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The distribution of minerals and flavonoids in the tea plant (*Camellia sinensis*)☆

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Abstract

Camellia sinensis is a plant growing in India, Sri Lanka, Java, Japan and its properties were known 4000 years ago. Since then, traditional Chinese medicine has recommended this plant for headaches, body aches and pains, digestion, depression, detoxification, as an energiser and, in general, to prolong life. Tea contains volatile oils, vitamins, minerals, purines, polyphenols, particularly carechins. We have analysed ten commercial teas from various countries to determine their mineral composition and we have analysed a green tea, an Oolong tea and a White tea to determine their polyphenols and flavonoids content. Our study shows that the variation of mineral composition, polyphenols and flavonoids are linked to different origins of the plant. For the determination of phenols compounds and flavonoids we used an HPLC apparatus and for mineral analysis an atomic absorption apparatus. © 2001 Éditions scientifiques et médicales Elsevier SAS

Keywords: *Camellia sinensis*; Theaceae; Flavonoids; Catechins, HPLC

1. Introduction

Camellia sinensis can be a shrub or evergreen tree up to 16 m tall. Leaves alternate, exstipulate, lanceolate to obovate, up to 30 cm long, 2–5 cm broad, pubescent, sometimes becoming glabrous, serrate, acute or acuminate; flowers 1–3, in axillary or subterminal cymes, deflexed, 2–5 cm broad, aromatic, white or pinkish, actinomorphic, sepals and petals 5–7, pedicels 5–15 mm long; stamens numerous; ovary 3–5 carpellate, each carpel 4–6 ovulate; capsules depressed-globose, brownish, lobate, to 2 cm broad, valvate, with 1–3 subglobose seeds in each lobe; approximately 500 seeds/kg.

According to Chinese legend, tea was discovered accidentally by an emperor 4000 years ago, while according to other sources the Chinese have been drinking tea since 3000 B.C. and over four million acres are devoted to its cultivation. It is drunk in almost every country around the world and has reached a ceremonial status in many places. There are three types of tea produced: green, oolong and black, but all come from the same plant. Green tea is prepared from fresh leaves and buds that are pan-fried then rolled and dried. Oolong is made by wilting the fresh leaves in the sun, then bruising them slightly and partially fermenting them. Black tea is made by fermenting the slightly wilted leaves [1].

The leaves of the tea plant are used both as a social and medicinal beverage: since 3000 B.C. traditional Chinese medicine has recommended green tea for headaches, body aches and pains, digestion, enhancement of immune defences, detoxification, as an energiser and to prolong life [2,3]. Now many of these health benefits are confirmed.

2. Experimental

We have analysed various commercial tea samples coming both from Italy and others countries: China, Russia and Syria.

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Two grams of each tea sample are ignited in a muffle (600°C) after a previous carbonisation phase. The colour of ash was not white even after treatment with $H_2SO_{4conc.}$

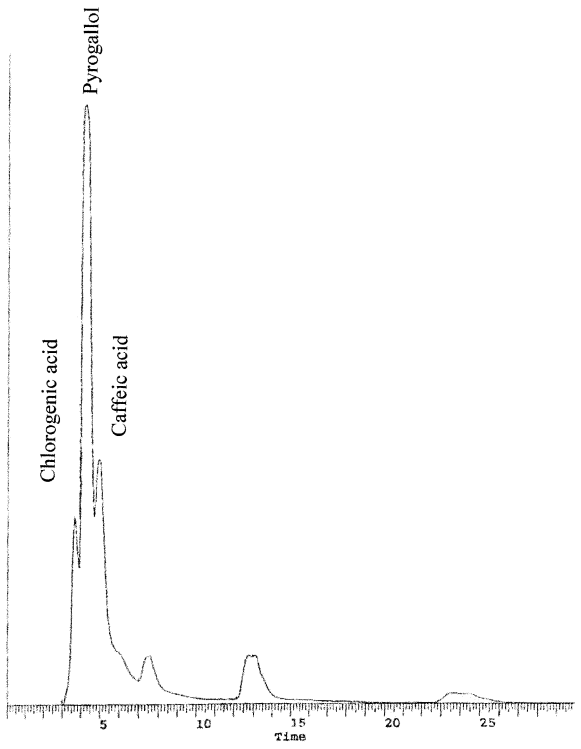

Fig. 1. Polyphenols in green tea.

