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我国西南元江大理茶的挥发性成分及其抗氧化活性*

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摘要： 大理茶（*Camellia taliensis*）为山茶科山茶属茶组植物，主要分布于云南横断山脉澜沧江至伊洛瓦底江流域，即从云南的西部及西南部至缅甸北部。在其分布区，大理茶亦被称为野生大茶树，常用于加工制作茶叶。采用水蒸气蒸馏法、GC 及 GC/MS 联用技术，首次对大理茶的鲜幼叶和鲜幼叶及老叶分别制成的绿茶中的挥发性成分进行提取和分析，共鉴定出 91 个化合物。研究结果表明，大理茶鲜幼叶的主要香气成分为棕榈酸（30.52%），亚油酸（19.82%），植醇（8.75%）和亚麻酸乙酯（2.54%）等有机酸及其酯和二萜类，而制成绿茶后，其主要香气成分则为芳樟醇（28.43%），脱氢芳樟醇（1.13%），α-松油醇（11.68%），橙花醇（4.92%）和香叶醇（12.34%）等单萜醇类成分。从大理茶鲜叶到由其制成的绿茶，香气成分发生了较大变化，形成了 28 种原鲜叶中未检测到的香气成分，其中，（Z，Z，Z）-9，12，15-十八烷三烯-1-醇的含量分别达到 1.21%（幼叶绿茶）和 11.2%（老叶绿茶），是大理茶制作的绿茶的特征香气成分。DPPH 和 $ABTS^+$ 自由基清除实验结果显示大理茶鲜叶及其制成的绿茶的挥发性成分均具有一定的抗氧化活性，但均弱于茶多酚的抗氧化活性。

关键词： 大理茶；鲜叶；绿茶；挥发性成分；水蒸汽蒸馏法；抗氧化活性
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Chemical Compositions and Antioxidant Activity of Essential Oil from Green Tea Produced from *Camellia taliensis* (Theaceae) in Yuanjiang, Southwestern China*

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Abstract: *Camellia taliensis* belonging to *Camellia* sect. *Thea* (Theaceae) is distributed from the western and south-western areas of Yunnan Province, China to the north of Myanmar. Known as the "wild" tea plant, it has been commonly used for making tea by the local people of its growing area. It is the first investigation of the volatile constituents of the fresh tender leaves of *C. taliensis* and green teas produced from its tender and older leaves. The volatile constitu-

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ents were obtained by hydrodistillation and analyzed by GC and GC-MS. Ninety-one compounds were identified. The results showed that the main compositions of volatile oil of the fresh tender leaves were hexadecanoic acid (30.52%), linoleic acid (19.82%), phytol (8.75%), and geraniol (2.54%), while monoterpenoids (58.51%) composing of linalool (28.43%), hotrienol (1.13%), α-terpineol (11.68%), nerol (4.92%) and geraniol (12.34%) were the major volatile components of its green tea product. From the fresh leaves to the green tea products, 28 aroma components were formed. Among then, the content of (*Z*, *Z*, *Z*)-9, 12, 15-octadecatrien-1-ol (peak 77) was up to 1.21% (from tender leaves) and 11.2% (from older leaves), respectively. The DPPH and $ABTS^+$ radical scavenging assays demonstrated a moderate activity of essential oil from the three essential oils of *C. taliensis*.

Key words: *Camellia taliensis*; Fresh tender leaves; Green tea products; Essential oil; Hydrodistillation; Antioxidant assays

Tea is one of the most popular beverages consumed in the world. Due to its special flavor, rich content of polyphenols, and various bioactivities including cancer prevention, hypotensive effects, antioxidative, antimicrobial, antitumor, and anti-mutagenesis (Almajano *et al.*, 2008; Henry and Stephen, 1984; Katiyar and Mukhtar, 1996; Khan and Mukhtar, 2007; Kuroda and Hara, 1999; Weisburger, 1997). The commercial tea is normally produced from the leaves of two cultivated tea plants, *Camellia sinensis* var. *sinensis* (L.) O. Kuntze and *C. sinensis* var. *assamica* (Masters) Kitamura (Theaceae). Besides, some wild tea plants have also been used for producing tea beverage by the local people of their growing areas.

