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Contents of fluoride, lead, copper, chromium, arsenic and cadmium in Chinese Pu-erh tea

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ABSTRACT

In order to assess safety for consumers and the levels of contamination in Pu-erh tea, the authors studied the contents of fluoride, lead, copper, chromium, arsenic and cadmium in 56 Chinese samples of Pu-erh tea collected from Dali City, Lincang City, Xishuangbanna City, Simao City and Dehong City in Yunnan province. The ranges obtained for the elements analyzed were 80.2–151.6 mg kg^{-1} (fluoride), 0.66–4.66 mg kg^{-1} (lead), 14.8–19.3 mg kg^{-1} (copper), 1.95–4.98 mg kg^{-1} (chromium), 0.07–0.25 mg kg^{-1} (arsenic) and 0.023–0.130 mg kg^{-1} (cadmium). The mean leached analyte concentrations in tea infusion were 523.86 μg L^{-1} for fluoride, 5.70 μg L^{-1} for lead, 43.18 μg L^{-1} for copper, 13.67 μg L^{-1} for chromium, 0.43 μg L^{-1} for arsenic and 0.17 μg L^{-1} for cadmium after the tea leaves were brewed twice with boil water in a ratio of 1 g/50 ml for 5 min. The mean dissolving rates of fluoride, lead, copper, chromium, arsenic, and cadmium were 45.8%, 24.6%, 26.2%, 35.2%, 30.8% and 27.4%, respectively. Significant differences for the content of the studied elements except copper were generally observed with different Pu-erh tea's habitats. Pu-erh compressed tea had lower lead levels than loose tea. Based on a 70 kg individual consuming 15 g of Pu-erh tea daily or 105 g Pu-erh tea weekly, the dietary intake of the studied elements was below the safe limits recommended by various authorities. This suggested that under the current dietary intake, there are no possible health risks to Pu-erh tea drinking consumers.

1. Introduction

Pu-erh tea is a kind of post-fermented tea with special flavor and taste (Lv et al., 2012). It is originally produced in a few cities (such as Dali, Lincang, Xishuangbanna, Simao and Dehong) in Yunnan province of China, using the sun-dried crude green tea as the raw materials which produced from the leaves of large-leaf species tea plants, *Camellia sinensis* L. and *C. sinensis* var. *assamica* (Masters) Kitamura (Theaceae). According to shape, Pu-erh tea can be generally divided into loose tea and compressed tea (Fig. 1), and the latter is the most common type in market for it is more appealing for the consumers and easier to preserve. Compressed tea can be made by compressing the loose tea in molds. In recent times, Pu-erh tea has become increasingly popular especially in Southeast Asia for its notable beneficial health effects, such as reducing blood lipid and anti-obesity (Hou et al., 2009; Lin & Lin-Shiau, 2006). And the last decade has witnessed the rapid development of Chinese Pu-erh tea. Its output peaked in 2007 to about 10 thousand tons, an almost nine-fold increase since 2001(Tang, 2008).

At present, the chemical contaminants in food and drinks are becoming a global concern (Barroso et al., 2009; Djedjibegovic, Larssen, Skrbo, Marjanović, & Sober, 2012). As for tea, this issue has also received wide attention (Görür, Keser, Akçay, Dizman & Okumuşoğlu, 2011; Karak & Bhagat, 2010; Pehrsson, Patterson, & Perry, 2011, Sofuoglu & Kavcar, 2008) for the adverse effects on human health when the concentrations of some trace elements in tea infusion exceed a critical range. Fluoride is the most consumers concern. Unfortunately, several studies have reported that fluoride levels in some types of black tea (Cao et al., 2006; Emekli-Alturfan, Yarat, & Akyuz, 2009) and brick tea (Cao et al., 2003) were unsafe for children and adults, and that long-term consumption of tea containing high levels of fluoride could result in chronic fluoride intoxication (Quock, Gao, & Chan, 2012; Yi & Cao, 2008). Other major concerns include arsenic and certain heavy metals (e.g., lead, copper, chromium, cadmium). During the growth of tea plants and the procedure for tea processing, tea may be contaminated by heavy metals, such as lead (Han, Zhao, Shi, Ma, & Ruan, 2006) and arsenic (Cao, Qiao, Zhang, & Chen, 2010). Recently, toxic metals in some of tea infusions have been reported to exceed the maximum permissible limits stipulated for different countries, which has received much attention internationally (Karak & Bhagat, 2010).

