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Determination of Catechin Content in Representative Chinese Tea Germplasms

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Supporting Information

ABSTRACT: To understand tea germplasms better and to use them effectively for production and breeding, the catechin content of 403 accessions of representative tea germplasms collected from various locations in China were studied using HPLC. The catechin content of these tea germplasms varied from 56.6 to 231.9 mg/g and averaged 154.5 ± 18.1 mg/g. One germplasm with low total catechin (TC) content (<60 mg/g) and three with high TC (>200 mg/g) contents were found. Averages of the TC content of the three varieties of *Camellia sinensis* (L.) O. Kuntze, namely, *sinensis*, *assamica*, and *pubilimba*, were 152.9 ± 16.2 mg/g, 162.8 ± 22.3 mg/g, and 165.1 ± 21.3 mg/g, respectively. The TC content of the *sinensis* variety was significantly lower ($P < 0.05$) than that of the other two varieties. The *assamica* variety had the highest levels of (−)-epicatechin gallate (ECG), and (−)-epicatechin (EC), whereas the *pubilimba* variety had the highest levels of (−)-epigallocatechin gallate (EGCG), (+)-gallocatechin (GC), (+)-catechin (C), and (−)-gallocatechin gallate (GCG). Factor analysis indicated that GC, C, GCG, catechin index, and ECG greatly influenced the classification. The TC content of germplasms collected from the various provinces showed significant differences ($P < 0.05$). Tea germplasms of the southern provinces had higher degrees of variation in TC.

KEYWORDS: *catechins, China, tea plant, variation*

INTRODUCTION

Tea, a crop with worldwide significance that is used in healthful beverages, has socioeconomic and cultural importance for Asian countries such as China, India, Japan, and Sri Lanka, as well as African countries such as Kenya.[1] According to the Food and Agriculture Organization of the United Nations (http://faostat.fao.org/faostat/), China is the largest tea producer in the world. In 2011, China had 2.1 million hectares that produced 1.6 million tons of tea. Tea is made from the fresh leaves of the tea plant [*Camellia sinensis* (L.) O. Kuntze]. This plant originated in southwestern China.[2−4] Tea plants are classified into five species and three varieties based on morphology.[5] They belong to section *Thea* (L.) Dyer, genus *Camellia* L. of the family Theaceae. Three varieties of *C. sinensis* (L.) O. Kuntze, namely, *C. sinensis* var. *sinensis*, *C. sinensis* var. *assamica* (Masters) Kitamura, and *C. sinensis* var. *pubilimba* Chang, are cultivated worldwide.[6] A wide diversity of tea germplasms is a very valuable resource for tea breeding and production in the future.[7] Therefore, we have focused on tea germplasm collection, conservation, evaluation, and utilization. The China National Germplasm Tea Repository (CNGTR) has collected and preserved more than 3000 accessions of tea germplasms.[1]

Catechins constitute 8−26% of the dry weight of tea.[7] The main tea catechins are (−)-epigallocatechin gallate (EGCG), (−)-epicatechin gallate (ECG), (−)-epigallocatechin (EGC), (+)-gallocatechin (GC), (−)-epicatechin (EC), and (+)-catechin (C).[8] Tea catechins have various activities that greatly benefit human health, for example, antioxidative,[9] antihypertensive,[10] and anticarcinogenic activities.[11] Each catechin monomer has its unique bioactivity, bioavailability, and physiological pharmacokinetics,[12] which may be related to the different chemical structures of tea catechins.[13] For example, it has been reported that the antioxidant activity of green tea catechins is in the following order: ECG > EGCG > EC > EGC,[14] and EGCG is notably unstable and is known to have poor bioavailability.[15] Furthermore, catechins are important factors of the quality of tea.[16−19] For example, the ratio (EGCG + ECG) × 100/EGC has been suggested as a quality index for measuring the difference in catechin levels of fresh tea shoots across the growing seasons.[16,20] A higher ratio may indicate higher quality of the green tea.[16] Catechins are synthesized through the phenylpropanoid and flavonoid biosynthetic pathways.[21] Dihydroquercetin and dihydromyricetin are the precursors of dihydroxylated catechins (EC and ECG) and trihydroxylated catechins (EGC and EGCG), respectively. Formation of dihydroquercetin and dihydromyricetin is genetically determined.[21] The catechin index (CI) [(EC + ECG)/(EGC + EGCG)] has been used as a biochemical marker for studying the genetic diversity of tea germplasms.[22−24]

