	Darjeeling	Darjeeling tea manufacturer, Djukpana Plantation	146.5
4	Akbar Premium	Sri Lanka	138.6
5	Beta Tea Black Tea (Selected Quality)	Beta Tea Groups, Turkey	118.0
6	Presidential Ceylon Baikhovi Tea	Mlesna, Sri Lanka	118.0
7	Hyleys	Sri Lanka	109.4
8	Bahar	Sri Lanka	106.2
9	Darjeeling	Greenfield, UK	106.0
10	Beseda	Unilever	106.0
11	Darjeeling	Chaygorod	103.6
12	Darjeeling	Chaygorod	103.0
13	Alokozay	Dubai, UAE	102.1
14	English Breakfast Assam	India	97.8
15	Mabroc Earl Grey	Sri Lanka	96.4
16	Monzil Pride	Sri Lanka	94.9
17	Estate Pure Ceylon Tea Garden Mark	Sri Lanka	94.3
18	Riston Exclusive Quality	Sri Lanka	90.0
19	Victorian Tea	Curtis&Patridge London, Ltd., England	88.4
20	Ahmad Earl Grey	Ahmad Tea Ltd., Moscow Region, Mytischensky District	88.0
21	Jungle Call	Kenya	86.6
22	White Nights Aromatized Black Tea	OOO Russian Tea Company	79.9

No.	Name	Manufacturer/Country	CCA mg/g
23	Greenfield Golden Ceylon	Greenfield, UK	79.5
24	Beta Tea	Sri Lanka	79.4
25	Borodinsky	India, Ceylon	78.5
26	St. Clairs 100% Pure Ceylon Tea	Founder St. Clairs Tea Plantation	77.7
27	Chelton Tea Collection, Gunpowder	Jafferjee Brothers, Sri Lanka	76.3
28	Curtis Lemon Lane	Under control of Curtis Partidge London, Ltd.	73.0
29	Pearl of China	Forsman Tea, Finland	63.9
30	Assam No. 17	Tea Collection, India	63.7
31	Impra Black Tea	Imperial Tea Exports (Pvt) Ltd.	58.8
32	Darling with Blueberries and Mango (British Royal Academy of Tea)	English present tea 100% Ceylon tea	57.0
33	Just the One Indian	OOO Moscow Tea Company	56.3
34	Black Tea	Indonesia	55.2
35	Black Tea with Bergamot	Azercay, Azerbaijan	54.6
36	Black Tea	Maryam, Azerbaijan	54.1
37	Akbar	Akbar Brothers Ltd., Sri Lanka (OOO Yakovlev Tea-Packing Factory, Russia)	51.0
38	Hyleys Earl Grey	Sri Lanka	46.4
39	Riston Premium	Sri Lanka	43.0
40	Ceylon Pekoe	Forsman Tea, Finland	39.8
41	Darjeeling	India, packed in Austria	39.0
42	Darjeeling in Bags	Ronnefeldt, Schwarzer Tee	32.0
43	Nadin, S Novym Godom, Large-Leaved Tea	OOO Lealanis, Moscow	28.0
44	Black Baikhovi Tea	Vietnam	28.0
45	Cherny Barkhat	OOO Russian Tea Company	23.7
46	Georgian	Mozhaisky House of Commerce	17.8

3. Determination of the Total Antioxidant Content Using an Amperometric Method.

Amperometric method (AM) used for determination of antioxidants is based on measuring an electric current in the detector cell which occurs during oxidation of the analyte on the working electrode surface when certain potentials are applied [18]. The signal is recorded as differential output curves. Using special software, the areas or peak heights (of the differential curves) are calculated for the analyte and for the reference substance. The average value of three to five consecutive measurements is used for the analysis. Well-known antioxidants, such as quercetin, dihydroquercetin, mexidol, trolox, gallic acid, etc., could be used as reference substances.

The amperometric method has several advantages for determining antioxidant activity: not taking into account sample preparation, one determination takes only a few minutes; analysis (data recording and processing) takes place in real time; accuracy and reproducibility of the analysis is ensured by accurate dosing with a six-way valve; standard deviation (SD) of valve dispensal is less than 0.5%; SD of the successive measurements of the analyzed samples is less than 5%; limit of detection for polyphenols and flavonoids is at the level of nanograms and picograms (10^{-9} – 10^{-12} g). At such low concentrations, the likelihood of the mutual influence of different jointly present antioxidants, such as by a manifestation of synergy, is significantly reduced.