Few study about the total fluoride content in Pu-erh tea in the last decade (Cao, Zhao, & Liu, 1998; Fung, Zhang, Wong, & Wang, 1999). And information about arsenic and heavy metals in Pu-erh tea is

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Fig. 1. The most common Pu-erh loose tea and Pu-erh compressed tea in current market: 1. loose tea and 2. compressed tea.

very limited. In addition, there are no study about the content difference of these trace elements among different habitats or between the compressed tea and loose tea. Therefore, it is necessary to analyze and evaluate the magnitude of contamination by these elements in Pu-erh tea. At the same time, the importance and necessity of safety assessment of these undesirable trace elements must be recognized. Since tea beverage is a solution, the concentration of trace elements in tea infusion as well as their dissolving rates should be our primary concern when we conduct the health risk assessment because tea infusions may contain very low levels of these trace elements but most of them still remain in tea leaves. However, there have been no relevant reports in the existing literature.

So this study mainly focus on (i) assessing the contamination status of fluoride, arsenic, lead, copper, chromium and cadmium in Chinese Pu-erh tea with different origins and shapes, (ii) determining the concentration of the studied elements in tea infusion as well as their dissolving rates according to the traditional custom of Pu-erh tea drinking habit, and (iii) examining the potential human health risks due to consumption of Pu-erh tea.

2. Materials and methods

2.1. Sample collection

Fifty-six representative samples of Pu-erh tea, including 26 loose tea samples and 30 compressed tea samples, were provided by the Biological Resource Development and Innovation Office of the People's of Yunnan province. All samples were obtained in situ from five areas in Yunnan province, namely Dali, Lincang, Xishuangbanna, Simao and Dehong (Fig. 2) and the numbers of samples from these areas were 10, 11, 13, 12 and 10, respectively.

2.2. Sample preparation

(i) The samples used to analyze the content of the studied elements were dried again to achieve constant weight in 105 °C for 2 h in an oven. They were ground into a powder with a stainless-steel grinder to enable passage through a 0.25-mm sieve and stored in polyethylene bags before analyses.

(ii) The samples used to analyze the leached analyte concentrations in tea infusion and the dissolving rates remained the same as the original status in order to simulate the traditional process of Pu-erh tea infusion.

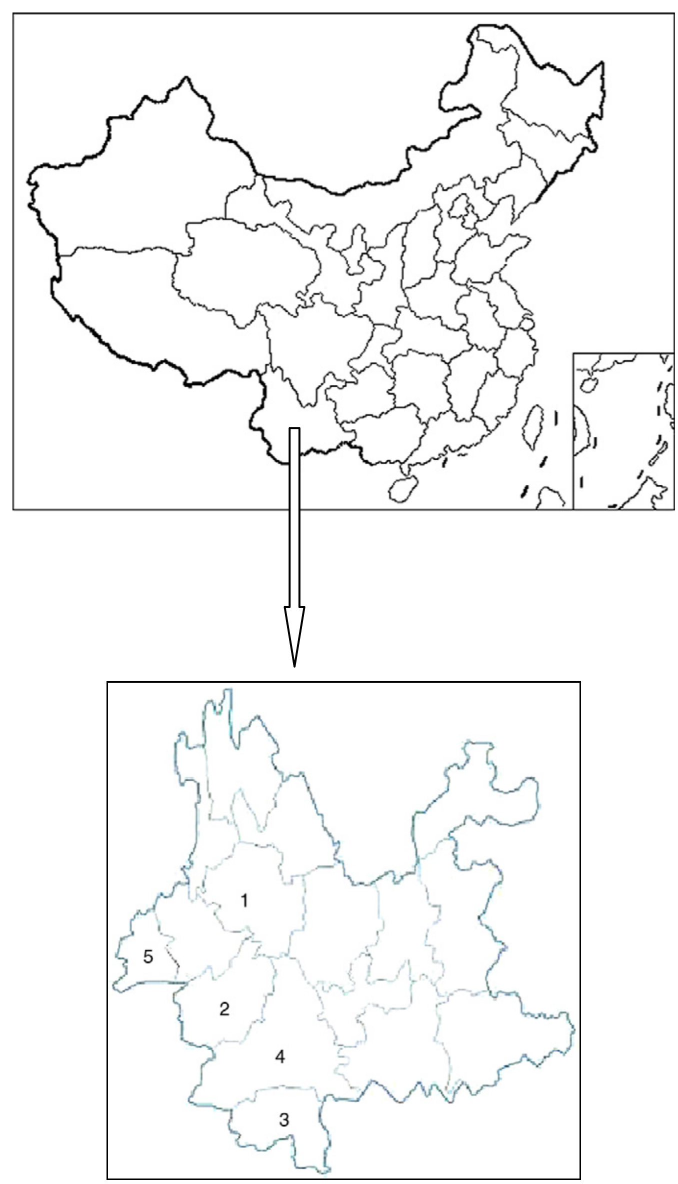

Fig. 2. Production areas of Pu-erh tea in Yunnan province: 1, Dali; 2, Lincang; 3, Xishuangbanna; 4, Simao; and 5, Dehong.