Identification and evaluation of tea germplasms is fundamentally important for cultivar development and processing, for improving extraction of bioactive compounds such as catechins, and for biotechnology work.[7] China has abundant and diverse

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tea germplasms.[1,6,7] However, there are no comprehensive investigations about the catechin content of Chinese tea germplasms. Variations of the total catechins (TC) content of 119 accessions have been reported by the CNGTR.[7] However, the catechin compositions of Chinese tea germplasms were not clarified. To understand tea germplasms better and to use them effectively for breeding and production, the present study had the following main objectives: (1) to clarify the variation and profile of major catechins in tea germplasms of China, (2) to investigate the variability in catechin content of tea varieties and, (3) to understand the diversity of catechins of tea germplasms from main tea-producing regions of China.

■ MATERIALS AND METHODS

Materials. A total of 403 accessions of representative tea germplasms were sampled for analysis. Having been introduced as cuttings or seedlings from 15 tea-growing provinces in China, they are currently preserved as genetic resources in the CNGTR (120°10′ E, 30°18′ N, 50 m in altitude) at Hangzhou, China, and are maintained through similar horticultural practices. Their geographic origins are shown in Figure 1. Among them, 320 accessions were *C. sinensis* var. *sinensis* (*sinensis* variety), 21 were *C. sinensis* var. *assamica* (*assamica* variety), 30 were *C. sinensis* var. *pubilimba* Chang (*pubilimba* variety), 8 were *C. taliensis* (W. W. Smith) Melchior, 4 were *C. crassicolumna* Chang, 3 were *C. tachangensis* F. C. Zhang, 1 was *C. gymnogyna* Chang, and 16 were uncategorized germplasms. All belong to the section *Thea* (L.) Dyer genus *Camellia* L. To analyze the main catechin components, 20−60 g of one bud and two leaves young shoots of the first flush in spring were harvested from individual plant of 403 accessions of tea germplasms in 2010 and 2011. All samples were immediately fixed with air at 120 °C for 5 min to deactivate polyphenol oxidase and then dried at 70 °C by a 1.1 kW drying machine (Zhejiang Chunjiang Tea Machinery Co., Hangzhou, China). The dried samples were stored in polyethylene bags and then kept frozen (−20 °C) until analysis. At the time of analysis, the frozen samples were ground and sifted through a 0.5 mm screen. Samples were analyzed in triplicate and results were averaged. Analysis of tea germplasms was performed over the course of two years. Because the difference in catechin content between two years was not significant ($P \geq 0.05$) (data not shown), data analysis utilized the mean catechin content of each tea accession in 2010 and 2011.

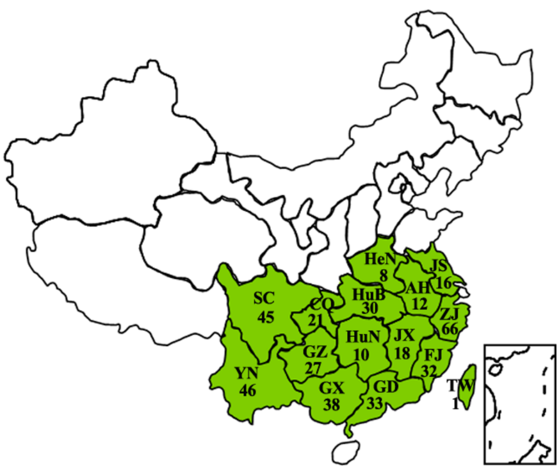

Figure 1. Sampling size and distribution of tea germplasms in China. Abbreviations represent different provinces. AH: Anhui, CQ: Chongqing, FJ: Fujian, GD: Guangdong, GX: Guangxi, GZ: Guizhou, HeN: Henan, HuB: Hubei, HuN: Hunan, JS: Jiangsu, JX: Jiangxi, SC: Sichuan, TW: Taiwan, YN: Yunnan, and ZJ: Zhejiang. A total of 403 accessions of tea germplasms were obtained.

