COMPARATIVE ANALYSIS THE MAJOR ACTIVE COMPONENTS AND ANTIOXIDANT ACTIVITY OF THE *CAMELLIA* SECT. *CHRYSANTHA* FLOWERS

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Abstract. The main active components of the *Camellia* sect. *Chrysantha* flowers were analyzed and the antioxidant activity of total flavonoids were compared. The results showed that among the flowers of the 10 species of Sect. *Chrysantha* plants, *C. nitidissima* had the highest contents of TFC (0.848 g/100 g) and TSC (6.824 g/100 g), and *C. insularis* had the highest content of TPOC (4.3 g/100 g). The TPC (17.188 g/100 g) and CTC (101.026 mg/100 g) of *C. achrysantha* was significantly higher than that of the other 9 species. *C. pubipetala* had the highest content of GAC (1.586 g/100 g), and the amino acids of *C. tunghinensis* had the highest amino acid content of all the 10 species. Comprehensive evaluation of the active components of *Camellia* sect. *Chrysantha* flowers, it rankings were: *C. achrysantha* > *C.insularis* > *C. pubipetala*> *C. quinqueloculosa* >*C. tunghinensis* > *C. impressinervis*> *C. longzhouensis* > *C. perpetua* > *C. nitidissima* >*C. micrantha* .This indicated that the combined value of the seven active ingredients was the highest in the flowers of *C. achrysantha* , followed by *C. insularis* in Vietnam and *C. pubipetala*. The results provide reference for the development and utilization of new plant food resources of Sect. *Chrysantha*.
Keywords: *Sect. Chrysantha, active components, antioxidant capacity, TFC, TPC, TAAC*

Introduction

Camellia sect. *Chrysantha* plants in the family Theaceae and genus *Camellia*, an evergreen shrub or small tree with yellow flowers (Tang et al., 2017). Different from common white tea cultivated all over the world, most of the original species of Sect. *Chrysantha* are distributed in the southwest of Guangxi Zhuang Autonomous Region of China and the areas bordering Guangxi Zhuang Autonomous Region of Vietnam, with a small number of distributions in the southeast of Yunnan Province and southwest of Guizhou Province. Up to now, more than 50 original species of Sect. *Chrysantha* have been discovered and named (Wei et al., 2023). The Sect. *Chrysantha* has golden flowers, a unique color in genus *Camellia* , with a high degree of ornamental. It known as the "giant panda" of the plant world and the "Queen of tea", has a good reputation in the world. *Camellia nitidissima* and *Cathaya argyrophylla, Alsophila spinulosa, Davidia*

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involucrata. are "plant living fossils", they are the germplasm resources of rare plants in the world (Tang et al., 2023).

The world's popular beverage is partly due to its health benefits which are linked to the presence of polyphenol antioxidants. As strong free radical scavenger, polyphenol compounds can mitigate free radical damage to biomolecules, thereby reducing oxidative stress and chronic disease (Higdon and Frei, 2003; Shahidi and Naczk, 2004). In the food industry, tea extracts are used to increase the oxidative stability of food lipids, and tea olyphenols were the active ingredient of the first plant medicine approved by the FDA for topical use (He and Shahidi, 1997). The flowers of *Camellia* sect. *Chrysantha* are rich in flavonoids (Huang et al., 2022), tea polyphenols (Song et al., 2019), tea polysaccharides, saponins (Cuc et al., 2023)., theanine (Li et al., 2020), and other active ingredients. It is of great importance to study its phytochemical characterization and its potential for utilization as a plant source of functional foods or beverages.

In recent decades, a wide range of scientific research and conservation, horticultural hobbyists, and new food-borne food development workers have targeted this rare species for resource collection and preservation (Liao et al., 2022), seedling breeding techniques (Wu et al., 2018), and highly efficient cultivation techniques (Chai et al., 2018; Chen et al., 2022), chemical composition (Zhang et al., 2020), and processing and utilization (Cheng et al., 2023), a great deal of research work has been carried out. The development and utilization of the flowers and leaves of golden camellia in the original producing areas of China has begun to take shape, and the products sell well, with very active market development and utilization, leading to large-scale and intensive base planting. As another major distribution center of golden camellia, Vietnam is also in full swing in the development of the golden camellia industry (Takahashi et al., 2023). With more and more research reports on the activity of chemical constituents of golden camellia in recent years. Through in vitro cell and animal model tests, it has been shown that golden camellia has a variety of effects such as antitumor (Hou et al., 2018), antioxidant (Wei et al., 2015), hypoglycemic (Yang et al., 2018), and so on, and the rich nutritional value and special health care effects harbor great potential for market development. However, the current literature is mostly on the study of a single constituent (Zhang et al., 2019) or a single species of *Camellia* sect. *Chrysantha* of plants and has not comprehensively evaluated the medicinal value of the plants. Different original species of Sect. *Chrysantha* of plants contain large differences in active ingredients, for this reason, the author chose seven chemical active ingredients with significant medicinal value: total flavonoids, total saponin, total polysaccharide, total phenol, and so on, as the indexes of investigation. Comparative study of Guangxi local golden camellia and the introduction of golden camellia from Vietnam, totaling 10 species in the difference analysis of the main active ingredients, as well as principal component analysis and correlation evaluation, and comparative study of its medicinal value and antioxidant activity of the differences in the aim of selecting the development of the use of the value of the high value of golden camellia to provide the basis for reference.

Materials and methods

Plant materials

The studied plant were 10 wild golden camellia species, respectively: *C.tunghinensis, C. pubipetala, C.longzhouensis, C. micrantha, C. impressinervis, C. achrysantha,*

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C.nitidissima, C.quinqueloculosa, C. perpetua, C.insularis. The golden camellia resources were introduced from wild resources and planted in the germplasm resource bank of Guangxi Institute of Botany. The plants are between 10-15 years old. The samples were collected from flowers of 10 species, each weighing 200 g, Blooming flowers were collected and each weighing 200 g, vacuum freeze-dried, and the samples were pulverized and sieved through a 60-mesh sieve to make sample powder for spare use. The samples were identified by Professor Xiao Wei and stored in Guangxi Institute of Botany (IBK00306615, IBK00306615, IBK00306615 et al.) (*Figure 1*).