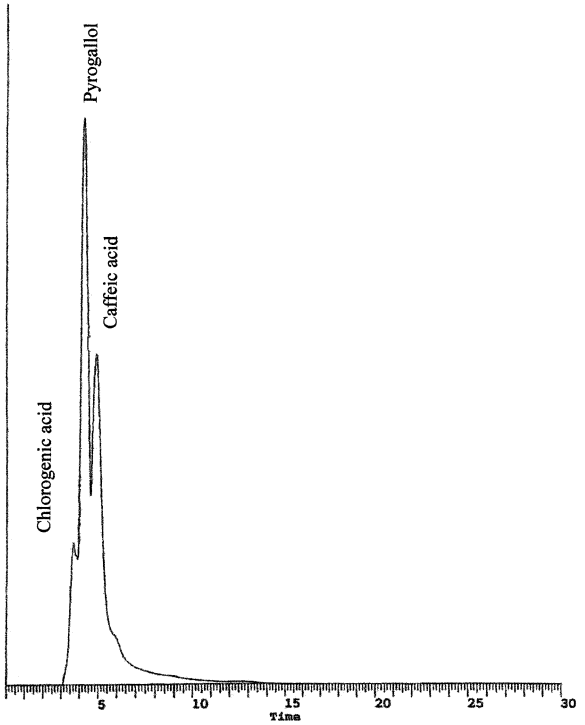

Fig. 2. HPLC: polyphenols in white tea.

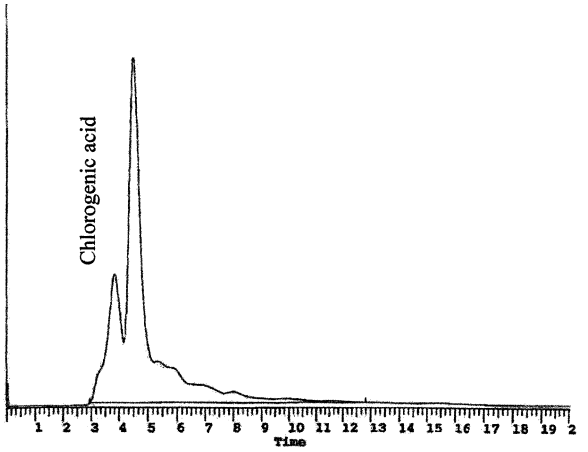

Fig. 3. HPLC: polyphenols in black tea.

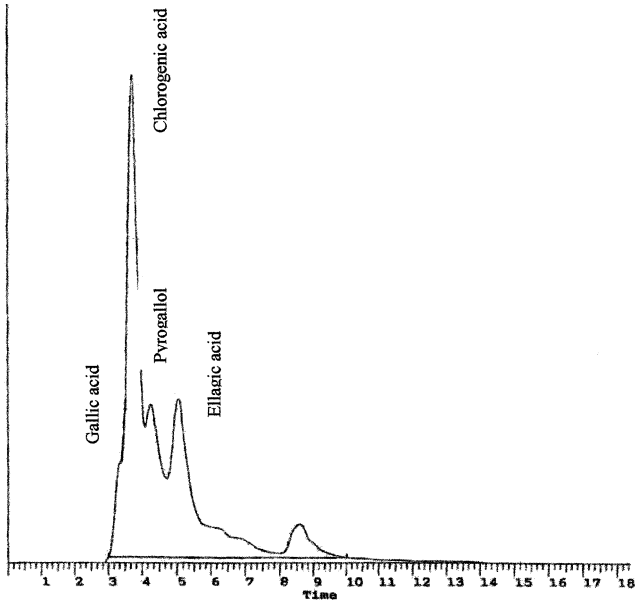

Fig. 4. HPLC: polyphenols in commercial tea.