Chemicals and Standards. The standard substances EGCG (97% purity), ECG (98% purity), EGC (95% purity), EC (98% purity), GC (98% purity), C (98% purity), and (−)-gallocatechin gallate (GCG) (98% purity) were bought from Sigma-Aldrich Chemicals Co. (St. Louis, MO, U.S.A.). Other chemicals were obtained from Huadong Medicine Co., Ltd. (Hangzhou, China).

Sample Preparation and HPLC Conditions. The isolation and detection of tea catechins, by high performance liquid chromatography (HPLC), was performed according to the International Standards Organization (ISO) ISO 14502-2-2005(E) procedure[25] with minor modifications. The powdered tea sample (0.2 g) was extracted by intermittent shaking with 5 mL of 70% (v/v) methanol at 70 °C, and the mixture was centrifuged at 1400*g* for 10 min. The supernatant was decanted into a 10 mL volumetric flask, and the extraction steps were repeated until a final volume of 10 mL was reached. The extracts were filtered through a 0.45 μm Millipore filter into autosampler vials. The sample injection volume was 10 μL. Tea extracts were analyzed for catechins. A Waters e2695 series HPLC system (Waters Co., Milford, MA, U.S.A.) with a reversed-phase C12 column (4 μm, 250 mm × 4.6 mm, Phenomenex) and a C12 guard column was utilized for analysis. The columns were maintained at 30 °C. The mobile phases were 0.5% (v/v) formic acid in double-distilled water (eluent A) and acetonitrile (eluent B). The flow rate was 1 mL/min. The gradient program was as follows: 0−16 min, linear gradient from 6.5% to 16% B; 16−20 min, linear gradient to 25% B; 20−25 min, 25% B; 25−26 min, linear gradient to 6.5% B; 26−30 min, 6.5% B. Corresponding changes in A were made. The eluate was monitored at 280 nm. Chromatographic peaks were identified by UV spectra using diode array detector, and retention times were compared with those of reference compounds. Figure 2 shows chromatograms of the standards and of a typical tea sample. Quantification was carried out by using the external standard method, and standard curves were constructed by linear regression analyses. The regression equations, linear ranges, and correlation coefficients of seven standards are summarized in Supporting Information Table S1. Recovery experiments were repeated three times. The samples were spiked with known amounts of the standards during the extraction. Mean values for the recoveries of EGCG, ECG, EGC, EC, GC, C, and GCG were 97.5% ± 2.6%, 96.9% ± 2.2%, 98.8% ± 4.1%, 97.3% ± 2.6%, 95.2% ± 6.5%, 96.4% ± 3.3%, and 93.1% ±