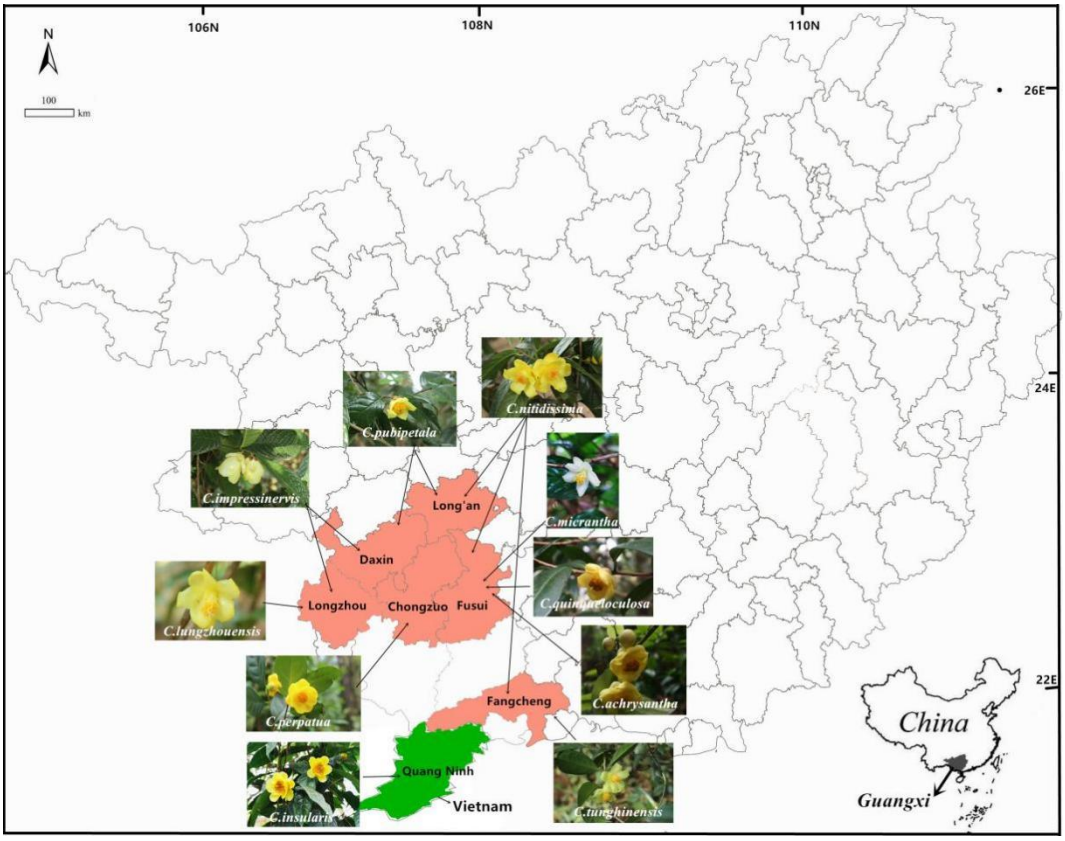

Figure 1. *Field distribution of 10 species of Camellia sect. Chrysantha*

Methods

The total polysaccharide content (TPOC) was determined by phenol sulfate method. The content of total flavone (TFC) was determined by sodium nitrite aluminum nitrate method. Determination of total phenols content (TPC) by Folin phenol method, determination of catechins (CTC) in golden camellia -HPLC method, the results of total catechins and caffeine relative correction factor (RRFsa) to quantify. Total saponins content (TSC) were determined by dinitrosalicylic acid method. Determination of gallic acid (GAC) in flowers by spectrophotometry. Total amino acid content (TAAC) was determined by an automatic amino acid analyzer in accordance with the national standard GB/T5009.124-2016 《Determination of amino acids in food under the National Standard for Food Safety》. Total antioxidant capacity test box, hydroxyl radical scavenging capacity test box and superoxide anion scavenging capacity test box were purchased from Suzhou Kaming Biotechnology Co., LTD. Each type of golden-flower

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tea is carried out in the following steps: weigh 0.2 g golden-flower tea powder, place it in a centrifuge tube, add 12 mL 75% ethanol, shake well, extract it with an ultrasonic cleaner at 60℃, 300W, and high frequency for 35 min, centrifuge, collect the supernatant, and keep it in 50 mL capacity. Clearance D%= (control group A - test group A)/(control group A - blank group) *100% (Li et al., 2020; Yang et al., 2022, 2023; Xiao et al., 2023)

Data processing

Excel 2010 software was used for data statistics, and SPSS21.0 software was used for variance analysis, significance test, principal component analysis and correlation analysis. Drawing with Origin8.0 software; A comprehensive evaluation model of plant active components of golden camellia was established with the variance contribution rate of each component as the weight.

Analysis and evaluation of amino acid composition

Amino acid ratio coefficient method was used evaluated the value of amino acids in the flowers of golden camellia group (Li et al., 2020; Liao et al., 2022; Yang et al., 2023). Amino acid ratio (RAA), amino acid ratio coefficient (RC) and amino acid ratio score (SRC) were calculated based on the essential amino acid model provided by the World Health Organization and the Food and Agriculture Organization of the United Nations (WHO/FAO) as the standard (WHO, 1973). The calculation method is as follows:

$$\text{Essential amino acid}\ (RAA) = \frac{\text{Sample essential amino acid content}\ (\text{g}/100g)}{WHO/FAO\ \text{essential amino acid content}\ (\text{g}/100g)} \quad \text{(Eq.1)}$$

$$\text{Amino acid ratio coefficient}\ (RC) = \frac{\text{Certain essential amino acid ratio}\ (RAA)}{\text{The average value of the ratio of all necessary amino acids in the sample}\ (\overline{RAA})} \quad \text{(Eq.2)}$$

$$\text{Amino acid ratio coefficient score}\ (SRC) = (1-\text{CV})*100 \quad \text{(Eq.3)}$$

$$RC.\text{Coefficient of variation}\ (CV) = \frac{\text{Standard deviation of amino acid ratio coefficient RC}\ (SD)}{\overline{RC}} \quad \text{(Eq.4)}$$