The residue is solubilised in HCl (2 N), diluted to 50 ml in a 50 ml flask and analysed using an atomic absorption apparatus (Perkin–Elmer 3030 B). In Tables 1 and 2 we have reported the metals present in tea samples.

Three grams of green tea, black tea and white tea are extracted after acid hydrolysis by ethyl acetate. The residue is solubilised in a mixture of acetonitrile–water, 1:1 v/v, and then 10 μl injected into the HPLC apparatus (Sunicom Oy) and analysed using a Ultracarb ODS column (20) 5 having 250 × 4.6 mm i.d. For elution we used a gradient system: acetonitrile–water (from 70:30 to 90:10 v/v) per 35 min adjusting the wavelength at 350 nm (flavonoids), Figs. 5–7, and an isocratic system eluting by acetonitrile–acetic acid 2% (80:20 v/v) per 20 min adjusting the wavelength at 254 nm (phenolic compounds). Figs. 1–4 ('Te Star Classic Blend', a commercial tea).

Table 1
Atomic absorption: three Syrian teas and a Russian tea (results are expressed in ppm)

Samples	mg residue	Cu	Fe	Ni	Cd	Mo	Mn	As	Na	K	Mg	Ca	Zn	Al	Pb	Cr
1. Black tea Syria	15.4	405.8	11 250	1964	0.0				32 142	286 688	34 415	22 451	730.5			32.5
2. Red Syrian tea (long leaf)	12.5	320.0	7940	140.0	0.0				16 600	388 800	31 400	20 580	440.0			
3. Red Syrian tea	17.1	321.6	9912	131.6	0.0.				18 421	36 8567	28 801	19 751	467.8			58.5
4. Russian tea	72.0	277.8	6541	97.2	0.0	0.0	15 277		12 156	186 046		25 347	565.8	22 694	20.8	83.3

Table 2
Atomic absorption: Chinese teas (results are expressed in ppm)

Samples Chinese teas	mg residue	Cu	Fe	Ni	Cd	Mo	Mn	As	Na	K	Mg	Ca	Zn	Al	Pb	Cr
1. Tè toucha yunnan	390.5	201.9	5198	103.4	0.0	161.9	7512		11.470	234 248		37 237	431.3	13 205	19.4	22.6
2. Kwong sang tea	167.0	260.5	4362	77.8	0.0		7934		8383	277 664		23 353	535.9	12 655		17.9
3. Green tea china	25.0	270.0	13 040	1340	0.0				1.800	262 000	30 800	13 750	630.0			10.0
4. Tiamu king ding	19.5	256.4	11 577	2025	0.0				3.641	309 359	30 256	17 769	1000			115.4
5. Tikuan yin	19.6	140.3	10 408	178.5	0.0				10 586	647 959	26 658	19 323	663.3			25.5
6. Long-ching	21.4	175.2	6179.9	151.8	0.0				6074	379 672	23 130	17 535	735.9		81.8	58.4
7. Oolong china	16.7	104.8	6751.5	134.7	0.0				11 377	359 131	27 844	23 980	523.9			0.0

Table 3
Atomic absorption: commercial teas (results are expressed in ppm)

Samples commercial teas	mg residue	Cu	Fe	Ni	As	Cd	Mo	Mn	Na	K	Mg	Ca	Zn	Al	Pb	Cr
1. Lipton tea light quality	237.0	377.6	2141	8.4	0.0	4.2	0.0	12 658	11 181	266 033		46 616	523.2	13 489	21.1	31.6
2. Compagnia del tè	176.3	501.9	3678	48.2	0.0	2.8	0.0	4679	18 718	22 7027		47 929	737.3	18 057	22.7	19.8
3. Star tea detanninated	116.6	385.9	2367	0.0	0.0	0.0	0.0	15 866	13 078	26 7581		41 380	600.3	13 827	4.2	25.8
4. Twinning english tea	73.0	582.2	5801	136.9	0.0	0.0	0.0	15 068	8219	26 1301		41 780	705.5	13 753	13.7	54.8
5. The lyons ceylon tea	116.2	413.1	6463	111.8	0.0	0.0	0.0	14 414	32 271	219 449		38 296	645.4	21 600	0.0	129.1
6. Twinning earl grey tea	58.3	566.0	11 672	128.6	0.0	8.6	0.0	13 293	14 579	188 679		29 588	874.8	24 245	240.1	60.0
7. Tè star classic blend	86.1	377.5	2404	75.4	0.0	0.0	0.0	5685	7839	273 519		14 808	621.3	12 352	139.4	23.2
8. Twinning Prince of Wales tea	47.3	602.5	6828	52.8	0.0	0.0	570.8	12 156	12 156	186 046		23 255	1120	27 162	116.3	52.8
9. Te Ati (det.)	124.3	382.1	2172	132.7	0.0	0.0	0.0	11 464	20 716	312 148		29 163	490.7	15 201	44.3	20.1