The amperometric method is the only method which allows for direct measurement of all antioxidants in a sample. Other methods are indirect—they measure the inhibition of reaction mixtures (free radicals) generated by certain reactions.

Using the amperometric method, the total content of antioxidants was determined in many varieties of teas produced by different companies. Table 2 provides data for green tea and Table 3 for black tea.

Table 3. Total Content of Antioxidants (CCA) in Green Tea (Quercetin Used as Reference)

No.	Name	Manufacturer/ Country	CCA mg/g
1	T-Sips Ceylon Tea in Bags	Sri Lanka	190.0
2	Alokozay	Dubai, UAE	171.2
3	Riston Green Exotic	Sri Lanka	155.0
4	Lipton	Unilever Foodsolutions	143.0
5	Minamoto	Yunako Company, Japan	143.0
6	NamaCha Live Green Tea	Japan	139.6
7	Tea Tang Sour Sap	Sri Lanka	138.0
8	Azercay (Yastl Cay)	Azerbaijan	133.2
9	Greenfield Flying Dragon	London	130.0
10	Merlin	Brand Tea, Sri Lanka	126.8
11	Green Tea Gift	Mirax Pharma	125.3
12	Nadin Super AOX Verbena	Vitali Tea	125.0
13	Green Elephant	Sri Lanka	125.0

No.	Name	Manufacturer/ Country	CCA mg/g
14	Selenium Green Tea	Wahan Mingcha Tea Industry Ltd, Hubei, China	123.6
15	Green Tea with Jasmine	Mabroc Teas Ltd., Sri Lanka	120.1
16	Tea Tang Green Tea with Mango	Tea Tang, China	117.0
17	Ahmad	Ahmad Tea Inc., Sri Lanka	116.0
18	Jaf Tea, Green Tea with Pieces of Strawberries and Kiwi	Jafferjee Brothers, Sri Lanka	115.0
19	Zhong Guo Mig Cha Milk Green Tea	China	115.0
20	Green Tea with Jasmine	Newby, London	114.0
21	Tian Ren	ZAO Tian Ren	108.1
22	Mlesna Green Ceylon Baikhovi Tea with Strawberries	Sri Lanka	107.0
23	Dobroe Utro (with Jasmine)	Dobrynya-Rus, Ltd.	104.0
24	Maitre	Maitre, France	98.0
25	Tian Ren	ZAO Tian Ren Academy of Chinese Culture and Medicine	97.0
26	Mabroc Earl Grey	Sri Lanka	96.4
27	Jaf Tea, Earl Grey Green Tea with Bergamot	Sri Lanka	95.0
28	Super Pekoe No.1	Tea Tang Ltd, Colombo, Sri Lanka	91.8
29	Yu Shan Yin Yellow Tea (Yellow Needles from a High Mountain)	Tea Yard, China	90.0
30	Laurel Flower Tea	China	88.9
31	Silver Cilia	China	84.4
32	Tian Ren with Jasmine	ZAO Tian Ren	84.4
33	Ahmad Baikhovi Leaf Tea with Jasmine	Sri Lanka	83.0
34	Jasmine tea 632	China	82.7
35	Hyleys English Large-Leaved Green Tea	Sri Lanka	80.4
36	Jasmine Tea	China	80.4
37	Chelton Tea Collection, Gunpowder	Jafferjee Brothers, Sri Lanka	76.3

No.	Name	Manufacturer/ Country	CCA mg/g
38	Royal Sprouts White Tea	Tea Yard, China	74.0
39	Mlesna Green Ceylon Baikhovi Tea with Mango	Sri Lanka	69.0
40	Jasmine Tea	Shin Kong Mitsukoshi Dep.	68.1
41	Flower of Tenderness with Red Saffron	Nadin Company, Copenhagen	66.0
42	Mo Li Hua Cha Jasmine Tea	Tea Yard, China	66.0
43	Hyleys Large-Leaved Tea	Sri Lanka	63.6
44	Hilltop Collection Tea Lemon Green Tea	Tea Collection, Mozhaysk	63.3
45	Greenfield Green Mekissa	London	60.7
46	Xinyang Green Tea	Dabieshan Tea Company, Henan, China	60.0
47	Dr. Green (Jasmine Tea)	China	57.2
48	Green tea from Pogadaev	Sochi, Lazorevskoye, Tea House	56.4
49	Quan Xin Huang Mountain Mao Feng	China	56.3
50	Organic GreenTea	China	55.5
51	Yunnan Mao Feng	China	53.9
52	Bambu Shaolin Strength (Large-Leaved)	China	52.2
53	Green tea No. 371	China	51.2
54	Indu from Top Two Leaves, Chinese Large-Leaved Tea with Ginseng	Indu Enterprises, China	46.5
55	Camel	Zhejiang Tea Company in China	45.7
56	SVAY Fresh Fantasy large-leaved tea with passion fruit, orange, and Lemon	Germany	44.8
57	Imperial Gunpowder Chinese Elite Tea	China	44.0
58	Indu from Top Two Leaves, Chinese Large-Leaved Tea	Indu Enterprises, China	43.7
59	Indu from Top Two Leaves, Chinese Large-Leaved Tea with Mint	Indu Enterprises, China	43.7
60	Teh Melati Jasmine Tea	Bali	31.2