Results

The main active components in the flowers of 10 species in Camellia sect. Chrysantha

The content of TFC, TSC, TPOC, TPC, catechin, GAC and amino acid in the flowers of 10 golden camellias was determined. According to *Table 1*, the differences in TPC, TSC, TPOC, CTC, GAC, and TAAC among the 10 golden camellia groups was significant level ($P < 0.05$). The content of TFC and TSC in *C. nitidissima* were the highest, 0.848 g / 100 g and 6.824 g / 100 g, respectively, significantly higher than other plants . The TFC of *C. quinqueloculosa* and *C. tunghinensis* were low, containing only 0.31 g /100 g and 0.32 g /100 g, respectively: the lowest. The TSC in *C. perpatua* was the lowest. *C. insularis* had the highest TPOC content of 4.3 g /100 g. The TPC in *C. achrysantha* was the highest, reaching 17.188 g/100 g, and the CTC were significantly higher than that of the other nine species; the highest hydrolytic content of GAC in *C.pubipetala*, 1.586 g / 100 g, and the amino acids of *C.tunghinensis* had the highest TAAC of all the 10 species , which amounted to 6.076 g/100 g.

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Table 1. *Content of active ingredients in flowers of 10 species in Camellia sect. Chrysantha plants*

Species	TFC/（g/100g）	TSC/（g/100g）	TPOC/（g/100g）	TPC/（g/100g）	CTC/（mg/100g）	GAT/（mg/100g）	TAAC/（g/100g）
C.tunghinensis	0.32±0.012a	6.352±0.019h	3.424±0.22e	5.988±0.023a	28.68±0.471d	0.754±0.021a	6.076±0.021d
C.longzhouensis	0.506±0.011d	4.462±0.015b	4.244±0.011i	14.406±0.024f	14.5±0.224b	1.166±0.015c	5.08±0.016bc
C.pubipetala	0.428±0.013c	4.61±0.016d	3.364±0.023d	17±0.158i	29.394±0.024d	1.586±0.023f	4.542±0.026ab
C.quinqueloculosa	0.31±0.016a	4.926±0.029e	2.992±0.024b	14.796±0.018g	21.86±0.466c	1.15±0.046c	5.228±0.028c
C.achrysantha	0.536±0.011e	5.638±0.015g	3.654±0.040g	17.188±0.092j	101.026±0.051e	1.376±0.127e	4.286±0.011a
C.impressinervis	0.662±0.015f	6.542±0.019i	3.712±0.026h	14.21±0.016e	13.898±0.040b	1.076±0.017b	5.574±0.011cd
C.insularis	0.826±0.009g	5.348±0.016f	4.3±0.031j	16.506±0.031h	26.396±12.967cd	1.108±0.015bc	4.268±1.350a
C.perpatua	0.842±0.008gh	4.036±0.019a	3.612±0.031f	7.608±0.031d	9.4±0.016ab	1.07±0.016b	4.52±0.022ab
C.micrantha	0.346±0.011b	4.552±0.031c	3.236±0.021c	6.326±0.021b	6.376±0.011a	1.074±0.011b	5.448±0.072c
C.nitidissima	0.848±0.034h	6.824±0.015j	2.944±0.011a	7.422±0.019c	5.388±0.015a	1.31±0.019d	5.36±0.014c
Mean	0.4934	5.589	3.672	12.73	31.318	1.198	5.034

Note: The data in the table are the mean ± standard error, and the different lower-case letters in the same column indicate the interspecific differences reaching a significant level ($P < 0.05$)

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Principal components Analysis of active ingredient index

Principal component analysis of 7 main active components in the flowers of 10 golden camellias, According to *Tables 2* and *3*, principal components were extracted based on the principal component feature value greater than 1, first principal component (PC1) is 2.53, variance contribution was 36.141%, second principal component (PC2) is 1.482 and 21.173%, third principal component (PC3) is 1.211, variance contribution was 17.306%, fourth principal component (PC4) was 0.935, and variance contribution was 13.356%. The cumulative contribution rate of the variance of the four principal components reached 87.976%, reflecting the 87.976% of the information of the original evaluation index. It can fully reflect the relationship between the 7 main active ingredient of 10 species of *Camellia* sect. *Chrysantha*.

Table 2. *Principal component eigenvalue and cumulative variance rate on active ingredient of Camellia sect. Chrysantha*

Component	Initial eigenvalue			The sum of the load squares		
	Total	Variance percentage	Accumulate %	Total	Variance percentage	Accumulate %
PC1	2.53	36.141	36.141	2.53	36.141	36.141
PC2	1.482	21.173	57.314	1.482	21.173	57.314
PC3	1.211	17.306	74.62	1.211	17.306	74.62
PC4	0.935	13.356	87.976			
PC5	0.48	6.854	94.83			
PC6	0.263	3.757	98.587			
PC7	0.099	1.413	100			

Table 3. *Principal component load matrix and component score coefficient matrix on active ingredient of Camellia sect. Chrysantha*

Indicators	Component matrix			The component score coefficient matrix		
	1	2	3	1	2	3
TFC	0.267	0.188	0.914	0.106	0.127	0.754
TPC	0.832	-0.218	-0.163	0.329	-0.147	-0.135
TPOC	-0.027	-0.833	0.254	-0.011	-0.562	0.21
TSC	-0.007	0.808	0.05	-0.003	0.545	0.041
TAAC	-0.83	0.079	-0.274	-0.328	0.053	-0.226
CTC	0.644	0.01	-0.453	0.255	0.007	-0.374
GAC	0.813	0.213	-0.046	0.322	0.143	-0.038

The feature root obtained from the data in the principal component matrix in *Table 4* yields the following principal component formula:

F1=TFC×0.267+TPC×0.832-TPOC×0.027-TSC×0.007-TAAC×0.83+CTC×0.644+GAC×0.813;

F2=TFC×0.188-TPC×0.218-TPOC×0.833+TSC×0.808+TAAC×0.079+CTC×0.01+GAC×0.213;

F3=TFC×0.914-TPC×0.163+TPOC×0.254+TSC×0.05-TAAC×0.274-CTC×0.453-GAC×0.046

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Table 4. *Active ingredient scores of 10 species of Camellia sect. Chrysantha Chang*