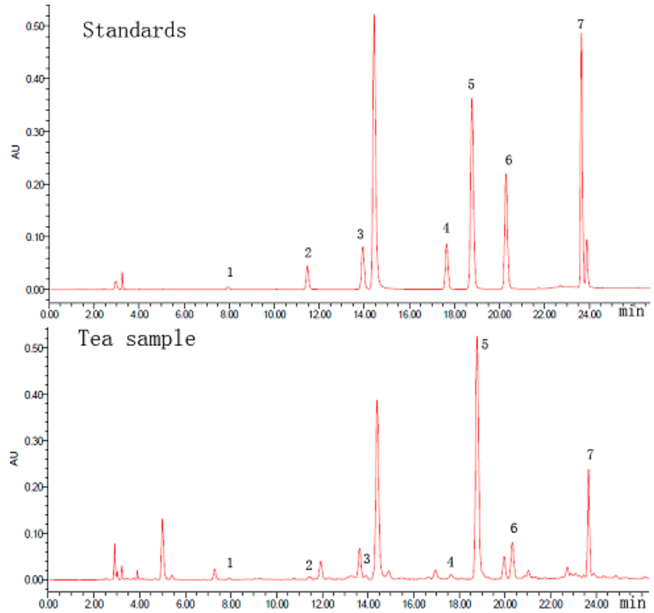

Figure 2. Chromatograms of standards and of a typical tea sample. 1, (+)-gallocatechin (GC); 2, (−)-epigallocatechin (EGC); 3, (+)-catechin (C); 4, (−)-epicatechin (EC); 5, (−)-epigallocatechin gallate (EGCG); 6, (−)-gallocatechin gallate (GCG); and 7, (−)-epicatechin gallate (ECG).

Table 1. Variation and Distribution of Catechins in Chinese Tea Germplasms (n = 403)[a]

catechin	min (mg/g)	max (mg/g)	median (mg/g)	mean ± SD (mg/g)	CV (%)	kurtosis	skewness	H'
GC	1.4	22.7	2.7	3.6 ± 3.0	81.9	13.3	3.4	1.32
EGC	2.1	39.4	15.6	16.1 ± 5.6	35.0	0.9	0.6	2.03
C	0.3	30.9	2.0	2.3 ± 2.0	87.9	135.9	10.4	1.31
EC	2.0	54.0	7.6	8.2 ± 3.7	45.7	56.7	5.3	1.86
EGCG	13.0	137.5	94.3	94.1 ± 14.6	15.6	3.3	−0.5	2.05
GCG	0.1	77.6	0.5	1.5 ± 4.7	323.6	169.4	11.3	1.36
ECG	3.2	72.8	27.6	28.9 ± 7.8	27.1	5.3	1.6	1.85
TC	56.6	231.9	153.3	154.5 ± 18.1	11.7	2.13	0.03	2.05

[a]The catechin content of each accession was the mean of two years. C, (+)-catechin; EC, (−)-epicatechin; ECG, (−)-epicatechin gallate; EGC, (−)-epigallocatechin; EGCG, (−)-epigallocatechin gallate; GC, (+)-gallocatechin; GCG, (−)-gallocatechin gallate; TC, total catechins; min, minimum value; max, maximum value; SD, standard deviation; CV, coefficient of variation; and H', diversity index.

1.9%, respectively. The TC content was calculated as the sum of the above seven individual catechins.

Statistical Analysis. The results were analyzed by using SPSS 13.0 (SPSS Inc., Chicago, U.S.A.) statistical software. Differences among means were evaluated using Tukey's test. Factor analysis was performed using the method of principal component extraction to derive the factor matrix. The structure of the original factor matrix was simplified using Varimax rotation. A scatter plot of the first two factors was prepared to bring out their distribution in the factor space represented by these two factors.[26] The overall entry mean (X) and standard deviation (σ) for the parameters examined in this study were used to subdivide the accession values (x_i) into ten frequency classes ranging from class 1 (if $x_i < X - 2\sigma$) to 10 (if $x_i > X + 2\sigma$), with class interval of 0.5σ.[27] The diversity of each parameter was estimated by using the Shannon−Weave index (H'),[28] expressed as $H' = -\Sigma P_i \ln P_i$, where P_i is the proportion of the total number of entries in the ith class.

RESULTS

Variation in Catechin Content among Different Germplasms. The variation and distribution for catechins contents of the 403 accessions are summarized in Table 1. Wide variation and diversity of the Chinese tea germplasms were observed. The average TC content was 154.5 ± 18.1 mg/g, varying from 56.6 to 231.9 mg/g, and that of the 396 accessions ranged from 120.0 to 200.0 mg/g (Tables 1 and 2). EGCG was the most abundant catechin (60.9%), its amount averaging 94.1 ± 14.6 mg/g; ECG, EGC, EC, GC, C, and GCG were next in abundance.

