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Evaluation of Trace Metals in Tea Samples from Jeddah and Jazan, Saudi Arabia by Atomic Absorption Spectrometry

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Abstract The Cd, Pb, Mn, Zn, Ni, Co, Fe, Cr and Cu content were determined in various teas available in local markets of Jeddah and Jazan, Saudi Arabia. Concentrations of the trace metals were measured after acid digestion using a flame atomic absorption spectrometer. Validation of the digestion procedure was performed by the analysis of a certified reference material. The cadmium, lead, manganese, zinc, nickel, cobalt, iron, chromium and copper concentrations were found in the range of below the detection limit (BDL)—0.7 μg/g, BDL—8.7 μg/g, 48–859 μg/g, 6.6–120 μg/g, BDL—16.9 μg/g, BDL—3.1 μg/g, 46–348 μg/g, BDL—4.9 μg/g and 5.2–21.6 μg/g respectively. The values found in this study were compared with literature values.

Keywords Trace metals · Tea · Jazan · Jeddah

All trace elements are toxic when ingested in excess amounts, yet many elements such as copper, selenium and cobalt are necessary at trace levels for various bodily functions (Narin et al. 2004). Due to their effects on human life and the environment, many laboratories are focused on the detection, toxicity and bioaccumulation of trace metals in environmental samples, including water and food. Flame atomic absorption spectrometry (FAAS) is the most widely used analytical technique for the determination of metallic elements because it is inexpensive and easy to use.

Black and herbal teas are important because they are consumed in large amounts by people around the world, particularly in middle eastern countries. As established in the literature (Colak et al. 2005; Lagad et al. 2011; Desideri et al. 2011; Mahani and Maragheh 2011), tea consumption is a significant avenue of intake for the gradual accumulation of trace heavy metals in the human body. Thus, analyses of the metal content of various tea samples around the world have been performed (Fernandez-Caceres et al. 2001; Rao et al. 2009; Vulcano et al. 2008; Ashraf and Mian 2008; Haban et al. 2008; Mehra and Baker 2007; AL-Oud 2003). In this work, the cadmium, lead, manganese, zinc, nickel, cobalt, iron, chromium and copper concentrations of various tea samples purchased from markets in Jazan and Jeddah, Saudi Arabia have been determined after acid digestion by FAAS.

Materials and Methods

The analyte concentrations were determined in an air-acetylene flame with a Perkin-Elmer 3110 model atomic absorption spectrometer (Norwalk, CT, USA). The instrumental parameters for FAAS for the detection of each element were set as recommended by the manufacturer and are given in Table 1.

All reagents were of analytical grade. reverse osmosis water was used for the preparation of solutions. All plastic

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Table 1 Instrument settings

Elements	Parameters		
	Wavelength (nm)	Slit width (nm)	Lamp current (mA)
Cd	228.8	0.7	4
Pb	283.3	0.7	10
Mn	279.5	0.2	25
Zn	213.9	0.7	30
Ni	232.0	0.2	30
Co	240.7	0.2	30
Fe	248.3	0.2	25
Cr	357.9	0.7	30
Cu	324.8	0.7	30

and glassware were cleaned by soaking overnight in a 10 % nitric acid solution and then rinsed with water prior to use. The standard solutions used for calibration were prepared by diluting a 1,000 mg/L stock solution that was supplied by merck. The certified reference material used in the experimental studies was SRM 1568 A Rice Flour.

A 1.0 g sample of tea or SRM 1568 A Rice Flour was transferred to a beaker, and 20-mL of aqua regia was added. The solution was evaporated to dryness in a hood, and the process was repeated twice. Ten milliliters of water was added to the residue, and the suspension was filtered through blue band filter paper. The insoluble material was washed with water, and the metal content was determined by FAAS.

Results and Discussion

The accuracy of the digestion method used was evaluated by trace element determination of SRM 1568 A Rice Flour certified reference material. The results obtained are in good agreement with certified values and are given in Table 2.