4. Determination of the Total Antioxidant Content Using High Performance Liquid Chromatography (HPLC)

Table 4 shows the total content of catechins, all polyphenols, theaflavins, and thearubigins in different varieties of tea from Kenya, Japan, and China [43]. The total content of catechins ranged from 3.07 to 4.62 mg/g for black tea and from 3.31 to 14.93 mg/g for green tea. The total content of polyphenols is rather high for almost all types of tea. Significant content of theaflavins and thearubigins was found in some green teas. This was probably caused by a breach of green tea production technology. Green tea which was prepared by traditional technology and was properly stored contains virtually no theaflavins or thearubigins. This fact is confirmed by data shown in Table 5. The total content of theaflavins is very small in green teas.

The total content of catechins estimated by HPLC relative to the sum of all peak areas for all detected catechins is provided in Table 6. The measurements were made for the most famous and expensive teas (black, white, yellow, and green).

All types of tea contained epigallocatechin gallate (EGCG) in the greatest amounts, followed by ECG and EGC. Catechin and epicatechin were present in significantly lower amounts.

Table 4. Total Content of Catechins, All Polyphenols, Theaflavins, and Thearubigins in Different Tea Grades, in mg/g of Dry Tea [44].

No.	Type of tea	Total catechins	Total polyphenols	Theaflavins	Thearubigins
	Kenyan Teas				
1.	Black Tea (Pekoe Dust)	5.91	20.65	11.61	10.30
2.	Black Tea (Broken Pekoe)	3.07	17.45	18.75	15.65
3.	Black Tea (Orthodox)	4.62	22.25	13.80	11.51
4.	Green Tea (Pekoe Fanning's)	14.93	26.85	0.46	5.59
	Green Tea (Broken Pekoe)				
5.	Green Tea (Orthodox)	10.04	25.70	1.63	8.38
6.	White Tea (Silvery Tip)	11.06	27.10	0.41	5.77
7.	Oolong (Orthodox)	10.20	21.30	0.85	1.75
8.		9.49	26.15	6.81	8.75
	Japanese Teas				
9.	Green Tea (Yabukita)	12.69	19.35	0.25	9.06
10.	Green Tea (Yutakamidori)	12.24	19.78	0.45	7.69
	Chinese Teas				
11.	Green Tea (Hanlu)	11.19	18.82	0.81	9.30
12.	Green Tea (Yinghong)	3.31	11.42	11.57	13.55

Note: Teas numbered 1, 2, 4, 5, 9, 10, 11, 12 are made by CTC technology (Cut, Tear, Curl).

Table 5. Determination of Catechins and Theaflavins in Green and Black Tea Purchased in Singapore [27].

No.	Tea grade	Content, mg/g					
		EC	ECG	EGC	EGCG	Total catechins	Theaflavins
1.	Green Tea Longjing	5.27	9.97	28.09	35.46	78.77	1.50
2.	Jasmine green tea	6.06	12.66	23.46	29.83	72.01	1.81
3.	Chrysanthemum Green tea	8.59	12.58	18.62	16.85	56.64	1.03
4.	Iron Buddha Green Tea	4.27	3.35	30.61	11.82	50.05	0.66
5.	Japanese Green Tea	6.06	5.34	36.53	18.10	66.03	0.88
6.	Oolong tea	1.75	3.58	7.70	8.99	47.76	0.66
7.	Ceylon Black Tea	1.41	6.82	2.84	5.52	16.59	10.70
8.	Pu-erh Tea	0.49	0.07	0.60	0.30	1.46	1.03

In one study, the contribution of individual components of green and black tea into the overall antioxidant activity as well as their concentration, was determined. The compounds in tea were identified by HPLC-MS. Antioxidant activity was determined relative to $ABTS^{+}$, which is a stable free radical (2,2[1]-azinobis-(3-ethylbenzthiazoline-6-sulfonic acid). C-trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was used as a reference compound. The green tea samples were from Kenya. 3 g of tea leaves were brewed in 300 ml of boiling water.