Table 2. Variation in Total Catechin Content among Tea Germplasms in China

catechins (mg/g)	accessions	percent (%)
<120	4	1.0
120.1−140.0	80	19.9
140.1−160.0	178	44.2
160.1−180.0	106	26.3
180.1−200.0	32	7.9
>200.1	3	0.7
total	403	100

Levels of TC, EGCG, ECG, EC, and EGC in the 403 accessions had a normal distribution and their H' values were high (>1.85) (Table 1). In contrast, minor components such as GC, C, and GCG did not have a normal distribution and their H' values were lower, although their coefficient of variation (CV) was higher. Through this study, several valuable transnormal tea germplasms were found in the 403 accessions, including one low-TC (<60 mg/g) and three high-TC (>200.0 mg/g) accessions.

Variations in Catechin Content among the Three Varieties of *C. sinensis*. Average values of the TC content of *sinensis*, *assamica*, and *pubilimba* varieties of *C. sinensis* (L.) O. Kuntze were 152.9 ± 16.2 mg/g, 162.8 ± 22.3 mg/g, and 165.1 ± 21.3 mg/g, respectively (Table 3). The TC content of the *assamica* and *pubilimba* varieties was significantly higher than that of the *sinensis* variety. Data in Table 3 clearly illustrate that there were statistically significant differences ($P < 0.05$) in the catechin content among the three varieties. The *assamica* variety had the highest levels of ECG and EC and the lowest levels of EGCG and GCG, whereas the *pubilimba* variety had the highest levels of EGCG, GC, C, and GCG and the lowest levels of EGC and EC. In particular, the GCG content of the *pubilimba* variety was 6−9 times higher than that of the other two varieties (Table 3). The CI value of the *assamica* variety was significantly higher ($P < 0.05$) than those of the *pubilimba* and *sinensis* varieties. The CI value of more than half of the accessions for the *assamica* variety was higher than 0.45.

Table 3. Catechin Profile of Three Varieties of *C. sinensis*[a]

	var. *sinensis* (n = 320)	var. *assamica* (n = 21)	var. *pubilimba* (n = 30)
GC	3.2 ± 2.3b	3.4 ± 1.5b	7.7 ± 4.9a
EGC	16.6 ± 5.6a	17.0 ± 5.5a	12.4 ± 5.4b
C	2.0 ± 0.7c	2.7 ± 1.1b	3.3 ± 1.3a
EC	7.9 ± 2.3b	10.6 ± 3.9a	6.3 ± 3.9c
EGCG	94.6 ± 12.6ab	90.7 ± 18.0b	99.5 ± 15.4a
GCG	0.9 ± 2.2b	0.6 ± 1.1b	5.7 ± 5.3a
ECG	28.0 ± 6.7b	37.8 ± 10.2a	29.9 ± 9.3b
TC	152.9 ± 16.2b	162.8 ± 22.3a	165.1 ± 21.3a
CI	0.35 ± 0.16b	0.50 ± 0.16a	0.36 ± 0.17b

C, (+)-catechin; EC, (−)-epicatechin; ECG, (−)-epicatechin gallate; EGC, (−)-epigallocatechin; EGCG, (−)-epigallocatechin gallate; GC, (+)-gallocatechin; GCG, (−)-gallocatechin gallate; TC, total catechins; CI, catechin index. All units except those for CI are in mg/g. [a]Values are mean ± SD. Means within each line that are followed by the same letter are not different at $P \geq 0.05$, based on Tukey's honestly different significance test.

