Study on the main biochemical components of CH-1 and the suitability of green tea

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Abstract. In this experiment, CH-1 was used as material to study its main biochemical components and the suitability of green tea. The results showed that the content of the water extract, caffeine and tea polyphenols in CH-1 were significantly higher than those in FD, which were higher 0.44%~12.29%, 3.03%~7.05%, 11.39%~20.46%, respectively. A lower level of amino acid but a proper phenol-ammonia ratio of catechins in CH-1 contributed to a good quality of green tea made by CH-1, which was consistent with the results of sensory evaluation.

1. Introduction
Tea is one of the most popular beverage around the world mainly because of its significant health benefits and specific flavors [1]. According to statistics, over two billion people drink tea in > 125 countries [2]. During the period of long-term natural hybridization and artificial hybridization, the color of tea leaves is not only green, but also diverse. Chinese cultivar ‘Zijuan’, the Japanese cultivar ‘Sunrouge’ and the Kenyan tea TRFK 306 are the representative of purple cultivars whose buds and leaves are purple and abundant anthocyanins [3-5]. The research findings suggested anthocyanins protect tea plants from various adversity such as freezing, salt, and low phosphate stresses [6-8]. Anji Baicha contains higher levels of amino acids than general cultivars whose leaves exhibit a white color at low temperatures but turn green when temperatures rise [9]. Over the past several decades, yellow albino tea cultivars created enormous economic value. Consequently, yellow cultivars are extensively cultivated. Baijiguan, Huangjinya, Jinguang are considered as the representative of yellow cultivars and also have a higher level of amino acid [10]. Recently, we developed a novel tea cultivar ‘Chuanhuang 1’ whose new shoots are yellow all year round. Through previous studies, biological characteristic, biochemical components of CH-1 had been preliminarily understood, but its processing suitability needs to be further explored. In this study, the main biochemical components of CH-1 were determined in different seasons and the quality of green tea was compared with a national cultivar, which all provided theoretical support for the promotion and utilization of CH-1.

2. Materials and Methods

2.1. Materials
The material used in the experiment was a novel tea cultivar ‘CH-1’ with distinct yellow leaves. The control was a national fine cultivar named FD. All experimental materials were six years old cultivated in Tongxincun Experimental Garden in Chengdu, Sichuan Province. The area of the experimental plot was 13.5 m². Random block arrangement was adopted and repeated three times. Planting method: Big
row spacing is 150 cm, small row spacing is 40 cm, and plant spacing is 20 cm. Double row single plant planting is adopted, and the cultivation management measures are consistent. In spring, summer and autumn, young tender shoots of one bud and two leaves were harvested and steamed into dry simples for water extract, caffeine, amino acid, and polyphenol analysis. In addition, spring shoots with one bud and one leave were processed into green tea for the analysis of catechin components and sensory evaluation of quality.

2.2. Methods
The water extract content was analyzed by using Chinese National Standard GB/T8305-2013. The caffeine content was measured by GB/T8312-2002. The polyphenol content was determined by reference to Folin-Ciocalteu method, that is, GB/T 8313-2008. The free amino acid was analyzed referring to GB/T 8314-2013. In the study, catechins were measured by the HPLC method according to ISO 14502-2-2005E. The procedure of making green tea consisted of withering, fixing, rolling, drying. However, the processing technology of yellow tea was slightly different from green tea composed of withering-fixing-sealed yellowing-drying. The assessment of tea quality followed GB/T 23776-2009. 3g tea sample was took and brew in 150 ml water for 4 minutes and scored including shape, soup color, aroma, taste and leaf residue. The final results were calculated by weight method. The weight of each factor of green tea was 25%, 25%, 10%, 30% and 10%.

2.3. Statistical Analyses
Statistical analyses were performed using SPSS 22.0 statistical software (SPSS Inc., Chicago, IL, USA). Data were analyzed with one-way analysis of variance with least significant difference at the 5% significance level.

