Evaluation of fluorine level in different tea cultivars for Sichuan dark tea production

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Abstract: Tea plant (*Camellia sinensis*) could accumulate fluorine (F) in leaves efficiently. Fresh tea leaves are always regarded as the culprit of excess F in Sichuan dark tea (SDT). The present study evaluated F level in different tea cultivars and young shoots to select the appropriate production raw materials. Results showed that F level varied greatly among tea cultivars, from 65.9 to 821.6 mg kg^{-1} in the young shoots with five expanded leaves and increased with the age of young shoots. Young shoots with up to seven leaves of Zhongcha 108 or Fuding Dabaicha had the lower F level and could be used as the appropriate raw materials to produce Sichuan dark tea.

1. Introduction

Sichuan dark tea (SDT) is one of the most important dark teas in China [1]. For centuries, SDT has always been the life necessity to the minority ethnic groups living Tibet who has the diets mainly consist of red meat and milk products. For them, SDT is not only a beverage but also a folk medicine due to the significant activities of hypolipidemic and lifting greasy [2, 3], and is also a source of Vitamin C [4].

Sichuan dark tea is usually made from relatively old shoots of tea plant (*Camellia sinensis*), however, this plant just like F hyper-accumulator, high level of F is always discovered in its matured leaves [5, 6]. Therefore, compared with other teas, the content of F in SDT is usual over 700 mg·kg^{-1} (dry weight, DW), sometimes even up to 1000 mg·kg^{-1}[7]. Excessive consumption of SDT with high F level for a long time has been blamed as the culprit of "brick tea fluorosis" in northern Tibet [8]. In recent years, many strategies, such as chemical defluorination, physical defluorination, special cultivation techniques and breeding methods, have been performed to reduce F level in SDT [9, 10]. However, on account of the security, defluorination effects and time costs, these strategies have seldom been used in SDT production to date.

In the present study, F levels of 55 tea cultivars planted in Sichuan were investigated.

2. Materials and methods

2.1 Tea plants

55 tea cultivars growing in the national tea breeding field in Ya'an city Sichuan province had been selected as experimental materials. Young shoots with one bud and five to ten leaves of experimental tea plants were harvested individually. A part of shoots were disassembled into stems and leaves for independent analyses. All the samples were cleaned with distilled water, then, dried at 60℃ for 24h, crushed and passed through a 2-mm sieve. Five replicates for each sample.

In addition, we also collected the soil in the breeding field at the depths of 20-40 cm for F level and PH measurements.

2.2 Chemical analysis

Water-soluble F of samples were extracted with distilled water, and measured with F-ion selective

electrode according to the national standard method of China [11]. Soil PH was detected by the agricultural standard method of China [12].

2.3 Data analysis

Descriptive statistics and significant difference test were performed with SPSS software 19.0 (SPSS Inc. USA). Histogram was generated by Origin 9.0 software (OriginLab Co., USA) and SPSS 19.0.

3. Results and discussion

3.1 F level in different tea cultivars

F level in young shoots with a bud and five expanded leaves of the tested tea plants varied greatly , the range of which up to 755.69 and the variation coefficient among the cultivars was 0.547(table 1). F content of 85.45% tested plants was less than 300mg·kg^{-1} and 10.91% cultivars was less than 100mg·kg^{-1}. Zhongcha 108 had the lowest F content (65.93mg·kg^{-1}) while Taicha 12 had the highest F content (821.58 mg·kg^{-1}).

Table 1 F content in different tea cultivars

Tea cultivars	F content (mg·kg^{-1})	Tea cultivars	F content (mg·kg^{-1})	Tea cultivars	F content (mg·kg^{-1})
Zhongcha108	65.93±2.12	Qianmei419	166.13±2.16	Ying shuang	267.22±3.69
Fuding Dabaicha	72.34±2.96	Emei Wenchun	168.52±3.18	Shancha1	270.03±2.54
Xiangshanzao	84.22±4.12	Mabianlv	185.23±3.06	Nanjiang4	273.44±2.06
Fuxuan 9	90.52±3.65	Echa8	185.81±2.26	Wuniuzao	274.93±3.29
Huangjingui	90.81±2.48	Chuancha3	186.92±2.46	Longjing43	279.91±5.06
Qianmei 419	96.04±3.78	Longjing Changye	187.73±1.92	Yunkang10	285.34±2.73
Cuifeng	108.22±3.21	Zhongcha102	195.14±3.06	Pingyang Tezao	288.54±3.66
Juhuachun	118.13±2.61	Jinguanyin	209.01±1.65	Nanjiang Daye	292.62±4.06
Zhenong 117	118.11±4.65	Mingshan213	214.62±3.66	Yunnan Daye	293.83±2.49
Qingxin1	128.84±5.62	Huangyazao	216.63±2.39	Mingshanzao	317.13±5.61
Tieguanyin	133.12±3.12	Qianmei303	219.86±3.12	Mingshan Tezao	329.93±2.12
Juhuaxiang	133.24±3.52	Chuanmu217	219.80±2.67	Mengshan11	336.03±2.64
Zaofengchun	136.23±4.03	Zhongcha302	222.83±4.03	Chunbolv	349.21±3.54
Hongyan2	141.20±4.12	Huangye Shuixian	235.41±1.98	Huangjinya	371.32±4.19
Meizhan	147.14±5.21	Chuancha2	240.92±2.31	Mingshan131	383.21±4.44
Echa 5	148.90±4.23	Sichuan Qunti	241.61±4.22	Jianhe Xiangcha	519.03±4.65
Huangyezao	153.0±3.68	Zhenong113	254.74±3.21	Taicha12	821.62±6.51
Hongyan12	154.63±2.74	Yuanxiaozao	261.23±1.29		
Chuanmu28	158.54±3.63	Fuyun 6	261.62±2.34		