A recovery test of the analytical procedure was performed for some of the metals in selected samples by spiking the analyzed samples with aliquots of metal standards and then reanalyzing the samples. The results are given in Table 3. Acceptable recoveries (generally >95 %) were obtained for the analytes.

The cadmium levels in four of the tea samples presented in Table 4 were found to be below the detection limit (BDL) of FAAS. The concentration range of cadmium in six other tea samples was 0.1–0.7 μg/g. The highest cadmium level was in pure chamomile tea manufactured by Twinings of London. AL-Oud (2003) has reported a cadmium range in tea samples of 0.01–0.18 μg/g.

The lead concentration range in the tea samples from Jazan to Jeddah was measured at 3.9–8.7 μg/g (Table 4).

Table 2 FAAS results for SRM 1568A Rice Flour

Analyte	Found (μg/g)	Certified value (μg/g)	Recovery (%)
Cu	2.5 ± 0.0	2.4	104
Fe	7.2 ± 1.5	7.4	97
Mn	20.0 ± 0.0	20.0	100
Zn	21.1 ± 0.0	19.4	109

Table 3 Spike analysis for Wadi AL Nahil Anise tea

Analyte	Added (μg)	Found (μg)	Recovery (%)
Pb	0	8.7 ± 2.5	
	10	18.3 ± 5.2	96
	20	29.4 ± 0.0	103
Cd	0	BDL	
	10	9.8 ± 2.0	98
	20	20.5 ± 2.2	102
Fe	0	3.2 ± 1.8	
	10	13.0 ± 2.5	98
	20	23.0 ± 3.1	99
Cu	0	14.3 ± 1.7	
	10	26.0 ± 0.5	117
	20	36.4 ± 3.2	110
Zn	0	1.3 ± 0.4	
	10	10.8 ± 0.3	95
	20	20.1 ± 0.9	94
Mn	0	2.7 ± 1.0	
	10	12.9 ± 0.0	102
	20	22.6 ± 0.7	100
Cr	0	BDL	
	10	10.3 ± 1.2	103
	20	20.0 ± 3.0	100
Ni	0	BDL	
	10	9.6 ± 1.5	96
	20	20.1 ± 3.2	100
Co	0	BDL	
	10	9.9 ± 1.5	99
	20	20.5 ± 1.5	102

BDL below the detection limit

The level of lead in the other six samples was BDL of FAAS. The levels of lead in tea samples from Brazil were reported as 0.53 μg/g by Vulcano et al. (2008). Ashraf and Mian (2008) reported lead levels in the range of 0.30–2.2 μg/g in tea samples. The mean lead level in tea samples from Saudi Arabia was reported as 2.26 μg/g (AL-Oud 2003).

The second most abundant element in the analyzed tea samples was found to be manganese in the range of

Table 4 The concentrations of some metal ions at the samples from Jazan and Jeddah, Saudi Arabia

Sample	Concentration (μg/g)								
	Cd	Pb	Mn	Zn	Ni	Co	Fe	Cr	Cu
Majoram black tea	0.4	BDL	145	12.9	16.9	3.1	348	4.9	21.6
Lipton yellow label tea	0.1	BDL	859	6.6	1.7	BDL	96	BDL	13.4
Lord black tea	0.1	BDL	712	3.6	3.3	BDL	112	BDL	14.8
Lipton clear green tea	0.3	BDL	658	24.5	5.1	BDL	163	BDL	16.1
Lemon tea by Twinings of London	0.3	BDL	154	6.6	3.3	BDL	336	BDL	5.2
Pure Chamomile from Twinings of London	0.7	BDL	48	13.9	1.7	BDL	158	BDL	9.9
Wadi AL Nahil Anise tea	BDL	8.7	140	61.1	BDL	BDL	205	BDL	14.3
AL Kaobus black tea	BDL	3.9	192	31.2	1.8	BDL	179	BDL	12.8
Tea Rabef premium full leaf black tea	BDL	5.5	98	45.5	2.3	BDL	46	BDL	14.2
Abu Jabal authentic black tea	BDL	5.5	98.3	120	1.4	BDL	237	BDL	12.2

