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HERBS AND HERBAL TEAS WITH ANTIOXIDANT PROPERTIES COMPARABLE TO OR SUPERIOR THAN THOSE OF *CAMELLIA SINENSIS*

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ABSTRACT: The antioxidant properties of 20 herbs and 28 herbal teas were analyzed in comparison with those of *Camellia sinensis* based on total phenolic content (TPC), free radical scavenging (FRS) activity, ferric reducing power (FRP) and ferrous ion chelating (FIC) ability. The main objective was to find out if there are herbs and herbal teas with antioxidant properties comparable to or superior to those of *C. sinensis*. Results showed that TPC, FRS, and FRP of *C. sinensis* leave outperformed all herbs. FIC values were, however, weaker than those of banaba and cashew leaves. TPC, FRS, and FRP of *C. sinensis* teas outperformed all herbal teas except those of banaba, lemon myrtle and stevia. Eleven herbal teas displayed stronger FIC values than *C. sinensis* teas with those of banaba, spearmint, and peppermint being the most potent. Overall, *C. sinensis* leaves and teas remain the king of antioxidants based on phenolic content and primary antioxidant properties of FRS and FRP, but not on secondary antioxidant properties of FIC.

INTRODUCTION: The tea plant *Camellia sinensis* (L.) Kuntze is a shrub or small tree of the family Theaceae. Leaves are leathery with serrated margin and flowers are solitary, white with conspicuous yellow stamens **Fig. 1**. Cultivated mostly in the highlands worldwide, teas of *C. sinensis* are the most widely consumed beverage in the world, second only to water [1]. Of the total amount of teas produced and consumed in the world, 78% are black, 20% are green and 2% are oolong tea. The health-promotion and pharmacological properties of *C. sinensis* teas are widely recognized.

FIG. 1: THE TEA PLANT *CAMELLIA SINENSIS*

In this short note, data of our research work in the last decade on the antioxidant properties (AOP) of 20 fresh herbs and 28 herbal teas were analyzed in comparison with leaves and teas of *C. sinensis*. AOP was based on total phenolic content (TPC), free radical scavenging (FRS) activity, ferric reducing power (FRP) and ferrous ion chelating

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(FIC) ability. The main objective was to find out if there are species of herbs and herbal teas with AOP comparable to or superior to those of *C. sinensis*.

Leaves of *C. sinensis* were sampled from tea plantations in Bukit Cheeding, Malaysia. Fresh herbs were purchased from markets in Kuala Lumpur, Malaysia. Of the 28 herbal teas analyzed, 13 were from Thailand, and the remaining 15 were from Malaysia, USA, UK, Japan, South Africa, Sri Lanka, and Vietnam. The green, oolong and black teas of *C. sinensis* were from China, Malaysia, and Thailand.

MATERIAL AND METHODS: Leaves of fresh herbs (1 g) were powdered in a mortar using liquid nitrogen and extracted with 50 ml of methanol. Teas (1 g) were extracted with 50 ml of boiling water, mimicking the natural process of brewing tea. Infusions were allowed to steep for 1 h with continuous swirling. The extracts were then filtered under suction and stored at 4 ºC for analysis in triplicate within a week. TPC, FRS, FRP, and FIC of the extracts were measured using the respective Folin-Ciocalteu, DPPH, potassium ferricyanide, and ferrozine assays, following the procedures described earlier [2-4]. TPC and FRP were expressed as mg gallic acid equivalent (GAE)/100g. FRS was expressed as ascorbic acid equivalent antioxidant capacity (AEAC) in mg ascorbic acid (AA)/100 g. FIC ability was expressed as chelating efficiency concentration (CEC_{50}) in mg/ml or the effective concentration of the extract to chelate ferrous ions by 50%.

RESULT AND DISCUSSION: Fresh herbs with AOP comparable to or superior to *C. sinensis* leaves are shown in **Table 1**. Based on TPC, AEAC, FRP, and CEC_{50}, values of leaf shoots and young leaves of *C. sinensis* were significantly higher than mature leaves. Leaves of *C. sinensis* outperformed all 20 fresh herbs except for *Lagerstroemia speciosa* and *Anacardium occidentale*. These two herbs had stronger CEC_{50} values than leaf shoots and young leaves, and higher FRP values than mature leaves of *C. sinensis*.