Species	F1	F2	F3	F4	score	rank
C. achrysantha	76.962	-0.486	-48.093	19.389	19.389	1
C. insularis	32.387	-1.862	-16.224	8.503	8.503	2
C. perpatua	30.583	-1.712	-15.938	7.932	7.932	3
C. quinqueloculosa	23.032	-0.806	-12.587	5.975	5.975	4
C. tunghinensis	18.919	1.953	-14.153	4.802	4.802	5
C. impressinervis	17.043	0.021	-8.312	4.725	4.725	6
C. longzhouensis	18.033	-2.180	-8.604	4.567	4.567	7
C. pubipetala	9.593	-0.579	-4.896	2.497	2.497	8
C. nitidissima	6.363	2.370	-3.306	2.229	2.229	9
C. micrantha	5.696	0.394	-4.094	1.433	1.433	10

Therefore, taking the variance contribution rate of each component as the weight, we established a comprehensive evaluation model of plant active components in *Camellia* sect. *Chrysantha*: The F of the calculation formula is: F=F1×0.361+F2×0.212+F3×0.173

The contents of 7 main active ingredients in the plant samples of 10 Sect. *Chrysantha* were analyzed for correlation, and the results are shown in *Table 5*. The results showed that the TPC content was significantly positively correlated with CTC and GAC (P <0.01), the correlation coefficient was 0.521 and 0.595, respectively; the TAAC content was significantly negatively correlated with TFC, TPC, CTC and GAC (P <0.01): -0.392, -0.42-0.542, -0.379 and-0.576; GAC was significantly negatively correlated with TAAC (P<0.01), and the correlation coefficient was-0.576. TPOC showed a negative correlation with TSC, and the correlation coefficients were-0.391 (P <0.01) and-0.307 (P <0.05), respectively (*Figures 2, 3*).

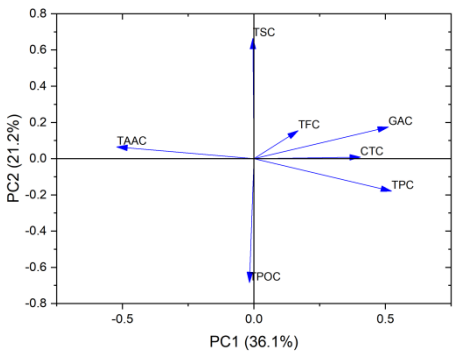

Figure 2. *Principal component analysis diagram*

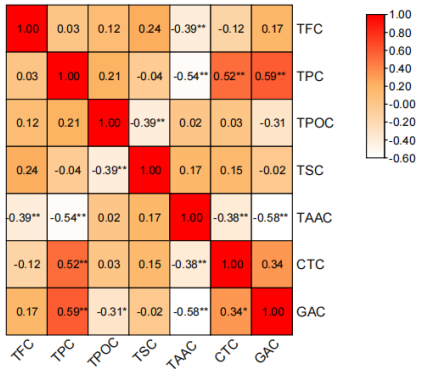

Figure 3. *Correlation analysis. (Note:* At 0.05; **at 0.01 with significant correlation)*

Comprehensive evaluation of the active components of Camellia sect. Chrysantha flowers

The content data of 7 active ingredients of the 10 species of *Camellia* sect. *Chrysantha* were standardized and brought into the model equation of comprehensive evaluation of active ingredients, resulting in *Table 4*. A higher score indicates a better overall nutritional quality of the sample.

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Table 5. *Amino acid composition of flowers in 10 species of Camellia sect. Chrysantha*

