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Antioxidant properties and color parameters of herbal teas in China

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ABSTRACT

The popularity of herbal tea is increasing in China because of its beneficial effect on human health, especially for antioxidant function. Color is one of the important organoleptic characteristics of tea. The aim of this study was to supply new information on the antioxidant properties and color parameters of herbal teas for researchers and the general public. The *in vitro* antioxidant properties and color parameters of 110 herbal teas were systematically investigated in comparison with eight green teas in China. The results showed that the antioxidant property values and color parameters of herbal teas were more variable than those of green teas. The antioxidant property values of most herbal teas were lower than those of green teas, except for a few herbal teas with high values, which could be analogous or superior to green teas. Rattan tea 'Teng Cha' (*Ampelopsis grossedentata* (Hand.-Mazz.) W. T. Wang) and Chinese rose tea 'Yue Ji Hua' (*Rosa chinensis* Jacq.) showed significantly higher property values than green teas. Among all the herbal teas, a highly significant correlation coefficient was found between antioxidant capacity and total phenolic content. No significant correlations were detected between the color parameters and the antioxidant properties. Principal component analysis and hierarchical cluster analysis showed that the properties of five herbal teas were similar to green teas, whereas Yue Ji Hua and Teng Cha were superior to green teas. The results suggested that the some commonly consumed herbal teas in China might be promising and economic dietary sources of natural antioxidants.

1. Introduction

Tea brewed from leaves or buds of *Camellia sinensis* (L.) O. Ktze. is the most widely consumed beverage worldwide, next to water (Mukhtar and Ahmad, 2000). Green tea has been used in traditional Chinese medicine as a healthful beverage for thousands of years. Tea consumption is associated with reduced risk of cardiovascular disease and cancer, and the healthy benefit of tea is due to its high phytochemicals content with antioxidant property (Cabrera et al., 2006; Mukhtar and Ahmad, 2000). In general, green tea is a 'non-fermented' tea, and contains more catechins than black tea or oolong tea. Catechins are *in vitro* and *in vivo* strong antioxidants (Cabrera et al., 2006). Green tea also shows higher antioxidant activity than the semi-fermented and black tea (Cheng, 2004).

To date, herbal teas, as well as green teas, are a popular beverage worldwide, particularly in China, because of their fragrance, antioxidant properties, therapeutic applications and other beneficial effects on health (Aoshima et al., 2007; Chan et al., 2010; Craig, 1999; Farzaneh and Carvalho, 2015; Lasekan and Lasekan, 2012; Naithani et al., 2006; Sarwar and Lockwood, 2010; Wong et al., 2006b; Zhao et al., 2013). Herbal teas brewed from the leaves, flowers, seeds, fruits, stems, and roots of plant species rather than the leaves of *C. sinensis* are common beverages, which have been widely used for health care and disease prevention for thousands of years (Aoshima et al., 2007; Chan et al., 2010; Dalar and Konczak, 2013; Deetae et al., 2012; Desideri et al., 2011; Zhao et al., 2013). Most herbal teas are region specific, such as mate tea and rooibos tea that are confined in South American countries and South Africa, respectively (Lasekan and Lasekan, 2012).

In China, the concept of "Let food be thy medicine and medicine be thy food" was widely accepted for thousand years. Hence, the history of using herbal teas may be as long as the usage of traditional Chinese medicines and many of these medicines are also consumed

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in the form of teas (Zhao et al., 2013). Herbal teas are abundant in China because of its vast territory, various landforms and climate. Hundreds of herbal teas are sold in supermarkets, drugstores and health food stores. Several of these teas are native to China, such as Teng Cha (rattan tea), Shi Ya Cha (cliff tea) and Guangxi Tian Cha (Guangxi sweet tea).

In recent years, researchers have been of considerable interest in determining the antioxidant capacities and total phenolic contents in vegetables, fruits, spices, cereals, beverages and medicinal plants (Cai et al., 2004; Carlsen et al., 2010; Gan et al., 2010; Li et al., 2008; Stangeland et al., 2009; Wong et al., 2006a). Antioxidants play important roles in maintaining human health because they could scavenge the overproduction of free radicals, which are speculated to be a significant cause of aging and carcinogenesis. (Lambert and Yang, 2003). Herbal teas are considered as an important alternative source of antioxidants in addition to many other food groups, such as fruits, berries, cereals and vegetables (Dragland et al., 2003; Speisky et al., 2006). Several studies have been published on the antioxidant properties of several herbal teas (Aoshima et al., 2007; Chan et al., 2010; Dalar and Konczak, 2013; Deetae et al., 2012; Naithani et al., 2006; Oh et al., 2013). Recent studies have shown that several herbal teas have antioxidant capacities analogues to black tea (Chan et al., 2010; Deetae et al., 2012). However, these study results do not facilitate the comparisons between various herbal teas.

