

DETECTION AND ESTIMATION OF ESSENTIAL TRACE ELEMENTS IN TEA (*THEA SINENSIS*) BY ICPAES AND FAAS METHODS

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Seven essential trace elements have been detected and estimated, including cobalt and chromium in six samples of tea. The use of inductively coupled plasma atomic emission spectroscopy (ICPAES) and flame atomic absorption spectrophotometry (FAAS) has been made. Hot water extraction limits for these elements have also been estimated. The standardization of the methods was carried out by using Orchard Leaves NBS-1571.

Key words: Essential, Trace elements, Tea.

Introduction

Tea is a very popular caffeine-containing beverage obtained from *Thea sinensis*. Trace elements occur naturally, but may also be due to contamination from dust, fumes, pesticides and contact metals during production. Some contaminations are produced deliberately arising due to food additives during processing. The study of trace elements in tea has been taken up as trace elements play an important role in the complex metabolic pathways in human system and their deficiency or excess may cause diseases.

More than 60 elements in various parts of human body have been detected. It has been reported by Schwarz [1] and Manser [2] that at least 25 elements are essential and out of which 14 are termed as trace elements (their concentration being less than 50 mg/kg body weight).

Aziz-Al-Rehman [3] estimated copper in tea by using two different methods of solution preparation for FAAS methods. Tarafdar *et al.* [4] analysed copper, nickel, zinc and manganese in Bangladesh tea by FAAS. Takeo [5] determined a number of inorganic components, including copper, iron, zinc and manganese by ICPAES in Japanese green and black tea. Imtiaz *et al.* [6] have reported the analysis of major and minor trace elements in tea, coffee and cocoa samples using ICPAES.

In the present study seven essential trace elements have been detected and estimated in tea by using flame atomic absorption spectrophotometry (FAAS) and inductively coupled plasma atomic emission spectroscopy (ICPAES). A very close comparison for the estimation of these elements by the two methods has been achieved. The presence of chromium in tea samples, not reported elsewhere, has also been determined.

Experimental

Instruments. The Atomic Absorption Spectrophotometer used was GBC Model SB900 with air-acetylene flame. The Inductively Coupled Plasma Atomic Emission Spectro-

photometer, LABTAM - Model V-25, equipped with 100-2000 source and CRT - 1000-A computer, was used.

Preparation of solution of FAAS. The method of wet oxidation with HNO_3 and a mixture of HNO_3 and H_2SO_4 was adopted, in order to remove organic matter. Solutions were prepared by two methods, i.e. (a) a routine method for direct FAAS measurements and (b) solvent extraction (used for elements having very low concentrations such as zinc, nickel, cobalt and chromium).

For direct FAAS measurements, 1 g powdered tea was digested in 10ml conc. HNO_3 in a Kjeldahl flask for 16 hrs. The volume was reduced to 1ml and transferred into a 10ml volumetric flask and diluted up to the mark with distilled water. A blank was prepared similarly.

For solvent extraction method, 2.5 g of powdered tea was digested with 10 ml conc. HNO_3 and 10 ml conc. H_2SO_4 . A further 20 ml conc. HNO_3 were added in aliquots of 5 ml at intervals. When the solution was clear, it was heated gently to remove excess of acid till the volume was reduced to 1 ml. This was dissolved in 50 ml distilled water and transferred to a 250 ml beaker. The pH of the solution was adjusted to 4 with NaOH solution, 5 ml 1% APDC (Ammonium pyrrolidine dithiocarbamate), aqueous solution was added and the pH was raised to 12 by further addition of NaOH. The solution was left for 5 min. when the pH was readjusted to 5 with dilute acetic acid. The solution was transferred to 250 ml separating funnel and extracted with 10 ml portions of chloroform till the solvent layer was colourless (40 ml in total required). 2 ml of 1% APDC were added followed by extraction with another portion of 10 ml chloroform. The extracts were mixed and evaporated to dryness. The residue was heated with 5 ml conc. HCl to remove organic matter till, evaporation reducing it to 1 ml, which was transferred to a 10 ml volumetric flask and made up to the mark with distilled water. A blank was prepared similarly.

Hot water extraction method. Dried tea leaves (5 g) were boiled with distilled water (10 ml) for about 5 min. The liquor was filtered and evaporated to dryness in a platinum dish. The residue was made into a solution in a similar way as the powdered tea samples.

Preparation of solution for ICPAES. Powdered tea (1 g) was digested with 10 ml conc. HNO₃ and when clear was reduced to 2 ml by evaporation. These were transferred to a 10 ml volumetric flask and made up to the mark with distilled water. A blank was prepared similarly.

Standard solutions. The standard solutions from Fixanal (R.D.H.), Germany were used for all elements.

Results and Discussion

Tea samples consisting of low, medium and high quality were procured from the market. Seven essential trace elements have been determined by FAAS and ICPAES (Table 1). In Table 2, the range of concentrations of these elements in tea samples and of their percent extraction by hot water are given.

The ratio of detection limits for FAAS and ICPAES [7] are given in Table 3. It should be noted that, except for zinc, the detection limit by ICPAES is lower than by FAAS. The standardization of the methods has been accomplished using trace elements in Orchard leaves NBS-1571, as shown in Table 4. The concentration of cobalt and chromium have not been certified for NBS-1571; we consider our measurements

by ICPAES as the more reliable. Other elements are in agreement with the certified values (Table 4), except for Fe, which lies just outside the standard deviation.