Amino acid (g/100 g)	*C.tunghinensis*	*C.longzhouensis*	*C.pubipetala*	*C.quinqueloculosa*	*C.achrysantha*	*C.impressinervis*	*C.insularis*	*C.perpatua*	*C.micrantha*	*C.nitidissima*
Asp^{MD}	0.83±0.18d	0.69±0.14c	0.54±0.26ab	0.69±0.08c	0.57±0.13b	0.91±0.05e	0.49±0.12a	0.47±0.11a	0.82±0.19d	0.61±0.15b
Thr$_{E}$	0.29±0.03b	0.23±0.9a	0.22±0.13a	0.24±0.08a	0.21±0.12a	0.28±0.11b	0.18±0.08a	0.16±0.11a	0.26±0.12b	0.25±0.14b
Ser	0.35±0.15c	0.30±0.03c	0.29±0.09**b**	0.33±0.05c	0.25±0.11a	0.34±0.02c	0.22±0.16a	0.21±0.22a	0.33±0.01c	0.29±0.08b
Glu^{MD}	0.82±0.41c	0.81±0.06c	0.59±0.01ab	0.79±0.08c	0.57±0.07a	0.91±0.08d	0.48±0.06a	0.48±0.14a	0.62±0.11b	0.73±0.03bc
Pro	0.37±0.08b	0.33±0.04b	0.31±0.01b	0.32±0.06b	0.32±0.02b	0.25±0.01a	0.30±0.04b	0.23±0.02a	0.50±0.05c	0.33±0.03b
Gly^{M}	0.34±0.05c	0.26±0.11b	0.26±0.05b	0.28±0.11b	0.23±0.03b	0.29±0.05b	0.20±0.13a	0.16±0.11a	0.31±0.04c	0.28±0.08b
Ala	0.45±0.11d	0.37±0.05c	0.34±0.01b	0.40±0.11d	0.25±0.11b	0.38±0.08c	0.20±0.09b	0.13±0.12a	0.35±0.03c	0.3±0.09b
Val^{E}	0.43±0.15c	0.33±0.16b	0.32±0.12b	0.33±0.21b	0.31±0.11b	0.34±0.11b	0.26±0.12a	0.49±0.14d	0.34±0.13b	0.34±0.14b
Ile^{EM}	0.30±0.1c	0.23±0.04a	0.21±0.02a	0.25±0.03b	0.20±0.02a	0.24±0.04b	0.19±0.01a	0.19±0.01a	0.25±0.03b	0.27±0.05b
Leu^{EM}	0.50±0.05c	0.39±0.08a	0.38±0.07a	0.42±0.07b	0.36±0.03a	0.42±0.3b	0.32±0.01a	0.42±0.1b	0.44±0.04b	0.42±0.07b
Tyr	0.14±0.03b	0.10±0.04a	0.09±0.02a	0.11±0.01a	0.09±0.01a	0.11±0.01a	0.07±0.03a	0.46±0.21c	0.13±0.05b	0.12±0.02b
Phe^{EM}	0.32±0.08c	0.24±0.01a	0.23±0.01a	0.25±0.04b	0.23±0.03a	0.25±0.04b	0.20±0.02a	0.53±0.15d	0.30±0.05b	0.23±0.11a
Lys	0.49±0.08c	0.42±0.02b	0.42±0.01b	0.44±0.01bc	0.37±0.03b	0.47±0.07c	0.31±0.01a	0.25±0.02a	0.44±0.01b	0.4±0.04b
His	0.12±0.01a	0.11±0.01a	0.12±0.01a	0.12±0.01a	0.10±0.01a	0.12±0.01a	0.08±0.01a	0.10±0.01a	0.11±0.02a	0.16±0.01b
Arg^{M}	0.31±0.03c	0.27±0.03bc	0.22±0.01a	0.27±0.03a	0.23±0.02a	0.26±0.05a	0.17±0.01a	0.24±0.01a	0.25±0.01a	0.46±0.06d
Total	6.06±0.36e	5.08±0.11c	4.54±0.01b	5.24±0.14c	4.29±0.01b	5.57±0.36d	3.67±0.01a	4.52±0.05b	5.45±0.25d	5.36±0.05c
essential amino acid (EAA)	2.33±0.19d	1.84±0.04b	1.78±0.05b	1.93±0.12c	1.68±0.03a	2±0.21d	1.46±0.01a	2.04±0.09d	2.03±0.01d	1.91±0.11c
non-essential amino acid (n-EAA)	3.73±0.19d	3.24±0.09c	2.76±0.11b	3.31±0.26c	2.61±0.03a	3.57±0.12d	2.21±0.01a	2.48±0.04a	3.42±0.09d	3.28±0.1c
Medicinal amino acids (MAA)	3.6±0.34e	3.04±0.13c	2.63±0.06b	3.12±0.08c	2.53±0.03b	3.49±023d	2.19±0.01a	2.5±0.01b	3.18±0.08c	2.94±0.11c
flavor amino acid (FAA)	1.65±0.09e	1.5±0.06d	1.13±0.04b	1.48±0.07d	1.14±0.04b	1.82±0.11f	0.97±0.01a	0.95±0.02a	1.44±0.08c	1.34±0.02c
EAA/n-EAA	0.62 ±0.06b	0.57 ±0.01a	0.64±0.04b	0.58±0.01a	0.64±0.02b	0.56±0.01a	0.66±0.02b	0.82±0.07c	0.59± 0.01a	0.58 ±0.01a
EAA/Total	0.38±0.01a	0.36±0.02a	0.39±0.03b	0.37±0.09a	0.39±0.01b	0.36±0.02a	0.40±0.01b	0.45±0.04b	0.37±0.04a	0.36±0.02a
MAA/Total	0.59±0.02a	0.60±0.02a	0.58±0.01a	0.60±0.03a	0.59±0.01a	0.63±0.04a	0.60±0.02a	0.55±0.02a	0.58±0.01a	0.55±0.031a
FAA/Total	0.27±0.01b	0.30±0.04c	0.25±0.01a	0.28±0.03b	0.27±0.02b	0.33±0.05c	0.26±0.01a	0.21±0.01a	0.26±0.01a	0.25±0.01a

Note: E in the upper right corner of the amino acid name in-dicates that the amino acid is essential amino acid, M indicates that the amino acid is medicinal amino acid, D indicates that the amino acid is delicious amino acid, MD indicates that the amino acid is both medicinal amino acid and delicious amino acid, and EM indicates that the amino acid is both essential amino acid and medicinal amino acid. The data in the table are the mean ± standard error, and the different lower-case letters in the same column indicate the interspecific differences reaching a significant level ($P < 0.05$)

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The quality of the active ingredients in the flowers of the 10 species, it rankings of large and small scavenging abilities were: *C.achrysantha* > *C.insularis* > *C. pubipetala*> *C.quinqueloculosa* >*C. tunghinensis* > *C.impressinervis*> *C.longzhouensis* > *C. perpetua* > *C. nitidissima* >*C. micrantha*.

Amino acid composition of flowers in Sect. Chrysantha plants and evaluate

The content of amino acids in the flowers of 10 kinds of Sect. *Chrysantha* was determined by amino acid automatic analyzer, of which 15 amino acids were detected. The highest amino acid content was *C. tunghinensis* (6.06 g / 100 g), followed by *C. impressinervis* (5.57 g / 100 g), and the lowest was *C. insularis* (3.67 g / 100 g). The amounts of Asp and Glu were higher in the flowers of the plants, while the contents of His and Tyr were too low. Among 15 amino acid contents of flowers, Asp, Glu, Pro, Ala, Arg and Phe were significantly. Among them, the Asp (0.91 g/100 g), Glu (0.91 g/100 g) content of *C.impressinervis* is the highest in 10 kinds in Sect. *Chrysantha*; The Thr (0.29 g/100 g), Ser (0.35 g/100 g), Ala (0.45 g/100 g, Met (0.30 g/100 g, Leu (0.50 g/100 g, Lys (0.49 g/100 g) content of *C. tunghinensis* is the highest in 10 kinds of camellia group; The Tyr (0.46 g/100 g), Phe (0.53 g/100 g) is the highest in *C. perpetua*; The Pro content of *C. micrantha* (0.50 g/100 g) is the highest in 10 kinds of golden camellia group; The His (0.16 g/100 g), Arg (0.46 g/100 g) of *C. nitidissima* was the highest in 10 kinds of golden camellia flowers. The essential amino acids, non-essential amino acids, 8 kinds of medicinal amino acids and 2 kinds of umami amino acids of the flowers, among which the TAAC, essential amino acid, non-essential amino acid and medicinal amino acid are 6.06/2.33/3.73/3.6 g/100 g respectively; they are significantly higher than other. The umami amino acid content was the highest, with 1.82 g / 100 g. In the flowers of 10 species of golden camellia group, essential amino acids / nonessential amino acids were 0.58 to 0.82, with significant interspecific differences, and essential amino acids were 0.36 to 0.45. Moreover, the highest content was *C. perpetua*. The medicinal amino acids / TAAC were 0.55~0.63, and the umami amino acids / TAAC were 0.21~0.33, and the highest content was significant in *C. impressinervis*.