C. taliensis (W. W. Smith) Melchior is distributed from the western and southwestern areas of Yunnan Province, China to the north of Myanmar. It belongs to the *Camellia* section *Thea*, which is the same as the two widely cultivated tea plants (*C. sinensis* var. *sinensis* and *C. sinensis* var. *assamica*). Known as the "wild" tea plant, it has been used widely to make green tea or Pu-er tea by the local people of its growing area.

So far, most of the interests in tea research were mainly focused on the non-volatile constituents of *C. sinensis* and *C. sinensis* var. *assamica* tea and their bioactivities (Nonaka *et al.*, 1983, 1984, 1989). Our previous work on the leaves of *C. taliensis* collected from Lincang area of Yunnan province, China, indicated that it contained rich level of flavan-3-ols and caffeine, same as the widely cultivated tea plants. In addition, abundant hydrolysable tannins were found to be the characteristic and mark phenolic constituents in *C. taliensis*, which was different from those of *C. sinensis* var. *assamica* (Gao *et al.*, 2008). However, the essential oil compositions of *C. taliensis* and their bioactivities are not known well thus far.

During the course of our study on *C. taliensis* collected from Yuanjiang area of Yunnan Province, China, it expressed strong and sweet fragrance. The essential oil of the fresh tender leaves of *C. taliensis* in Yuanjiang prefecture, together with its green tea products was extracted by hydrodistillation and further analyzed by GC and GC/MS. Their antioxidant activities were evaluated by DPPH and $ABTS^+$ assays. The present paper describes this study.

Materials and methods

Plant material The fresh tender leaves (A) of *Camellia taliensis* (W. W. Smith) Melchior and its green tea product (B) were collected at Yangchajie, Yuanjiang Prefecture, Yunnan Province of China, on March 2012, and prepared by the local people. Another green tea product (C) was prepared from older leaves collected on May 2010. The plant species were identified by Dr. Shi-Xiong Yang, Key Lab of Biodiversity & Biogeography, Kunming Institute of Botany, Chinese Academy of Sciences.

Recovery of the essential oil The fresh leaves (A) of *C. taliensis* and its green tea samples (B and C) (each 200 g) were subjected to hydrodistillation for 7 hours using Clevenger type apparatus.

After dried with anhydrous Na_2SO_4, the obtained essential oils were stored at 0 ℃. The percentage yields of essential oils were about 0.0105% for the fresh tender leaves of *C. taliensis*, on a wet weight basis, and 0.03% and 0.02% for green teas produced from tender and older leaves, (W/W) on a dry weight basis, respectively.

GC and GC-MS analysis For the identification of the components, gas-chromatographic analysis was performed on a HP5890 gas chromatograph, with FID, a split ratio 1∶50 using an HP-5 capillary column (30 mm × 0.32 mm × 0.25 μm). The oven temperature was initially held at 80 ℃ and then increased from 5 ℃/min to 280 ℃. The carrier gas was nitrogen (1.5 mL/min); the injector and detector temperatures were 250 ℃; injection volume was 5.0 μL. GC/MS analysis was performed with a HP6890 gas chromatograph equipped with a HP5973 mass detector. Analytical conditions: injector and transfer, line temperatures 250 ℃; oven temperature was programmed from 80 to 260 ℃ at 5 ℃/min; carrier gas was helium at 1.0 mL/min; injection volume was 1.0 μL; split ratio was 1∶10. EI mass spectrum was collected at 70 eV ionization voltages over the range of *m/z* 35 – 500. The ion source and quadrupole temperatures were set at 230 and 150 ℃, respectively. The identification of the volatile components was based on comparison of the retention times with those of authentic samples, comparing their Kovats indices and the mass spectra of individual components with the reference mass spectra in the wiley 7n.1.

2, 2′-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay The DPPH assay was performed as described in our previous paper (Gao *et al.*, 2008, 2010; Liu *et al.*, 2009), and ascorbic acid was used as positive control. Briefly, reaction mixtures containing a MeOH solution (100 μL) of DPPH (100 μM) and 2-fold serial dilutions of the essential oil samples (100 μL in MeOH, with amounts of sample ranging from 2 to 1 000 $\mu g \cdot mL^{-1}$) were placed in a 96 well microplate and incubated at room temperature for 15 min. After incubation, the absorbance was read at 490 nm and the scavenging activity was determined according to the following equation: percentage of DPPH reduction (%) = $[A_{control} - A_{sample}] / A_{control} \times 100$. Then, a linear plot of percentage of DPPH reduction and sample concentration was made (correlation coefficient $R^2 = 0.90 - 1$). The antioxidant activity was evaluated by SC_{50} values (the concentration of sample required to scavenge 50% of DPPH radicals), which were obtained through extrapolation from the linear plot. In this assay, each sample was evaluated in triplicate and the data presented are means ± *SD* of three determinations.