BDL below the detection limit

48–859 μg/g. The highest manganese concentration was found in Lord Black tea, and the lowest was found in Anise tea (Table 4). Yemane et al. (2008) reported manganese levels in tea leaf samples from Ethiopia in the range of 501–1281 μg/g. The manganese level in tea samples from the Kingdom of Saudi Arabia varied from 390 to 900 μg/g (AL-Oud 2003). Gebretsadik and Chandravanshi (2010) reported a manganese concentration range in black tea samples from Ethiopia of 1,242–1,421 mg/kg

The concentration range of zinc in the samples analyzed in this study was 6.6–120 μg/g. The highest was found in the Abu Jabal Authentic black tea sample, whereas the lowest was in Lipton yellow label tea sample (Table 4). Zinc levels in tea leaf samples from Syria have been reported in the range of 18.0–44.2 μg/g Antakli and Al-Check (2011). The concentration of zinc in black tea samples from Saudi Arabia was reported in the range of 26.69 μg/g (Azizia tea)–53.89 μg/g (Chinese green tea) by AL-Oud (2003). Gebretsadik and Chandravanshi (2010) reported that the range of zinc in Ethiopian Black tea samples is 20.2–21.6 mg/kg.

The concentration range of nickel in the analyzed samples was 1.4–16.9 μg/g, with the lowest in Abu Jabal Authentic black tea and the highest in Majoram black tea (Table 4). The nickel concentration was BDL of FAAS in Wadi AL Nahil Anise tea. The nickel and cadmium concentrations in tea samples from South India were found to be 2.53 and 0.11 μg/g respectively (Seenivasan et al. 2008). Nickel levels in tea samples from Saudi Arabia were reported in the range of 3.50–6.48 μg/g (AL-Oud 2003).

The concentration of cobalt was 3.1 μg/g in Majoram black tea. In all other samples, the cobalt concentration was BDL of FAAS (Table 4). Concentrations of Co and Zn in black tea samples were reported by Ashraf and Mian (2008) in the range of 4.5–17.4 and 23.7–122.4 μg/g respectively. AL-Oud (2003) reported cobalt levels in three tea samples that were BDL. Cobalt concentrations of tea samples from Saudi Arabia were reported in the range of 0.05–2.35 μg/g by AL-Oud (2003).

As shown in Table 4, iron was found to be the predominant micronutrient metal in the tea samples analyzed in the present work, ranging between 46 and 348 μg/g. Levels of iron in samples from Ethiopia have been reported by Yemane et al. (2008) in the range of 29.6–100 μg/g and from Saudi Arabia in the range of 123.9–513.3 μg/g (AL-Oud 2003).

Chromium was detected only in the Majoram black tea sample at 4.9 μg/g (Table 4). In all other samples, the chromium concentration was BDL. Hussain et al. (2006) reported a high chromium level in a commercial black tea sample. Seenivasan et al. (2008) reported the mean chromium level in black tea samples from India as 4.76 μg/g.

In this study, the mean level of copper ranged from 5.2 to 21.6 μg/g. The copper concentration was lowest in Lemon tea by Twinings of London tea and highest in Majoram black tea. AL-Oud (2003) reported the copper content of tea and herb leaves from Saudi Arabia in the range of 9.04–40.66 μg/g. The copper level of black tea samples from South India has been reported as 24.07 μg/g (Seenivasan et al. 2008). The concentration of copper in tea leaf samples from Syria varied between 10.6 and 54.4 μg/g Antakli and Al-Check (2011) and from Ethiopia in the range of 9.1–11.5 mg/kg (Gebretsadik and Chandravanshi 2010).

Tea is an important beverage for people from middle eastern countries. The data obtained in this work compare well with similar data reported internationally. The trace element concentrations were generally found to be lower than the concentrations reported in international studies. Therefore, the tea samples analyzed in this study were found to be safe for human consumption.

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