Evaluation of essential amino acids nutrition of flowers and their comparison with pattern profiles

As can be seen from the *Tables 6* and *7*, the total content of essential amino acids of flowers of 10 camellia plants was 37.87% to 55.31%, which was higher than 35.00% of WHO / FAO pattern spectrum. Ile, Leu, Lys, Phe + Tyr, Thr and Val accounted for 4.65%, 7.08%, 4.69%, 8.22%, 8.58% and 8.06%, with 16.25%, 41.6%, 17.25%, 17.41%, 43% and 61.2% higher than the pattern spectrum, respectively. It shows that the plant flowers of the Sect. *Chrysantha* have certain development value in supplementing human amino acids.

According to the FAO / WHO standard mode, the necessary amino acid ratio (RAA), amino acid ratio coefficient (RC) and amino acid ratio coefficient (SRC) were calculated with RC value <1, indicating the relative insufficient amino acid; RC value> 1, indicating the relative excess of this amino acid (Hou et al., 2019; Li et al., 2023). According to the table, the mean SRC of essential amino acids of flowers of 10 plants was 50.608. Overall, the RC value of essential amino acids of flowers of 10 plants was greater than 1, indicating their relative abundance. The RC values of Leu, Thr, and Ile are relatively small, indicating that these three amino acids are relatively low, which are the first, second, and third limiting amino acids of the plant flowers of the Sect. *Chrysantha*, respectively.

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Individually, the RC values of Ile, Leu, Lys and Thr in *C. perpetua* were less than 1, indicating that the content of these four amino acids in *C. perpetua* was relatively insufficient *C. perpetua*. The SRC values of amino acids are different among golden camellia, *C. nitidissima* was the highest, followed by *C. tunghinensis* and *C.insularis; C.perpetua* was the lowest (SRC value 19.121). Modern nutrition research believes that the deficiency and excess of amino acids can limit the nutritional value of food. The essential amino acid ratio coefficient score (SRC) is often used to comprehensively evaluate the amino acids of food protein. SRC compares the composition of amino acids in a food protein with the recommended pattern. If consistent, SRC = 100, the higher the nutritional value of protein; if the larger difference from the recommended pattern, the smaller the SRC, the worse the nutritional value of protein. The SRC values of 10 kinds of golden camellia plants are: *C. nitidissima* (54.993)> *C. tunghinensis*(54.79)> Vietnam *C.insularis* (54.751)> *C. micrantha* (54.695)> *C. quinqueloculosa* (54.06)> *C.achrysantha* (53.989)> *C. longzhouensis* (53.723)> *C. impressinervis* (53.161)> *C.pubipetala*(52.799)> *C. perpetua*(19.121).

Table 6. *Amino acid ratio coefficient score of Camellia sect. Chrysantha*

Species	Thr	Val	Ile	Leu	Phe+Tyr	Lys	total content
C.tunghinensis	4.79	7.10	4.95	8.25	7.59	8.09	40.76
C.longzhouensis	4.53	6.50	4.53	7.68	6.69	8.27	38.19
C.pubipetala	4.85	7.05	4.63	8.37	7.05	9.25	41.19
C.quinqueloculosa	4.58	6.30	4.77	8.02	6.87	8.40	38.93
C.achrysantha	4.90	7.23	4.66	8.39	7.46	8.62	41.26
C.impressinervis	5.03	6.10	4.31	7.54	6.46	8.44	37.88
C.insularis	4.90	7.08	5.18	8.72	7.36	8.45	41.69
C.perpatua	3.54	10.84	4.20	9.29	21.90	5.53	55.31
C.micrantha	4.77	6.24	4.59	8.07	7.89	8.07	39.63
C.nitidissima	4.66	6.34	5.04	7.84	6.53	7.46	37.87
Mean	4.65	7.08	4.69	8.22	8.58	8.06	41.27
WHO/FAO	4	5	4	7	6	5.5	31.5

Comparison of antioxidant activity of total flavonoids extract

In vitro evaluation of the antioxidant activity of plant compounds or plant extracts is an important aspect of studying functional factors (Cui et al., 2023). The DPPH method is often used to evaluate the antioxidant activity of chemical compounds or plant extracts. Free radicals are atoms or atomic groups with unpaired electrons in the periphery, such as superoxide anion radical (O_2-), hydroxyl radical (-OH), etc., collectively called reactive oxygen species. A large number of studies have proved that the role of free radicals, biological aging and the pathogenesis of some diseases, eliminates free radicals and is beneficial to human health (Gu et al., 2022; Qin et al., 2022). Using VC as the reference article for the reducing capacity determination, Compare the differences in their reducing ability; At a concentration of 0.25 g/ml; The total antioxidant capacity (DPPH) of TFC extract was higher between the 10 golden camellia groups of plants; The clearance of DPPH by TFC ranged between 66.40% and 91.67%, Higher clearance of DPPH than VC (82.5%) in the same concentration state, It shows that the TFC extract of golden

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camellia has a good clearance effect on DPPH; Among them, *C. longzhouensis* has the strongest DPPH ability, The second is *C. nitidissima*; The worst one is *C.tunghinensis*. The ability ranking were: *C. longzhouensis* > *C. nitidissima* > *C.quinqueloculosa* > *C. perpatua* > *C. pubipetala* > *C. achrysantha* > *C. impressinervis* > *VC* > *C. insularis* > *C. micrantha* > *C. tunghinensis.* Superoxide anion radical clearance is between 36.8% - 67.17%; The ability ranking respectively were *C. longzhouensis* > *C. pubipetala* > *C. tunghinensis* > *C. micrantha* > *C.nitidissima* > *C. quinqueloculosa* > *C. insularis* > *C. achrysantha* > *C. perpatua* > *VC* > *C.impressinervis*; *C. longzhouensis* has the strongest ability. Hydroxyl radical clearance rate (-OH) is between 0.7% and 28.77%, respectively, VC > *C. achrysantha* > *C. tunghinensis* > *C. impressinervis* > *C. longzhouensis* > *C. nitidissima* > *C. perpatua* > *C. micrantha* > *C. quinqueloculosa* > *C. pubipetala* > *C. insularis*; hydroxyl radical scavenging capacity is lower than VC (*Figure 4*).