Color is one of the most important food qualities that require evaluation. It is also one of the important organoleptic characteristics of tea that is relevant to market acceptance (Wu and Sun, 2013). However, the knowledge on the color parameters of herbal teas is limited. Herbal tea consumption shows regional characteristics, which is influenced by the local culture, traditions, and diversity of local flora. To date, many Chinese herbal teas are underutilized. The information on the antioxidant properties and color parameters of many herbal teas is sporadic and lacking. Meanwhile, the term "rich in antioxidants" is often used to describe several herbal teas, but it usually lacks scientific evidence and evaluation criterion (Fu et al., 2011).

This study is the first to evaluate the antioxidant properties and color parameters of a wide variety of herbal teas marketed and consumed in China. Comparisons were made with eight green teas of *C. sinensis*. The antioxidant properties that were studied are as follows: 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS) radical scavenging capacity, ferric-reducing antioxidant power (FRAP), and total phenolic content (TPC). The results of this study will provide useful information for human health and contribute to the potential commercial application of herbal teas as healthy beverage.

2. Materials and methods

2.1. Chemicals and reagents

Folin-Ciocalteu's phenol reagent, DPPH, ABTS, 2,4,6-Tris(2-pyridyl)-s-triazine (TPTZ), sodium carbonate, (±)-6-hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid (Trolox), potassium persulfate, iron(III) chloride hexahydrate and gallic acid were purchased from Sigma-Aldrich (St Louis, MO, USA). All other reagents were either of analytical grade or of the highest quality available.

2.2. Plant materials

A total of 110 herbal teas (code: H1–H110), including 103 originally from 23 provinces of China and 7 from 6 other countries (Argentina, Canada, Germany, South Africa, India, and France), were collected with 250–500 g per sample from well-known local markets and drugstores. Eight representative green teas (code: G1–G8) of *C. sinensis* from five provinces of China were used as controls. These herbal teas were distributed in 45 families, mainly Asteraceae ($n = 14$), Labiatae ($n = 5$), Fabaceae ($n = 9$), Poaceae ($n = 5$), and Rosaceae ($n = 10$). Table 1 presents the 110 herbal teas and eight green teas used in this study, along with the information on Chinese/English names, family, species, plant parts used for infusion, and growing region. All of the collected tea samples were sealed with plastic bags and stored in a desiccator with silica gel at room temperature.

2.3. Sample preparation

The collected herbal and green tea samples were initially ground to fine powder and passed through a sieve (40 mesh). The ground samples were dried to constant weight over a desiccant at room temperature. For water extraction, 1.00 g of the powdered sample was extracted with 250 mL of boiling ultra-filtered water. Infusions were allowed to steep for 1 h with continuous swirling and then cooled. Subsequently, the infusions were filtered and stored at 4 °C for further analysis within 8 h.

2.4. Determination of antioxidant capacity

2.4.1. DPPH assay

The DPPH radical-scavenging activity was determined using the method proposed by Wojdylo et al. (2007) with some modifications. The DPPH$^{\bullet}$ solution (4.0 mL, absorbance of 0.700 ± 0.02 at 517 nm) was added to 0.1 mL of sample, which was properly diluted and mixed thoroughly. The reaction mixture was stored at room temperature (~23 °C) for 6 h, and absorbance was immediately recorded at 517 nm by using a Shimadzu UV-2550 UV–vis spectrophotometer (Kyoto, Japan). Trolox standard solution (final concentration 50–800 μmol/L) was prepared and assayed under the same conditions. Results were expressed in terms of mmol Trolox equivalent antioxidant capacity per 100 g dry weight (TEAC). All determinations were performed in triplicate.

2.4.2. ABTS assay

The free radical-scavenging activity was carried out using a spectrophotometer by the improved ABTS radical cation decolorization method as described (Cai et al., 2004; Wojdylo et al., 2007). ABTS radical cation (ABTS$^{\bullet+}$) was produced by reacting 7.0 mmol/L ABTS solution with 2.45 mmol/L potassium persulfate at 2:1 (v/v) and allowing the mixture to stand in the dark at room temperature for 16 h prior to use. The ABTS$^{\bullet+}$ solution was diluted with 80% ethanol to yield an absorbance of 0.700 ± 0.02 at 734 nm. The ABTS$^{\bullet+}$ solution (4.0 mL, absorbance of 0.700 ± 0.02) was added to 0.1 mL of appropriately diluted sample and was mixed thoroughly. The reaction mixture was stored at room temperature for 6 min, and absorbance was immediately measured at 734 nm. Trolox standard solution (final concentration 50–700 μmol/L) was prepared and assayed under the same conditions. Results were expressed in terms of mmol TEAC.

2.4.3. FRAP assay

The reducing antioxidant power of samples were measured using FRAP assay (Benzie and Strain 1996; Benzie and Szeto, 1999; Wojdylo et al., 2007) with slight modifications. In brief, the FRAP reagent was freshly prepared by mixing acetate buffer (0.3 M, pH 3.6), a solution of 10 M TPTZ in 40 M HCl, and 20 M $FeCl_3$ at 10:1:1 (v/v/v). The FRAP reagent (1.0 mL) and appropriately diluted sample solutions (0.05 mL) were added to each well and mixed thoroughly. The absorbance was taken at 593 nm after incubation at 37 °C for