$ABTS^+$ radical scavenging assay As described in literature (Chun *et al.*, 2005; Zhu *et al.*, 2009), $ABTS^+$ was prepared by reacting ABTS (7 mM, Sigma Chemical Co.) water solution (5 mL) with potassium persulphate (140 mM, 88 μL) with a ratio of 1∶0.35 and the mixture was kept in the dark at room temperature for 12 – 16 h before use. Prior to assay, $ABTS^+$ stock solution was diluted with MeOH (ratio 1∶88) to give an absorbance at 734 nm of 0.70 ± 0.02 and was equilibrated to 30 ℃. $ABTS^+$ solution (200 μL) was added to a 96 well microplate containing 10 μL of each sample and incubated at room temperature for 6 – 8 min. And the absorbance at 405 nm was immediately recorded. The scavenging activity was determined according to the following equation: percentage of $ABTS^+$ reduction (%) = $[A_{control} - A_{sample}] / A_{control} \times 100$. Then, a linear plot of percentage of $ABTS^+$ reduction and sample concentration was made (correlation coefficient $R^2 = 0.90 - 1$). The antioxidant activity was evaluated by SC_{50} values (the concentration of sample required to scavenge 50% of $ABTS^+$ radicals), which were obtained through extrapolation from the linear plot. In this assay, each sample was evaluated in triplicate and the data presented are means ± *SD* of three determinations.

Results and discussions

Volatile oils of *C. taliensis* The percentage of the volatile oils of the fresh tender leaves of *C.*

taliensis and the green tea products from its tender and older leaves were 105 mg·kg^{-1} on wet weight basis, and 300 and 200 mg·kg^{-1} on dry weight basis, respectively. The chemical compositions were analyzed by GC and GC-MS. Chromatographic analysis of the essential oils obtained by hydrodistillation enabled the identification of 91 volatile compounds in the three essential oils from *C. taliensis* (Table 1).

Fifty-two volatile components, accounting for 84.82%, were identified from the essential oil of the fresh tender leaves of *C. taliensis*. The detected major constituents were hexadecanoic acid (30.52%), linoleic acid (19.82%), phytol (8.75%), geraniol (2.54%), ethyl linolenate (2.59%), while *n*-pentacosane (1.98%), methyl 9, 12, 15-octadecatrienoate (1.83%), *n*-heptacosane (1.69%), *n*-tricosane (1.58%), linoleic acid ethyl ester (1.45%), α-terpineol (1.29%) and *n*-heneicosane (0.97%) were identified as small amount aroma.

Sixty-eight compounds, including 18 terpenoids, 10 ketones, 1 aromatic, 12 esters, 6 organic acid, 11 long-chain hydrocarbons, 4 alcohols, 5 aldehydes and 1 heterocycle compound were characterized and represented 90.04% of the essential oil of green tea produced from the frsh tender leaves of *C. taliensis*. In which, monoterpenoids (58.51%) composing of linalool (28.43%), hotrienol (1.13%), α-terpineol (11.68%), nerol (4.92%) and geraniol (12.34%) were the major volatile components. In addition, the content of diterpenoid, phytol, was up to 6.52%. The small amount constituents were ascribable to be β-ionone (0.65%), *n*-heptacosane (1.09%), 6, 10, 14-trimethyl-2-pentadecanone (1.18%), (*Z*, *Z*, *Z*)-9, 12, 15-octadecatrien-1-ol (1.21%), nerolidol (1.31%), *n*-pentacosane (1.41%), *n*-tricosane (1.58%), and hexadecanoic acid (3.97%).

Forty-six compounds were assigned to terpenoids (9 peaks), alcohols (1 peak), ketones (5 peaks), organic acids (8 peaks), aromatics (2 peaks), esters (8 peaks), amides (1 peak), and long-chain hydrocarbons (12 peaks), whose constitutes took 96.50% of the essential oil of green tea produced from the older leaves of *C. taliensis*. Among them, organic acid, alcohols and diterpenoids were dominant compositions on the basic of *n*-hexadecanoic acid (41.6%), linoleic acid (16.0%), (*Z*, *Z*, *Z*)-9, 12, 15-octadecatrien-1-ol (11.2%), and phytol (14.2%). The small amount remainders were characterized to be hexahydrofarnesyl acetone (2.2%), isophytol (1.0%), tetradecanoic acid (0.79%) and other type of compounds.