Table 7. *Amino acid ratio coefficient score of flowers in 10 species of C. sect. Chrysantha*

		Ile	**Leu**	**Lys**	**Phe+Tyr**	**Thr**	**Val**	**SRC**
C.tunghinensis	RAA	0.008	0.007	0.009	0.008	0.007	0.009	54.790
	RC	1.115	1.062	1.325	1.140	1.078	1.279	
C.longzhouensis	RAA	0.006	0.006	0.008	0.006	0.006	0.007	53.723
	RC	1.089	1.055	1.446	1.073	1.089	1.250	
C.pubipetala	RAA	0.005	0.005	0.008	0.005	0.006	0.006	52.799
	RC	1.034	1.069	1.504	1.050	1.083	1.260	
C.quinqueloculosa	RAA	0.006	0.006	0.008	0.006	0.006	0.007	54.060
	RC	1.126	1.081	1.441	1.081	1.081	1.189	
C.achrysantha	RAA	0.005	0.005	0.007	0.005	0.005	0.006	53.989
	RC	1.040	1.070	1.399	1.109	1.092	1.290	
C.impressinervis	RAA	0.006	0.006	0.009	0.006	0.007	0.007	53.161
	RC	1.041	1.041	1.483	1.041	1.215	1.180	
C.insularis	RAA	0.005	0.005	0.006	0.005	0.005	0.005	54.751
	RC	1.140	1.097	1.353	1.080	1.080	1.248	
C.perpatua	RAA	0.005	0.006	0.005	0.017	0.004	0.010	19.121
	RC	0.729	0.921	0.698	2.533	0.614	1.505	
C.micrantha	RAA	0.006	0.006	0.008	0.007	0.007	0.007	54.695
	RC	1.067	1.073	1.366	1.224	1.110	1.161	
C.nitidissima	RAA	0.007	0.006	0.007	0.006	0.006	0.007	54.993
	RC	1.214	1.080	1.309	1.050	1.125	1.223	
Mean	RAA	0.006	0.006	0.007	0.007	0.006	0.007	50.608
	RC	1.060	1.055	1.332	1.238	1.057	1.258	

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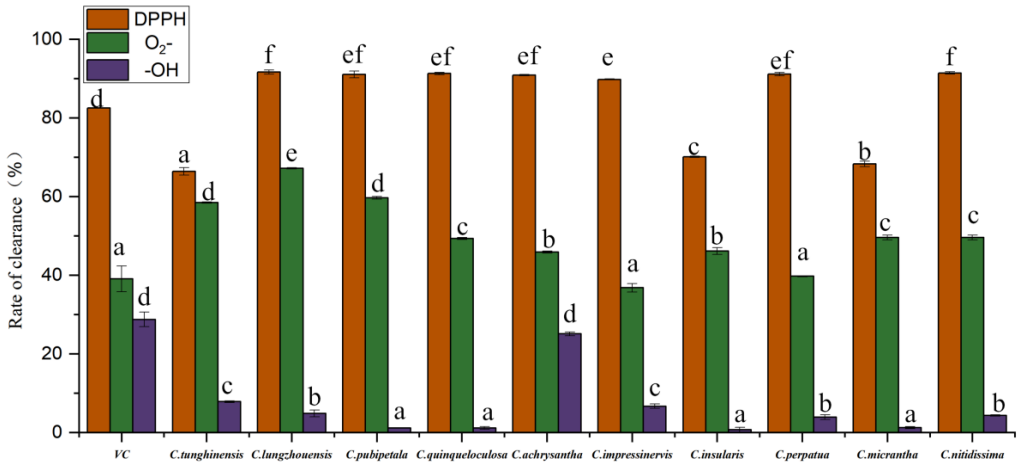

Figure 4. *Comparison of antioxidant activity of 10 species in Sect. Chrysantha. Note: The data in the table are the mean ± standard error, and the different lower-case letters in the same column indicate the interspecific differences reaching a significant level (P <0.05)*

Conclusion and discussion

With the major breakthroughs in seedling propagation technology (Chen et al., 2019), tissue culture technology (She, 2021) and high-efficiency cultivation technology (Shen et al., 2023) of plants in the Sect. *Chrysantha*, the resource problem of golden camellia has been completely solved, and it has become inevitable to carry out the return protection and multi-channel, multi-purpose and full development and utilization of golden camellia resources. In recent years, the number of tea leaves and flower-related products of the Sect. *Chrysantha* has gradually increased; At present, the main research and development of *C. nitidissima* is only one species among the many plants of the Sect. Chrysantha. By comparing the active ingredients and antioxidant capacity of many golden camellia species in the Sect. *Chrysantha*, we provide a scientific basis for the development of the Sect. *Chrysantha* plants, and at the same time find potential plant groups with the same high medicinal value to avoid the risk of extinction caused by the overdevelopment of a single species. The results of this study showed that the contents of TFC, TSC, TPOC, TPC, CTC, GAC, and TAAC in the flowers of 10 golden camellias were determined, and the 10 Sect. *Chrysantha* plants contained these seven active ingredients, and the differences between species were significant. The contents of TFC and TSC in the flowers of *C. nitidissima* were the highest, which were significantly higher than those of other. Vietnam's *C. insularis* has the highest TPOC content. The TPC content of *C. achrysantha* was the highest, and the catechin content was significantly higher than that of the others. The hydrolyzed tannin GAC content of *C. tunghinensis* was the highest, and the content of GAC in *C. tunghinensis* was the lowest, but the amino acid content of *C. achrysantha*> was the highest TAAC content among the 10 golden camellia plants. Phenols and flavonoids are a class of chemicals with rich nutritional value and a wide range of efficacy (Ma et al., 2023); It has a variety of physiological effects such as lowering blood lipids, antioxidant, anti-inflammatory, anti-cancer, etc., can reduce the fragility of blood vessels, improve the permeability of blood vessels, and is used to prevent and treat hypertension and cerebral hemorrhage in the elderly. Among the 10 plants in the Sect. Chrysantha. The content of flavonoids in *C. nitidissima* and *C. perpatua* was significantly higher than that of other species, it is consistent with Li's research on the high *C. pubipetala* was

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extremely high, which was significantly higher than that of other species. These four kinds of golden tea have high application prospects in flower tea, medicine, health care and food processing.