Chromium. Tea contains 1.4 - 3.5 µg/g of chromium and upto 55% is extractable by hot water. Chromium has an essential role in carbohydrate and liquid metabolism [9]. It activates several enzymes and stimulates fatty acid and cholesterol synthesis. It has important relationship with diabetes and its role in glucose utilization [10].

Cobalt. The concentration of cobalt ranges from 0.32 to 1.2 µg/g in tea and upto 32% is extractable by hot water. Cobalt is an essential trace element, being a component of vitamin B12.

Manganese. Tea is a rich source of manganese, having 400 - 1160 µg/g of which upto 51% is hot water extractable. Manganese is a cofactor of enzymes is protein synthesis and energy metabolism [11]. A cup of tea contains about 0.3 - 1.3 mg of manganese and therefore its safe upper level of intake comes into consideration. The Food and Nutrition Board lists 2.5 - 5 mg/day as a safe and adequate intake for adults [12].

Copper. Copper occurs in a range of 23 - 38 µg/g in tea and upto 19% to extracted in hot water. Copper is involved in a wide variety of enzymes and its role in haemoglobin synthesis, bone and elastic tissue development is well known. The maximum daily intake of copper for humans that can be safely maintained is 0.5 mg/kg body weight [8].

TABLE 1. ESTIMATION OF TRACE ELEMENTS IN TEA SAMPLES BY FAAS AND ICPAES.

Sample	Iron (ppm)		Copper (ppm)		Manganese (ppm)		Zinc (ppm)		Nickel (ppm)		Cobalt (ppm)		Chromium (ppm)	
	FAAS	ICPAES	FAAS	ICPAES	FAAS	ICPAES	FAAS	ICPAES	FAAS	ICPAES	FAAS	ICPAES	FAAS	ICPAES
1	185.0	195.0	26.40	26.60	774	750	35.60	36.90	3.10	3.50	1.20	1.10	1.40	2.30
2	126.0	125.0	25.60	26.90	574	586	35.60	35.70	3.70	3.60	0.44	0.50	1.60	3.00
3	227.0	199.0	38.40	36.50	1157	1160	29.60	30.00	3.80	3.60	1.14	1.20	2.80	3.50
4	302.0	284.0	25.60	26.00	1038	1103	40.00	38.95	7.10	6.50	1.10	1.00	3.00	2.90
5	130.0	88.0	23.20	23.40	400	400	44.40	44.20	4.80	4.70	0.46	0.32	1.80	2.30
6	200.0	203.0	28.80	31.00	748	752	30.00	30.50	3.50	3.60	0.48	0.40	3.00	3.00

TABLE 2. RANGE OF CONCENTRATION OF ELEMENTS AND PERCENTAGE OF HOT WATER EXTRACTS IN TEA SAMPLES ESTIMATIONS BY FAAS AND ICPAES METHODS.

Elements	Range of occurrence in tea samples (µg/g)	Range of hot water extracts in %
Chromium	1.40 - 3.50	28.57 - 55.5
Cobalt	0.32 - 1.20	9.16 - 31.8
Manganese	400.00 - 1160.00	43.72 - 51.20
Copper	23.20 - 38.40	4.40 - 19.00
Zinc	29.60 - 44.40	67.40 - 85.00
Nickel	3.10 - 7.10	2.60 - 7.02
Iron	88.00 - 302.00	3.24 - 8.26

TABLE 3. RATIO OF DETECTION LIMITS FOR FAAS AND ICPAES*.

No.	Element	Detection limits ng/ml		Ratio of detection limits FAAS/ICPAES
		FAAS	ICPAES	
1	Co	5	4	1
2	Cr	10	5	2
3	Cu	5	3	2
4	Fe	5	3	2
5	Mn	3	1	3
6	Zn	2	3	0.6
7	Ni	5	10	0.5

*(Ref. No. 7)

TABLE 4. CONCENTRATION OF TRACE ELEMENTS IN ORCHARD LEAVES NBS-1571 BY FAAS METHOD.

Elements	Standard concentration (ppm)	Concentration found in the present work (ppm)
Ni	1.3 ± 0.2	1.40
Cr	(2.3)*	3.15
Co	(0.2)*	0.3
Mn	91.0 ± 4.0	94.6
Cu	12.0 ± 1.0	11.0
Fe	300.0 ± 2.0	294.0
Zn	25.0 ± 3.0	24.0

* Not certified.

Zinc. Zinc is widely distributed in food; its presence in tea lies between 30 - 44 µg/g. It is highly extractable by hot water (upto than 85%). It occurs in a wide variety of enzymes and its role in protein and carbohydrate metabolism is well established. Nutritional problems from zinc arise from its deficiency rather than its excess.

Nickel. Nickel is present from 3.1 - 7.1 µg/g in tea and upto 7% is extractable by hot water.

Iron. Iron occurs in a range of 88 - 302 µg/g in tea and upto 8% is hot water extractable. Iron deficiency may cause anaemia.

It may be concluded that as regards the presence of essential trace elements, tea may be considered as a useful

beverage, supplying some of the nutritional trace elements. Only the richness of manganese in tea is alarming and that may be checked if, the habit of excess of tea drinking is avoided.

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