On the basis of the 9 catechin patterns of 371 tea accessions of *C. sinensis*, factor analysis was performed. The percentage variances explained by the first three factors are given in Table 4. These three factors together accounted for 81.9% of the total variance. GC, C, and GCG largely influenced the first factor, ECG, and CI dominated the second factor, while the third factor was largely associated with EGCG and TC. Spatial

Table 4. Factor Analysis of 371 Accessions of *C. sinensis*[a]

variable	factor 1	factor 2	factor 3
GC	0.88	−0.10	0.09
EGC	−0.42	0.09	0.68
C	0.85	0.26	−0.01
EC	−0.33	0.75	0.35
EGCG	0.05	−0.35	0.83
ECG	0.11	0.90	0.06
GCG	0.85	−0.15	−0.07
TC	0.23	0.23	0.93
CI	0.03	0.94	−0.31
Eigenalue	2.59	2.54	2.25
cumulative (%)	28.73	56.97	81.93

[a]C, (+)-catechin; EC, (−)-epicatechin; ECG, (−)-epicatechin gallate; EGC, (−)-epigallocatechin; EGCG, (−)-epigallocatechin gallate; GC, (+)-gallocatechin; GCG, (−)-gallocatechin gallate; TC, total catechins; and CI, catechin index.

distribution of 371 tea accessions of *C. sinensis* in relation to first two factors is presented in Figure 3. Most of the accessions from the *sinensis*, *assamica*, and *pubilimba* varieties were in groups I, II, and III, respectively.

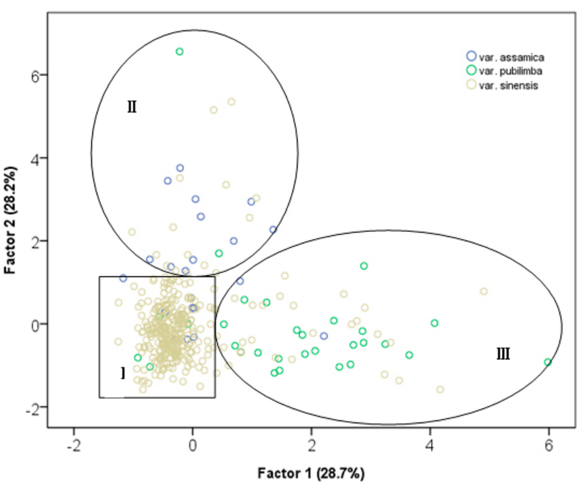

Figure 3. Spatial distribution of 371 accessions of *C. sinensis* in relation to the first two factors.

Variation in Catechin Content of Germplasms from Different Geographical Origins. The levels of main catechin constituents in the germplasms collected from various provinces were significantly different ($P < 0.05$, Table 5). Catechin levels were affected by the geographical origin of the tea plant. Germplasms from Henan province had the highest mean TC content (167.0 ± 14.6 mg/g), and those from Jiangsu had the lowest (141.6 ± 10.6 mg/g) (Table 5). The TC content of samples tended to decline from the southern to the northern provinces, with the exception of Henan. Henan had the highest average EGC and EGCG content, and the lowest mean ECG content. The highest mean ECG and combined EC and C contents were observed in germplasms from Yunnan. The CI value of genetic resources from Yunnan was significantly higher ($P < 0.05$) than that of the others (Table 5).

To survey the differentiation level of catechins among germplasms from the different provinces, 10 provinces with large number of accessions were selected for statistical analysis and comparison (Figure 4). Because of the differences in sample sizes, the calculation was based on a random selection of 18 accessions from each province. This selection was repeated three times for comparison. Samples from Yunnan province showed the highest differentiation level (H' = 1.89, CV = 15.6%), and those from Guangxi province had next highest level (H' = 1.87, CV = 13.5%). Those from Zhejiang and Fujian provinces had the lowest H' (1.39) and CV (7.5%), respectively. These results indicate that tea germplasms from the southern provinces had higher differentiation levels of TC.