3. Results and discussion

The tea plant contains different compounds having biological and pharmaceutical properties that are good for health. These properties are shown by various studies in vivo and in vitro. These compounds show various actions: antiallergic [4–7], antioxidant [8,9], antimutagenic and anticancer [10], antiatherosclerotic [11] and antibacterial [12,13].

The catechins [14] play a fundamental role in these actions. Our research is aimed at studying various flavonoids and polyphenols from tea leaves coming from different countries and mineral compounds. All the samples of tea leaves show a high content of mineral compounds, but only some samples contain very low concentration of heavy metals (toxic). It is important to note the absence of arsenic, cadmium and molybdenum (except Tuocha) and the low concentration of copper, chromium and zinc. The concentration of potassium, in all samples, is higher than sodium while the amount of Mg is higher than calcium. The presence of lead in commercial samples with respect to pure tea samples maybe derived by working steps.

All types of tea have the alkaloids caffeine, theobromine and theophylline but in varying amounts. They contain volatile oils, vitamins, minerals but the active constituents are polyphenols, particularly catechins including epigallocatechin, gallic acid and bioflavonoids.

Every type of tea has special properties of its own: green tea has a high amount of fluoride in it which may help strengthen teeth and bones and reduce tooth decay [15]. It also has catechins and bioflavonoids which may contribute to its potential to fight skin, esophageal, stomach and colon cancer. Green tea can be used externally to stop or slow bleeding from cuts and scrapes and to relieve itchy insect bites, finally it can also regulate blood sugar and insulin levels [16].

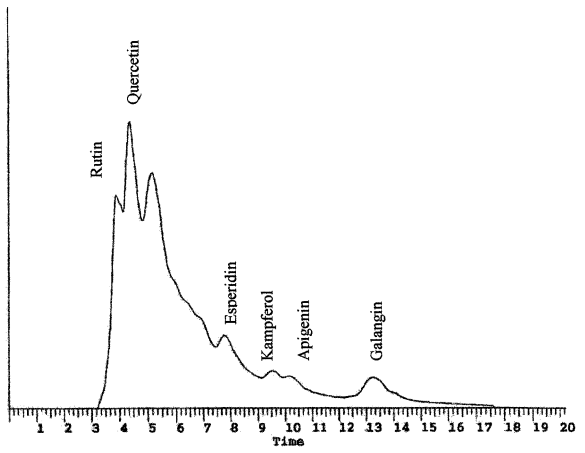

Fig. 5. HPLC: ethyl acetate extract from white tea.