Values are expressed as mean ± standard deviation of three replicates. F content and PH of soil in sampling location were 0.29-0.33 mg·kg^{-1} and 5.12-5.35 respectively; the variation coefficient of F content among the cultivars was 0.547.

3.2 F level in different young shoots of Zhongcha 108 and Fuding Dabaicha

Tea cultivars with the lower F level (Zhongcha108 and Fuding dabaicha) were selected as materials to investigate F content in young shoots of different maturity. The result showed that F level increased with the maturity of tea shoots. F content of all the shoots of Zhongcha 108 and the shoots with a bud and five to eight leaves of Fuding Dabaicha were less than 300 mg·kg^{-1}, especially, in the shoots with up to seven leaves of both cultivars, this value was less than 150 mg ·kg^{-1} (Fig.1).

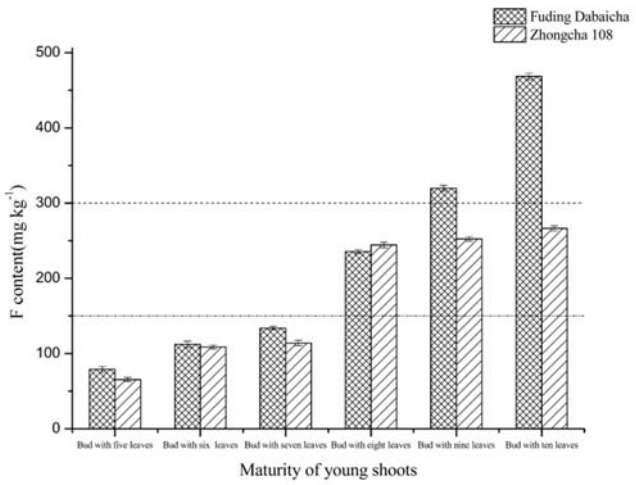

Fig.1 F content in different young shoots of Zhongcha 108 and Fuding Dabaicha.

3.3 F level in different parts of Zhongcha 108 and Fuding Dabaicha young shoots

The leaves and stems of Zhongcha 108 and Fuding Dabaicha young shoots were separated, and no matter in which cultivars, F was concentrated in leaves, the values varied from 152.31 to 411.38 mg·kg^{-1} and increased with the age of leaves, especially, in the leaves that older than 3rd leaf of Fuding dabaicha and 4th leaf of Zhongcha 108 this value was higher than 300 mg·kg^{-1}, but in stems, regardless of the position, F content was less than 10 mg·kg^{-1} in both cultivars(Fig.2).

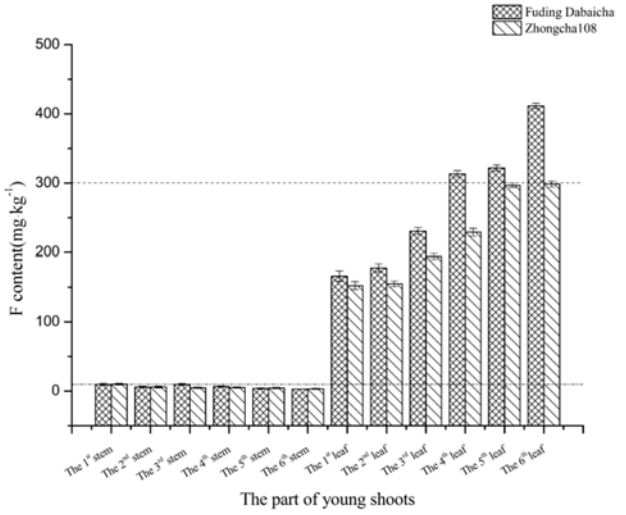

Fig.2 F content in different positions of Zhongcha 108 and Fuding Dabaicha young shoots

4. Conclusion

F level varied greatly among tea cultivars and increased with the age of young shoots, it mainly accumulated in leaves, scarcely in stems. Appropriate young shoot from the right cultivar was the key point to control F level in SDT. It was suggested that tea shoots with up to seven expanded leaves of Zhongcha 108 and Fuding Dabaicha were the appropriate production raw materials for Sichuan dark tea.

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