DISCUSSION

There were significant differences in the composition of catechins among the three varieties of *C. sinensis*. The CI value, a measure of the difference in catechin composition, has been proven to be affected by the genetic background.[22−24] The CI value of the *assamica* variety was significantly higher ($P < 0.05$) than those of the *pubilimba* and *sinensis* varieties. C and GC are mainly derived from leucocyanidin through a reaction catalyzed by leucoanthocyanidin reductase (LAR) instead of anthocyanidin reductase, as in the case of EC, ECG, EGC, or EGCG.[29,30] The higher GC and C content of the *pubilimba* variety might be attributed to changes in the LAR activity. Factor analysis result based on the catechins as phenetic markers shows that it is basically consistent with morphological classifications, and catechins can be utilized for quantitative data to determine the characteristics of tea plant.

Catechins are converted from nonesterified to esterified derivatives during flavan-3-ol biosynthesis.[31] Catechol or dihydroxy derivatives of catechins such as EC and C are found mostly in primitive tea plants.[31,32] The present study showed that Yunnan germplasms had the highest sum of EC and C contents, suggesting that these are more primitive than those from the other provinces. The genetic diversity decreased from the central region (Yunnan and Guangxi provinces) toward the northern and eastern regions, as revealed by expressed sequence tags based on simple sequence repeat (EST-SSR) markers.[1] Among the 10 provinces investigated, those from the southwestern provinces Yunnan and Guangxi had the highest differentiation level of TC, whereas those from Fujian and Zhejiang had the lowest differentiation level. Results for TC differentiation level show a similar tendency for the genetic diversity.

Depending on the type of processing, which mainly differ in the oxidization degree of the catechins, tea is generally divided into green, white, oolong, black, yellow, and dark varieties. Each tea variety has a unique character, taste, and chemical profile.[33] Different tea cultivars are suitable for different types of tea, and catechins are important factors for the quality of tea.[16−19] This study provides comprehensive information on the catechin content of Chinese tea germplasms, as well as useful guidance for tea manufacturing. Germplasms with high catechin content have been used as commercial raw materials for extracting functional components. Their extraction ratio is higher than that of conventional materials.[7] The TC content increased by ~40 mg/g or 26% from spring to autumn (data not shown). Therefore, autumn tea leaves might be of greater potential use in the extraction of natural catechins. Among the genetic resources of tea with varied catechin contents, germplasms with high catechin content are useful as breeding materials for black and green tea.[34] For black tea, the target individuals might be selected from progenies resulting from crosses between accessions with high catechin content and cultivars of *assamica*

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Table 5. Catechin Profiles of Tea Germplasms from Different Geographical Regions[a,b]

regions	EGC	EC + C	EGCG	ECG	TC	CI
Anhui (n = 12)	16.6 ± 5.5ab	8.5 ± 2.0b	92.9 ± 10.3bc	25.7 ± 4.6b	146.5 ± 14.4bc	0.33 ± 0.07b
Chongqing (n = 21)	16.3 ± 4.8ab	12.5 ± 10.0ab	94.3 ± 8.1bc	27.2 ± 4.2b	156.2 ± 15.9abc	0.38 ± 0.13ab
Fujian (n = 32)	17.4 ± 3.7ab	9.8 ± 1.4ab	95.1 ± 12.0abc	27.4 ± 5.3b	153.0 ± 13.8abc	0.34 ± 0.08b
Guangdong(n = 33)	12.7 ± 4.8b	10.7 ± 6.9ab	98.1 ± 20.2ab	30.0 ± 8.9ab	161.9 ± 15.8ab	0.40 ± 0.26ab
Guangxi (n = 38)	13.6 ± 7.4b	10.1 ± 4.1ab	94.8 ± 16.4abc	29.0 ± 9.9b	161.2 ± 22.3ab	0.37 ± 0.20b
Guizhou (n = 27)	17.8 ± 6.4ab	11.5 ± 2.7ab	93.5 ± 12.1bc	30.2 ± 6.0ab	156.0 ± 14.9abc	0.39 ± 0.11ab
Henan (n = 8)	20.9 ± 5.4a	9.8 ± 1.2ab	109.9 ± 12.3a	22.9 ± 3.6b	167.0 ± 14.6a	0.26 ± 0.04b
Hubei (n = 30)	16.0 ± 4.8ab	8.5 ± 1.7b	96.1 ± 12.2abc	27.1 ± 4.0b	151.2 ± 15.3abc	0.33 ± 0.07b
Hunan (n = 10)	15.8 ± 5.1ab	9.4 ± 2.8b	98.1 ± 11.2abc	26.7 ± 4.9b	154.8 ± 16.1abc	0.33 ± 0.06b
Jiangsu (n = 16)	15.4 ± 3.5ab	9.9 ± 1.8ab	84.2 ± 7.3c	29.2 ± 5.3ab	141.6 ± 10.6c	0.40 ± 0.07ab
Jiangxi (n = 18)	15.4 ± 7.4ab	9.4 ± 3.9b	100.1 ± 10.4ab	26.9 ± 5.3b	155.4 ± 15.5abc	0.33 ± 0.08b
Sichuan (n = 45)	17.7 ± 5.7ab	10.2 ± 2.0ab	96.5 ± 10.5abc	27.4 ± 3.7b	154.9 ± 15.3abc	0.34 ± 0.05b
Yunnan (n = 46)	16.8 ± 5.6ab	13.8 ± 5.2a	89.7 ± 21.7bc	36.8 ± 12.8a	160.6 ± 25.6ab	0.53 ± 0.24a
Zhejiang (n = 66)	15.8 ± 4.8ab	9.7 ± 2.1ab	90.4 ± 12.5bc	27.6 ± 6.1b	146.9 ± 15.3bc	0.36 ± 0.08b