The major volatile components in the fresh tender leaves of *C. taliensis* were organic acid (50.34%) and diterpenoids (8.75%), while monoterpenoids (58.51%) together with diterpenoids (6.52%) were found to be the major ones in its green tea product. From the fresh tender leaves to its green tea products, 28 constituents referring to seven terpenoids (peaks 3, 4, 8, 10, 13, 19, 29), eight ketons (peaks 27, 30, 31, 32, 37, 46, 64, 87), one aromatics (peak 53), one ester (peak 70), two long-chain hydrocarbons (peaks 33, 80), five alcohols (peaks 1, 7, 9, 49, 77), three aldehydes (peaks 14, 25, 43), and one heterocycle compound (peak 17) were formed. Among then, the content of (*Z*, *Z*, *Z*)-9, 12, 15-octadecatrien-1-ol (peak 77) was up to 1.21%. It is also found in the green tea product produced from the older leaves. (*Z*, *Z*, *Z*)-9, 12, 15-octadecatrien-1-ol should be the characteristic aroma in the green tea products of *C. taliensis*. On the other hand, 12 minor aroma constituents (peaks 2, 11, 16, 21, 24, 40, 44, 58, 59, 66, 82, 84) in the fresh tender leaves of *C. taliensis* were disappeared after the green tea product was formed. Compared with the green tea product produced from tender leaves, the one from older leave has less aroma constituents.

It is worthy of note that the contents of linalool (28.43%), hotrienol (1.13%), α-terpineol (11.68%), nerol (4.92%) and geraniol (12.34%) in the essential oil of green tea produced from the tender leaves of *C. taliensis* were much higher than those of its original fresh material, while the contents

Table 1　Volatile constituents of fresh leaves of *Camellia taliensis* and its green tea products

Peaks	Retation time /min	Components	Percentage/%		
			A	B	C
1	3.91	1-octen-3-ol	—	0.329	—
2	4.18	(*E*, *E*)-2, 4-heptadienal	0.096	—	—
3	5.51	*cis*-linalool oxide	—	0.439	—
4	5.91	*trans*-linalool oxide	—	0.264	—
5	6.21	linalool	0.638	28.434	0.202
6	6.25	hotrienol	0.105	1.126	—
7	6.40	benzeneethanol	—	0.074	—
8	7.15	nerol oxide	—	0.123	—
9	7.46	1-nonanal	—	0.207	—
10	7.73	4-terpineol	—	0.257	—
11	7.83	2, 6-dimethyl-3, 7-octadiene-2, 6-diol	0.135	—	—
12	8.14	α-terpineol	1.293	11.68	0.283
13	8.27	safranal	—	0.336	—
14	8.72	2, 6, 6-trimethyl-1-cyclohexene-1-carboxaldehyde	—	0.227	—
15	8.89	nerol	0.570	4.922	0.072
16	8.90	2, 3-epoxygeranial	0.086	—	—
17	9.14	5-methyl-isothiazole	—	0.351	—
18	9.58	geraniol	2.544	12.341	0.448
19	9.66	trans-2-decenal	—	0.596	—
20	9.94	nonanoic acid	0.272	0.434	0.675
21	10.02	3, 7-dimethylocta-1, 7-dien-3, 6-diol	0.141	—	—
22	10.36	(*E*, *E*)-2, 4-decadienal	0.081	0.091	—
23	11.84	geranic acid	0.165	0.100	0.092
24	11.87	3, 7-dimethyl-1, 5-octadien-3, 7-diol	0.097	—	—
25	12.02	undecenal	—	0.244	—
26	12.11	decanoic acid	0.120	0.069	0.120
27	12.61	β-damascenone	—	0.114	—
28	12.96	*cis*-jasmone	0.075	0.442	0.045
29	13.54	*trans*-caryophyllene	—	0.185	—
30	13.65	α-ionone	—	0.181	—
31	13.75	2, 3-dehydro-α-ionone	—	0.157	—
32	14.18	(*E*)-geranylacetone	—	0.541	—
33	14.35	hexadecane	—	0.196	—
34	15.00	undecanoic acid	—	—	0.052
35	15.05	β-ionone	0.079	0.646	—
36	15.15	2, 6-di(t-butyl)-4-hydroxy-4-methyl-2, 5-cyclohexadiene-1-one	—	—	0.056
37	15.18	2-tridecanone	—	0.181	—
38	15.50	*E*, *E*-α-farnesene	0.129	0.363	—
39	16.40	4-methyl-2, 6-di-tert-butylphenol	—	—	0.152
40	16.69	dodecanoic acid	0.125	—	0.161
41	16.83	nerolidol	0.608	1.308	0.322
42	17.02	*cis*-3-hexenyl benzoate	0.075	0.334	—
43	17.41	2-methyl-4-(2, 6, 6-trimethyl-1-cyclohexen-1-yl)-2-butenal	—	0.305	—
44	17.83	α-cedrol	0.065	—	—
45	19.23	(*Z*)-salicylic acid 3-hexenyl ester	0.110	0.451	—
46	19.80	2-pentadecanone	—	0.244	—
47	20.34	(*E*, *E*)-3, 7, 11-trimethyl-2, 6, 10-dodecatrien-1-ol	0.419	0.304	—
48	20.50	heptadecane	—	—	0.168