3. Results
The main biochemical components are showed (Table 1 and Table 2). The contents of water extract and caffeine in CH-1 were significantly higher than those in FD. The water extract content of CH-1 ranged from 45.22% to 48.61% and was 0.44%, 1.76% and 12.29% ($p < 0.05$) higher than that in the control in the corresponding season, respectively. In terms of caffeine, CH-1 contained 3.03% in spring, 7.05% in summer and 4.56% in autumn ($p < 0.05$) more compared with FD.

Table 1. Analysis of water extract and caffeine in steamed drying samples.

| Season | Cultivar | Water extract(%) | Caffeine(%) |
|--------|----------|------------------|-------------|
| spring | CH-1     | 45.22±0.10c      | 3.40±0.02b  |
|        | FD       | 45.02±0.08d      | 3.30±0.02d  |
| summer | CH-1     | 45.74±0.05b      | 3.34±0.03c  |
|        | FD       | 44.95±0.05d      | 3.12±0.02e  |
| autumn | CH-1     | 48.61±0.19a      | 3.44±0.02a  |
|        | FD       | 43.29±0.06e      | 3.29±0.01d  |
Values are means ± standard error of three replicate pots. The different letters following the numbers indicate significant differences between the two cultivars (p < 0.05).

There was a significant difference in tea polyphenol between CH-1 and FD during different seasons. Moreover, the control possessed a lower level of polyphenol and were 11.39%, 20.46% and 14.15% (p < 0.05) lower than CH-1, while the amino acid content was opposite. The ratio of tea polyphenol to amino acid (phenol-ammonia ratio) is a biochemical index reflecting the characteristics of tea varieties. It is generally believed that the ratio of phenol to ammonia is less than 8 for green tea, between 8 and 15 for black tea [11]. Despite CH-1 had a higher level of polyphenol and lower amino acid, the ratio of phenol to ammonia ranged from 4.00 to 6.85 < 8, which indicated that CH-1 contained the material basis for making green tea.

Table 2. Analysis of amino acid and polyphenol in steamed drying samples.

| Season | Cultivar | Amino acid(%) | Polyphenol(%) | Phenol/ammonia ratio |
|--------|----------|---------------|---------------|----------------------|
| spring | CH-1     | 4.40±0.01b    | 17.60±0.02d   | 4.00±0.01e           |
|        | FD       | 5.50±0.02a    | 15.80±0.02f   | 2.87±0.01f           |
|        | CH-1     | 4.00±0.05d    | 23.14±0.05a   | 5.78±0.06b           |
|        | FD       | 4.14±0.05c    | 19.21±0.01b   | 4.64±0.05d           |
|        | CH-1     | 2.79±0.02f    | 19.12±0.02c   | 6.86±0.05a           |
|        | FD       | 3.47±0.03e    | 16.75±0.02e   | 4.83±0.04c           |

Values are means ± standard error of three replicate pots. The different letters following the numbers indicate significant differences between the two cultivars (p < 0.05).

The green tea catechin content between CH-1 and FD was compared (Table 3). there was a significant difference in content of total catechin between two cultivar’s green tea and CH-1 possessed 35.76% more (p < 0.05). Ester catechins in two cultivars performed the same. Therefore, the total ester catechins in CH-1 was 46.07% higher than that in the control. As one of Ester catechins, EGCG accounted for the largest proportion. The EGCG content in CH-1 green tea was 56.08% significantly higher than that of FD (p<0.05). Catechin quality index was an empirical parameter for appraising the quality of tea, whose formula is (EGCG+ECG)*100/EGC [12]. According to the calculation, the quality index of green tea catechins in CH-1 was 2031.11 while that in FD was 1071.70. Generally speaking, CH-1 contained more catechins, and its tenderness and quality of fresh leaves were better than FD.