Table 7 shows the concentration and antioxidant activity of catechins and theaflavins in green and black teas, and Table 8 shows contribution of individual components to the total antioxidant activity.

As seen in Table 8, catechins contribute the most to the antioxidant activity in green tea, whereas in black tea antioxidant acids contribute more than theaflavins. For some reason, the contribution made by thearubigins is not mentioned in this study.

The total antioxidant activity measured by HPLC and by ABTS without separation varied greatly: HPLC showed 8340±60 for green tea and 1494±4.0 for black tea; ABTS showed 11302±226 for green tea and 7382±184 for black tea. The difference of antioxidant activity measured by these methods is 2682 for green tea and 5888 for black tea.

Such differences may indicate that most of the high-molecular compounds are not eluted from a chromatographic column. Therefore, HPLC method gives lower results. Thearubigins are not eluted from the column under these conditions.

Table 6. Content of Catechins in Various Tea Grades (Column 4x100 mm with GLWakosil C_{18} AR and Precolumn 5 µm. Amperometric Detector V = 1.3 V).

No.	Catechin	Peak Area				
		Black Darjeeling Tea	'White Monkey' White Tea	'Royal Sprouts' White Tea	Yu Shan Yin Yellow Tea	Mo Li Hua Cha Green Jasmine Tea
1.	Epigallocatechin (EGC)	165.2	1062.7	500.0	818.8	2191.0
2.	Catechin (C)	95.0	272.6	253.0	295.2	185.9
3.	Epicatechin (EC)	143.8	549.7	228.2	314.7	950.6
4.	Epigallocatechin-Gallate (EGCG)	909.7	1724.4	3139.2	3690.9	2350.4
5.	Epicatechin Gallate (ECG)	730.9	1152.9	1291.6	1482.7	1168.7
6.	The sum of all peak areas for catechins	2044.6	4762.3	4412.0	6602.3	68.46.6

Note. All measurements are made under the same conditions

Table 7. Concentration and Antioxidant Activity of the Major Components in Green and Black Teas [25].

No.	**Compounds**	**Concentration (µm)**		**Antioxidant activity (µm)**	
		Green Tea	**Black Tea**	**Green Tea**	**Black Tea**
	Catechins				
1	Gallocatechin	513±7.2	-	522±29	-
2	Epigallocatechin	1594±114	48±0.3	2032±146	36±3.2
3	Epicatechin	374±25	34±0.3	398±3.5	25±0.7
4	Epigallocatechin gallate	1202±7.4	52±2.9	3606±378	175±3.2
5	Epicatechin gallate	389±1.7	58±2.9	1092±32	195±5.9
	Theaflavins				
6	Theaflavin	-	117±4.2	-	54±2.5
7	Theaflavin-3-gallate	-	168±7.3	-	157±1.5
8	Theaflavin-3'-gallate	-	87±3.8	-	66±1.6
9	Theaflavin-3,3'-digallate	-	194±6.0	-	132±6.8
10	Caffeine	1194±11	1295±20	-	-

Table 8. Contribution of Individual Components—Antioxidants—into the Overall Antioxidant Activity of Green and Black Tea [25].

No.	Compound	Antioxidant Activity, %	
		Green Tea	Black Tea
1	Catechins	92.1	28.8
2	Oxyaromatic acids	6.6	39.6
3	Flavonols	0.4	4.6
4	Theaflavins	0	27.0

5. Conclusion

This review shows that tea has a high level of antioxidant activity. In overall antioxidant activity, tea takes a place among the highest rank, along with red wine and cocoa.

Antioxidant activity of tea is effected by many natural polyphenols: catechins, oxyaromatic acids, tannins, flavonols, thearubigins, theaflavins, etc.

Antioxidant activity of various tea grades, as identified by modern methods, descends in the following order: green>oolong>black>Pu-erh tea. Antioxidant activity of green tea is effected mainly by catechins (90%), of black tea—by theaflavins and thearubigins. Rapid determination of the total antioxidant content in tea by an amperometric method can be used to assess tea quality and authenticity.

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