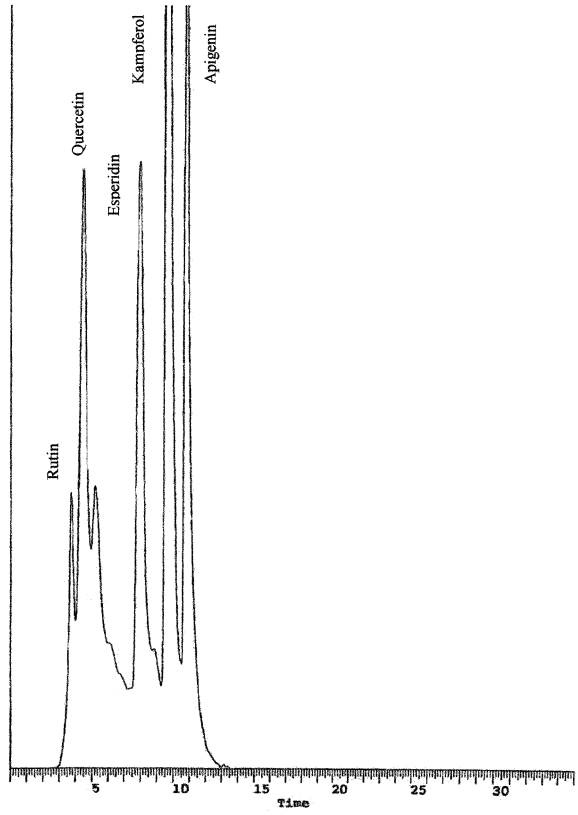

Fig. 6. HPLC: ethyl acetate extract from green tea.

Some types of oolong tea have cholesterol-lowering properties which are especially effective when drunk after a fatty meal; it can also reduce blood pressure and arterial disease possibly by decreasing the clotting tendency of blood.

Black tea is rich in tannins which gives it an astringent quality useful in treating diarrhoea and can help relieve certain types of headaches. Damp black tea bags can also be placed over tired, red eyes or on insect bites to relieve itching and redness.

In particular research demonstrates that green tea mildly guards against cardiovascular disease [17] in many ways. Green tea lowers total cholesterol levels and improves the cholesterol profile (the ratio of LDL cholesterol to HDL cholesterol), reduces platelet aggregation [18] and lowers blood pressure. The polyphenols in green tea have also been shown to decrease the risk of cancer of several types, stimulate the production of several immune system cells and have antibacterial properties even against the bacteria that cause dental plaque.

One study found that intake of ten cups or more of green tea per day improved blood test results, indicating protection against liver damage. Further studies are needed to determine if taking green tea helps those with liver disease.

All types of *C. sinensis* have stimulant properties, so people who are pregnant or nursing, who have anxiety

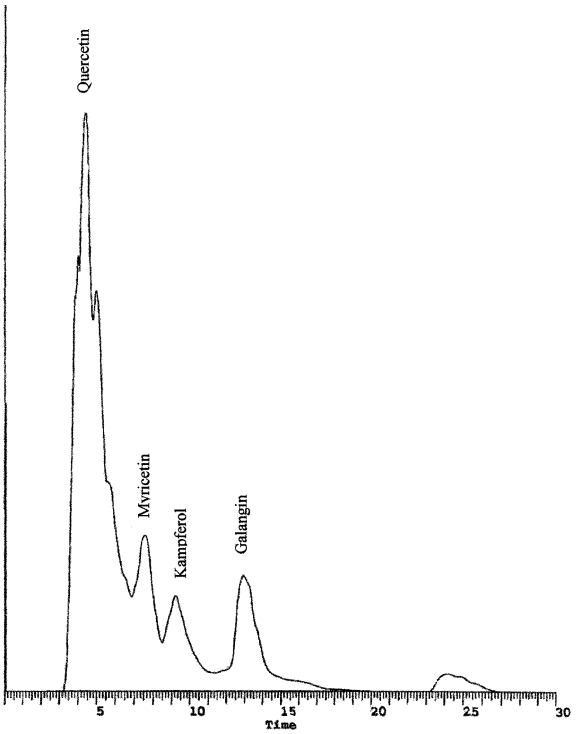

Fig. 7. HPLC: ethyl acetate extract from black tea.

disorders, who suffer from insomnia or have an irregular heart beat should limit their daily intake to 1 or 2 cups with the last cup being taken at least 3 h before bedtime. For these reasons a lot of the research documenting the health benefits of green tea is based on the amount of green tea typically drunk in Asian countries, about three cups per day (providing 240–320 mg of polyphenols).

Looking into the results shown in Figs. 1–7, green tea contains the highest amount of phenolic compounds and flavonoids [19] and this means that the kind of treatment the plant is subjected to influences its chemical composition. Even mineral composition [20] is connected to the place of origin of the plant — the variations are shown in Tables 1–3.

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