In this study, the principal component indexes contained in the flowers of 10 Sect. *Chrysantha* plants were analyzed, and the value of active ingredients contained in the flowers of 10 Sect. *Chrysantha* plants was comprehensively evaluated. Through principal component analysis, four principal components were extracted, the variance contribution rate of the first principal component (PC1) was 36.141%, the variance contribution rate of the second principal component (PC2) was 21.173%, the variance contribution rate of the third principal component (PC3) was 17.306%, and the variance contribution rate of the fourth principal component (PC4) was 13.356%. The cumulative variance contribution rate of the four principal components reached 87.976%, reflecting 87.976% of the original evaluation index. The results of this study were similar to those of Li's study (Li et al., 2020) on the main active components of 5 kinds of golden camellia, in which the total phenol content was significantly correlated, indicating that the total phenol was an important factor in plant evaluation of golden camellia group. In this study, the active ingredients were determined in more detail, and the results also showed that the amino acid content was also significantly correlated. The quality of the active ingredients in the flowers of the 10 species, it rankings of large and small scavenging abilities were:: *C. achrysantha* > *C.insularis* > *C. pubipetala*> *C.quinqueloculosa* >*C. tunghinensis* > *C. impressinervis*> *C.longzhouensis* > *C. perpetua* > *C. nitidissima* >*C. micrantha* .This indicated that the combined value of the seven active ingredients was the highest in the flowers of *C. achrysantha* , followed by *C.insularis* in Vietnam and *C. pubipetala*; and the combined value of *C. micrantha* was the lowest.

From the correlation analysis results, it can be seen that the TPC in the flowers is significantly and positively correlated with the content of CTC and GAC, that is, the higher TPC in the flowers of the plants in the golden camellia group, the higher the content of CTC and GAC. Polyphenols are called "Class VII nutrients", including phenolic substances such as flavonoids, tannins, phenolic acids, and anthocyanins; It plays an important role in the antioxidant activity of flowers of *Camellia* sect. *Chrysantha*, and is the main antioxidant active component in flowers (Zhang et al., 2023), a compound with potential health-promoting effects.

Free radicals are intermediate metabolites of many biochemical reactions in the process of aerobic biological life activities, and excessive free radicals will cause oxidative stress to cell tissues, causing oxidative damage to the body, and may lead to many diseases such as atherosclerosis, hypertension, diabetes, tumors, Parkinson's disease, Alzheimer's disease, etc. (Ruth et al., 2023). Consolidating antioxidant levels in the body and scavenging free radicals by ingesting natural antioxidants is beneficial to human health (Zhou et al., 2023). At present, many natural antioxidants have been made into functional foods, becoming one of the most important sources of exogenous antioxidants in the human body's daily supplement plants. Golden camellia plant is rich in polyphenolic components and has good antioxidant active ingredients. When the concentration is 0.25 g/ml; the total antioxidant capacity (DPPH) of the total flavonoid extracts of flowers among the 10 kinds plants has a high difference; the scavenging rate of TFC on DPPH is between 66.40% and 91.67%, all of which are higher than VC (82.5%) at the same concentration on DPPH, indicating that the extract of TFC has a better scavenging effect on DPPH; Among them, *C. longzhouensis* has the strongest DPPH ability, it rankings of large and small scavenging abilities were: *C. longzhouensis*> *C.*

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nitidissima> *C. quinqueloculosa*> *C. perpatua*>*C. pubipetala*>*C. achrysantha*>*C. impressinervis*>VC>*C. insularis*>*C. micrantha*>*C. tunghinensis*. The scavenging rate of superoxide anion radicals ranged from 36.8% to 67.17%; Compared with VC at the same concentration, the scavenging rate of superoxide anion radicals was higher. However, the hydroxyl radical scavenging rate (-OH) was between 0.7% and 28.77%, which was lower than that of VC at the same concentration for superoxide anion radical scavenging. The results showed that the antioxidant capacity of total flavonoid extracts was quite different among plant species in the Sect. Chrysantha. *C. longzhouensis, C. pubipetala, C. quinqueloculosa, C. achrysantha, C. perpatua, C. nitidissima* all have high total antioxidant capacity (DPPH) capacity (≥90% clearance); It is an excellent variety of plant functional and health food in the Sect. *Chrysantha*.

The content of amino acids in the flowers of 10 kinds of golden camellia group was determined by amino acid automatic analyzer, of which 15 amino acids were detected, among which the highest amino acid content was *C. tunghinensis* (6.06 g/100 g), followed by *C. impressinervis* (5.57 g/100 g), and the lowest was *C. insularis* (3.67 g/100 g). There were also obvious differences between the TAAC, essential amino acids, non-essential amino acids, 8 medicinal amino acids and 2 umami amino acids in the flowers of the 10 species, and the TAAC, essential amino acids, non-essential amino acids, and medicinal amino acids of *C. achrysantha* were significantly higher than those of other. The umami amino acid content is the highest in *C. achrysantha*. Among the flowers of the 10 golden camellia group plants, the ratio of essential amino acids/non-essential amino acids and EAA/TAAC was significantly different, and *C. perpatua* was significantly higher than that of other species. The ratio of MAA/TAAC and n-MAA/TAAC was significantly different, and the highest content was *C. impressinervis*. *C. tunghinensis* is rich in TAAC, and the umami and medicinal value of concave vein golden camellia have high value, which is a good material for the development of plant amino acid products of the Sect. *Chrysantha*, and has good application prospects in medicine, health care and food and other fields.

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