Table 3. Analysis of Catechin in green tea.

| Component | FD      | CH-1     |
|-----------|---------|----------|
| GC        | 0.42±0.03a | 0.30±0.02b |
| EGC       | 0.53±0.01b | 0.45±0.02c |
| C         | 0.24±0.01c | 0.35±0.02b |
| EC        | 0.54±0.01a | 0.41±0.01b |
| EGCG      | 4.03±0.03c | 6.29±0.05a |
| GCG       | 1.92±0.02c | 2.37±0.04a |
| CG        | 0.54±0.01a | 0.38±0.01b |
| ECG       | 1.65±0.02c | 2.85±0.02a |
| Ester catechins | 8.14±0.05c | 11.89±0.12a |
| Total catechins | 9.87±0.07c | 13.40±0.12a |
| Catechin index | 1071.70 | 2031.11 |

Values are means ± standard error of three replicate pots. The different letters following the numbers indicate significant differences between the two cultivars in terms of the same component (p < 0.05).

The quality characteristics and sensory evaluation result of green tea produced by CH-1 are shown in Table 4. As for green tea, CH-1 was equivalent to the control. In all, CH-1 had certain characteristic
with a tight shape, delicate green liquor color, tend aroma, slightly fresh taste and bright yellow residue. In conclusion, CH-1 was suitable for making green tea.

Table 4. Sensory evaluation results of CH-1 green tea.

| Tea  | Sensory evaluation score | Total |
|------|-------------------------|-------|
|      | Shape   | Liquor color  | Aroma          | Taste            | Tea residue |       |
| FD   | 23.5    | 8.2           | 23.5           | 27.5             | 9.1         | 91.8  |
|      | tight and slender | delicate yellow | chestnut aroma | fresh and mellow | green       |       |
| CH-1 | 23.0    | 8.5           | 23.7           | 26.8             | 9.2         | 91.2  |
|      | tight   | delicate green | tend aroma     | slightly fresh   | bright yellow|       |

4. Discussion

Amino acids, caffeine and tea polyphenols in tea acted together to form excellent quality of tea, resulting in unique flavors [13]. In this study, the contents of water extract, caffeine, tea polyphenols and catechin in CH-1 were significantly higher than those in FD, while the contents of amino acids were the opposite. Water extract was the general term of hot water soluble substances in tea, which could reflect the thickness and concentration of tea soup to a certain extent, and was positively related to the quality of tea [14]. The water extract content in CH-1 ranged from 45.22% to 48.61% and was from 0.44% to 12.29% (p < 0.05) higher than that in the control. Caffeine was the main bitter substance in tea soup, which in CH-1 ranged from 3.34% to 3.44% and was from 3.03% to 7.05% higher when compared to FD. As the main astringent substance, tea polyphenols content ranged from 17.60% to 23.14%. The new shoots in different seasons were 11.39%, 20.46% and 14.15% higher than those in the control, and there were significant differences. Amino acids, as one of the main flavoring substances in tea, were closely related to taste and aroma. At the same time, they cooperated with other substances in tea to reduce bitterness and astringency and improved freshness and refreshment [15]. Nevertheless, CH-1 had a low level of amino acids, that differed from general yellow cultivars [9]. Ratio of tea polyphenols to amino acids (phenol-ammonia ratio) was regarded as a biochemical index to reflect the characteristics of tea cultivars. The highest phenol-ammonia ratio of CH-1 was 6.85, less than 8, which indicated the material basis for making tea CH-1 contained. By analyzing the components of catechins, CH-1 owned a high level of total catechins and ester catechins. Sensory evaluation results showed that CH-1 was suitable for making green tea. We speculated that appropriate phenol-ammonia ratio promoted the quality of green tea of CH-1.

5. Conclusion

CH-1 is a new cultivar with new shoots are yellow all year round, which distinctly differs from FD, a green cultivar. In this study, we quantified the biochemical components difference between these two cultivars in three seasons and showed that CH-1 performed better in terms of polyphenols and catechins. In addition, green tea of two cultivars was also the same. The results of sensory evaluation showed CH-1 was suitable for making green tea, mainly because of the proper phenol-ammonia ratio.

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