TABLE 1: LEAVES OF FRESH HERBS WITH ANTIOXIDANT PROPERTIES COMPARABLE TO OR SUPERIOR TO THOSE OF *CAMELLIA SINENSIS*

Species	TPC	AEAC	FRP	CEC_{50}
Camellia sinensis (LS)	7670 ± 450	14,470 ± 580	5560 ± 180	3.0 ± 0.8
Camellia sinensis (YL)	7280 ± 130	12,820 ± 540	5450 ± 280	4.7 ± 1.4
Camellia sinensis (ML)	5840 ± 290	10,220 ± 670	2130 ± 350	7.0 ± 0.6
Anacardium occidentale	3890 ± 340	6620 ± 510	3260 ± 240	1.9 ± 0.2
Lagerstroemia speciosa	4150 ± 20	6120 ± 330	2960 ± 30	2.1 ± 0.6

Data on phenolic content and antioxidant activity in fresh weight are means ± standard deviations. Abbreviations and units: TPC = total phenolic content (mg GAE/100 g), AEAC = ascorbic acid equivalent antioxidant capacity (mg AA/100 g), FRP = ferric reducing power (mg GAE/100 g), CEC_{50} = chelating efficiency concentration to chelate ferrous ions by 50% (mg/ml), (LS) = leaf shoots, (YL) = young leaves and (ML) = mature leaves. Lower CEC_{50} values indicate stronger ferrous ion chelating ability. Values in bold are significantly stronger than or comparable to those of *C. sinensis* at $p<0.05$.

Three other herbs with stronger CEC_{50} than leaf shoots and young leaves of *C. sinensis* were *Citrus hystrix*, *Morus alba* and *Piper sarmentosum* with values of 1.2 ± 0.2, 2.7 ± 0.2 and 2.7 ± 0.2 mg/ml, respectively. Most of the 20 herbs had superior FIC than mature *C. sinensis* leaves. This would imply that these herbs have a better ability to chelate metal ions and inhibit metal-catalyzed free radical formation than *C. sinensis.*

The potent AOP of *C. sinensis* leaves is well documented [2, 5], which have been attributed to their 'signature' flavanols or catechins, which constitute up to 30% of dry weight [6]. Principal catechins are epigallocatechin- 3- gallate (EGCG), epigallo-catechin (EGC), epicatechin-3-gallate (ECG), gallocatechin (GC) and epicatechin (EC). Studies have been conducted on the chemical composition, and content of *C. sinensis* leaves of different ages. EGCG, the main flavanol in leaf shoots, constituted up to 115 mg/g dry weight [7]. The contents of EGC, EGCG, and ECG in young leaves were 1.7, 2.3 and 2.4 times greater than in mature leaves [8].

The outstanding AOP of *L. speciosa* and *A. occidentale* leaves far exceeded those of *Piper* species including temperate culinary herbs of rosemary, thyme and marjoram [9, 10].

Leaves of *L. speciosa* trees with purple flowers had significantly higher values than those with pink flowers [11]. Ellagitannins, terpenoids, flavonoids, phenolic acids, and ellagic acid derivatives are the major constituents of *L. speciosa* leaves [12]. Leaves of *A. occidentale* contain kaempferol 3-*O*-glucoside, kaempferol 3-*O*-arabinofuranoside, quercetin 3-*O*-glucoside and quercetin 3-*O*-galactoside as major flavonoids [13].

Herbal teas with AOP comparable to or superior to teas of *C. sinensis* are shown in **Table 2**. Only teas of *L. speciosa*, *Backhousia citriodora*, and *Stevia rebaudiana* could match those of *C. sinensis*. All teas of *C. sinensis* possessed very strong TPC, AEAC, and FRP with green tea having the highest values followed by oolong and black teas.