[a]Values are mean ± SD. Means within each column that are followed by the same letter are not different at $P \geq 0.05$, based on Tukey's honestly different significance test. [b]C, (+)-catechin; EC, (−)-epicatechin; ECG, (−)-epicatechin gallate; EGC, (−)-epigallocatechin; EGCG, (−)-epigallocatechin gallate; TC, total catechins; CI, catechin index. All units except those for CI are in mg/g.

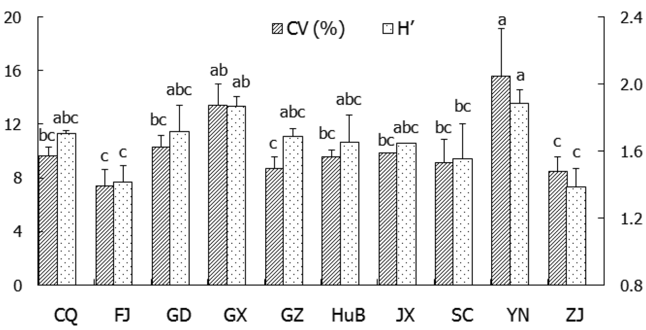

Figure 4. Coefficient of variation (CV) and diversity indices (H') of the total catechin (TC) content of tea germplasms from different provinces. Abbreviations represent different provinces. CQ: Chongqing, FJ: Fujian, GD: Guangdong, GX: Guangxi, GZ: Guizhou, HuB: Hubei, JX: Jiangxi, SC: Sichuan, YN: Yunnan, and ZJ: Zhejiang. Identical letters above columns denote the absence of significant difference ($P > 0.05$) based on Tukey's honestly different significance test.

variety. However, crosses between accessions with high catechin content and *sinensis* variety are usually more desirable for breeding green tea.

■ ASSOCIATED CONTENT

Supporting Information

Table S1. Regression equations, linear ranges, and correlation coefficients of seven standards. This material is available free of charge via the Internet at http://pubs.acs.org. .

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Notes

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■ ABBREVIATIONS USED

C, (+)-catechin; CI, catechin index; EC, (−)-epicatechin; ECG, (−)-epicatechin gallate; EGC, (−)-epigallocatechin; EGCG, (−)-epigallocatechin gallate; CV, coefficient of variation; FA, factor analysis; GC, (+)-gallocatechin; GCG, (−)-gallocatechin gallate; TC, total catechins

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