Continued table 1

Peaks	Retation time /min	Components	Percentage/%		
			A	B	C
49	20.57	3,7,11-trimethyl-1-dodecanol	—	0.127	—
50	20.62	2,6,10,14-tetramethyl-pentadecane	—	—	0.078
51	21.17	tetradecanoic acid	0.588	0.222	0.789
52	21.32	benzyl benzoate	0.067	0.077	—
53	21.62	phenanthrene	—	0.364	0.122
54	22.47	isopropyl myristate	0.078	0.082	—
55	22.64	octadecane	—	—	0.239
56	22.84	2,6,10,14-tetramethyl-hexadecane	—	—	0.161
57	22.90	6,10,14-trimethyl-2-pentadecanone	0.260	1.183	2.189
58	23.17	pentadecanoic acid	0.201	—	0.276
59	23.39	9-nonadecene	0.265	—	—
60	23.44	benzyl salicylate	0.322	0.161	—
61	23.48	neophytadiene	—	—	0.287
62	23.70	isobutyl phthalate	—	—	0.444
63	23.96	nonadecane	0.797	0.204	0.302
64	24.39	farnesyl acetone	—	0.195	0.216
65	24.49	methyl palmitate	0.147	0.126	0.456
66	24.81	9-hexadecenoic acid	0.390	—	—
67	24.93	isophytol	0.199	0.241	1.013
68	25.33	dibutyl phthalate	—	—	0.647
69	25.54	hexadecanoic acid	30.524	3.968	41.551
70	26.53	farnesol	—	0.091	—
71	26.65	geranyl linalool isomer	—	—	0.398
72	27.71	methyl linoleate	0.741	0.268	0.242
73	27.80	*n*-heneicosane	0.970	0.303	0.255
74	27.85	methyl 9,12,15-octadecatrienoate	1.834	0.601	0.699
75	28.16	phytol	8.752	6.521	14.188
76	28.48	linoleic acid	19.824	0.422	16.006
77	28.65	(*Z*,*Z*,*Z*)-9,12,15-octadecatrien-1-ol	—	1.209	11.205
78	28.95	linoleic acid ethyl ester	1.454	0.099	—
79	29.06	ethyl linolenate	2.587	0.178	—
80	29.57	*n*-docosane	—	0.121	0.510
81	31.32	*n*-tricosane	1.577	1.575	0.293
82	31.68	2-ethylhexyl *p*-methoxycinnamate	0.141	—	—
83	32.23	4,8,12,16-tetramethylheptadecan-4-olide	0.170	0.112	0.163
84	32.33	(*Z*)-9-octadecenamide	0.404	—	0.083
85	32.94	*n*-tetracosane	0.168	0.169	0.077
86	34.55	*n*-pentacosane	1.979	1.407	0.278
87	34.73	2-nonadecanone	—	0.075	—
88	35.30	bis (2-ethylhexyl) phthalate	—	—	0.131
89	36.05	hexacosane	0.146	0.072	—
90	37.72	*n*-heptacosane	1.685	1.092	0.149
91	39.01	neryl 2-methylpropanoate	—	—	0.083
92	39.93	bis (2-ethylhexyl) sebacate	0.340	0.081	0.089
93	42.08	nonacosane	0.182	0.096	—
Sum			84.820	90.038	96.467

A: fresh tender leaves of *C. taliensis*; B: green tea produced from tender leaves *C. taliensis*; C: green tea produced from older leaves of *C. taliensis*; —: not detected

of hexadecanoic acid (30.52%), linoleic acid (19.82%), phytol (8.75%) and ethyl linolenate (2.59%) in the fresh tender leaves were conversely higher than those in its green tea products. The result indicated that the aroma constituents of *C. taliensis* were changed during the green tea making process.