TABLE 2: HERBAL TEAS WITH ANTIOXIDANT PROPERTIES COMPARABLE TO OR SUPERIOR TO TEAS OF *CAMELLIA SINENSIS*

Species, tea, and brand	TPC	AEAC	FRP	CEC_{50}
Camellia sinensis, green, Boh	14,120 ± 1810	25,000 ± 2780	14,300 ± 1100	1.8 ± 0.3
Camellia sinensis, green, Sea Dyke	11,370 ± 1480	18,460 ± 1740	8400 ± 1100	1.4 ± 0.1
Lagerstroemia speciosa, banaba, TriSiam	10,300 ± 260	17,890 ± 170	7840 ± 140	0.3 ± 0.0
Camellia sinensis, oolong, Sea Dyke	9090 ± 460	16,170 ± 2480	6900 ± 420	1.9 ± 0.2
Camellia sinensis, black, Lipton	8490 ± 800	11,550 ± 1150	5300 ± 300	1.7 ± 0.1
Backhousia citriodora, lemon myrtle, Boh	7560 ± 130	13,600 ± 800	6100 ± 60	1.2 ± 0.2
Camellia sinensis, oolong, An Xi	7500 ± 460	14,450 ± 31	5900 ± 230	1.8 ± 0.5
Camellia sinensis, black, Boh	7410 ± 120	10,300 ± 560	5300 ± 300	1.0 ± 0.2
Stevia rebaudiana, stevia, TriSiam	7780 ± 660	7730 ± 400	4810 ± 400	1.2 ± 0.0

Data on phenolic content and antioxidant activity in dry weight are means ± standard deviations. Abbreviations and units: TPC = total phenolic content (mg GAE/100 g), AEAC = ascorbic acid equivalent antioxidant capacity (mg AA/100 g), FRP = ferric reducing power (mg GAE/100 g) and CEC_{50} = chelating efficiency concentration to chelate ferrous ions by 50% (mg/ml). Lower CEC_{50} values indicate stronger ferrous ion chelating ability. Values in bold are significantly stronger than or comparable to those of *C. sinensis* at $p<0.05$.

The potent AOP of *S. rebaudiana* can be attributed to its chemical constituents of diterpene glycosides comprising steviol, isosteviol, stevioside and rebaudioside [14]. Of these compounds, stevioside and rebaudioside have been reported to be active scavengers of hydroxyl and superoxide radicals [15]. Myricetin, hesperetin rhamnoside, and hesperetin hexoside are flavonoids reported in *B. citriodora* [16].

Many studies have reported stronger AOP in green tea than oolong and black teas [17, 18]. This might be due to fermentation during tea manufacturing which reduced the levels of catechins. Total catechins were 140 mg/g in green tea and 42 mg/g in black tea. Green tea contained 30-42% of catechins and 5-10% of flavonols in comparison to 3-10% and 6-8% in black tea [19]. EGCG, the most abundant catechin, is thought to be responsible for most of the biological activities of green tea. Conversely, black tea contained thearubigin (12-18%) and theaflavin (3-6%), not found in green tea.

In terms of CEC_{50}, a ranking of *C. sinensis* teas was black > green > oolong. Eleven out of 28 herbal teas displayed stronger chelating ability than *C. sinensis* teas. Strongest FIC was observed in teas of *Mentha spicata*, *Mentha piperita* and *L. speciosa* with values of 0.3 ± 0.0, 0.4 ± 0.1 and 0.3 ± 0.0 mg/ml, respectively. Other herbal teas with stronger or comparable FIC were *M. alba*, *Origanum vulgare*, *Alpinia zerumbet*, *Ficus deltoidea*, *Cassia angustifolia*, and *Syzygium guajava*. Complementing our findings, green tea possessed high phenolic content and strong antioxidant activities, but its FIC was weaker than that of black tea [20]. Among 15 Thai herbal teas analyzed, three had stronger metal chelating capacity than *C. sinensis* teas [21]. Six out of eight herbal teas had stronger FIC than green and black teas [22].

It is important to note that FRS and FRP are primary antioxidant activities, which prevent oxidative damage by donating hydrogen ions directly to free radicals. FIC is a secondary

antioxidant activity, which measures the ability of antioxidants to chelate metal ions. Secondary antioxidants act indirectly by preventing the formation of free radicals through the Fenton's reaction, which has been implicated in many diseases. Herbal teas with high TPC tend to have high FRS and FRP (both R^2 = 0.947). There is no such correlation with FIC (R^2 = 0.165), i.e. herbal teas with high TPC can have weak FIC and *vice versa*.

CONCLUSION: In conclusion, fresh leaves and teas of *C. sinensis* remain the king of antioxidants in terms of phenolic content, and primary antioxidant activities of FRS and FRP, when compared with other herbs and herbal teas. However, its supremacy fades in terms of FIC. Much has been documented on the chelating potency of green tea. It is time that the chelating ability of black tea and some herbal teas be given due attention.

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