The essential oil of green tea produced from *C. taliensis* was different from those of the cultivated tea plants (*C. sinensis* and *C. sinensis* var. *assamica*). Compared with the previous report about the essential oil of green tea produced from *C. sinensis* (Gong *et al.*, 2009; Tian *et al.*, 2007), (*Z*, *Z*, *Z*)-9, 12, 15-octadecatrien-1-ol (11.2%) and linoleic acid (16.0%) were the characteristic of *C. taliensis*. However, linalool, *cis*-jasmone, *β*-Ionone, geraniol, caryophyllene oxide, and caryophyllen were rich constituents in the green tea produced from *C. sinensis*, while these compositions were lower in the green tea produced from *C. taliensis*. In addition, the content of *n*-hexadecanoic acid (41.6%), phytol (14.2%), linoleic acid (16.0%), and (*Z*, *Z*, *Z*)-9, 12, 15- octadecatrien-1-ol (11.2%) were higher than those of *C. sinensis* var. *assamica*, while the content of linalool and *α*-terpineol were lower than the cultivated tea plants (An and Guo, 1997; Zhou *et al.*, 2006).

Antioxidant activity of the volatile oils of *C. taliensis* The antioxidant activity of the volatile oils from the fresh tender leaves of *C. taliensis* and the green tea products were tested by DPPH and $ABTS^+$ assays, and the results were shown in Table 2. All the essential oils of *C. taliensis* showed moderate antioxidant activity, which were weaker than those of (−)-epicatechin, one of the major phenolic constituents in *C. taliensis*, and other three positive controls, gallic acid, trolox, and ascorbic acid. What's more, the antioxidant activity of the oil of green tea produced from older leaves of *C. taliensis* were stronger than that of the oils of the fresh tender leaves and its green tea products, and the oil of fresh tender leaves exhibited the weakest antioxidant activity. The result suggested that the antioxidant activity of *C. taliensis* should mainly arise from the non-volatile components.

In summary, the essential oils of the fresh leaves of *C. taliensis* and its green tea products were very different. Higher volatiles were detected in the green tea products obtained from non-fermentation tea processing process. The aroma constituents of *C. taliensis* were changed during the processing process. In addition, the collecting time was also important for the aroma of tea, and tender leaves of *C. taliensis* are better for making green tea. The DPPH and $ABTS^+$ radical scavenging assays demonstrated a moderate antioxidant activities of the essential oils from the fresh leaves of *C. taliensis* and its green tea products. This could be concluded that the antioxidant property of green tea produced from *C. taliensis* was dominantly due to the rich content of flavan-3-ols and hydrolysable tannins.

Table 2　Antioxidant activity of the volatile oils from *Camellia taliensis*

Samples	DPPH[a] SC_{50} (μg·mL^{-1})[c]	ABTS[b] SC_{50} (μg·mL^{-1})[c]
Volatile oil of fresh tender leaves of *C. taliensis*	>1000	>1000
Volatile oil of green tea produced from the tender leaves	129.3 ± 9.0	138.1 ± 1.3
Volatile oil of green tea produced from the older leaves	308.2 ± 10.1	374.6 ± 6.7
Ascorbic acid	5.8 ± 0.1	21.4 ± 0.1
Gallic acid	0.6 ± 0.1	8.3 ± 0.4
(−)-Epicatechin	2.5 ± 0.1	9.4 ± 0.7
Trolox	8.9 ± 0.8	35.2 ± 1.7

[a] SC_{50} = concentration in μg·mL^{-1} required to scavenge 50% of DPPH radical; [b] SC_{50} = concentration in μg·mL^{-1} required to scavenge 50% of $ABTS^+$ radical; [c] Values represent means ± *SD* (n = 3)

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