

Determination of elemental content of black teas in land north of Iran

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ABSTRACT

Tea is one of the traditional and healthy drinks consumed enormously too many parts of the world. This non-alcoholic beverage is the most appropriate for its vitality and refreshing effects. The elemental content (K, Mn, Cu, Ni, Na, Cd and Pb) were determined in the black tea from the tea districts of north Iran such as Foman, Rasht, Shaft, Lahijan, Siahkal, Langerud, Rudsar, Amlash and Tonkabon state. Black tea samples were analyzed for 7 metals by atomic absorption spectrophotometer. The results of this study revealed that the level of Na and K content in all experimental black teas were in the range 32.3-74.3 µg/g and 17.3-23.2 mg/g, respectively. The Mn contents observed in the range 682 and 731 mg/kg and copper range was between 23.43 and 33.60 mg/kg. The Lead content in the samples was found as in the range of 0.20 and 0.43 mg/ kg Nickel amount in black tea leaves ranged between 2.30 and 3.68 mg/ kg. Fortunately total concentrations of Cd in all the tea leaf samples were too low to be detected by the analytical technique used in this research. The results of evaluation of tea indicated the amount of elemental content in all sample were completely lower than acceptable limit according to the international standards.

Keywords: Elemental contents; Tea drink; north of Iran

INTRODUCTION

Tea is one of the traditional and healthy drinks consumed enormously to many parts of the world. This non-alcoholic beverage which made from the young tender shoots of *Camellia sinensis* (L.) O. Kuntze is the most appropriate for its vitality and refreshing effects [1]. This plant is valued in medicines as the leaves are of use for making cigarettes and fumigating powders for the relief of asthma. The juice of this plant is believed to be a cure of hydrophobia. The leaves are boiled and used as a poultice to relieve pain[2]. Complex chemical composition such as flavonols, alkaloids, tannin substances, proteins and amino acids, enzymes, aroma forming substances, vitamins, and minerals are present in tea leaves [3]. It was reported by Cao that concentration of different elements in black tea leaves divided into three levels 1- level mg/g such as Ca, Na, K, Mg and Mn, 2- level elements mg/g such as Cr, Fe, Co, Ni, Cu, Zn and Cd, 3- several rare elements present at ng/g level [4]. Recent decades, tea could be beneficial for hypertensive patients due to its manganese-rich content and its potassium amount. On the other hand, presence of heavy metal concentration in food and beverages has restricted by several countries according to food laws [5,6]. About trace element composition, several studies have been done to figure out the causes of these wide variations. Setia et al., (1989) found that, the concentration of heavy metals being affected by the agro inputs, soil, nutrient, pesticides, fertilizers and the ability of plants to accumulate some of these elements [7], according to Powell, different agents such as country of origin and processing methodology are important [8]. Different methods establish to found element levels in tea leaves such as: Wang et al., (1993) evaluated the elements of the Chinese tea samples with Atomic Absorption Spectroscopy (AAS), Neutron Activation Analysis (NAA) and Inductively Coupled Plasma-

Atomic Emission Spectrometry (ICP-AES) method [9] and in another study in India Chute et al., (1990) have been used of a substoichiometric isotope dilution (IDA) method [10]. Also Dutta and Basu (1997) used of IDA method [11], Liu et al., (1995) evaluated the elements in tea leaves of china by a catalytic kinetic spectrophotometric method [12], several elements in tea leaves were analyzed with a dropping mercury electrode method by Lu et al., (1996) [13]. Liang and Li (2000) determined some elements in tea by microwave plasma torch atomic emission spectroscopy [14]. And also Jiang et al., (1997) extracted the tea elements by a novel photochemical voltammetric method [15].

Iran's population is about 1% of the population in the world but account for over 5% of the world's total consumption of tea to Iran. Although Iran with about 6.2% of the world's tea production of tea-producing countries is only 6.47% of the domestic production can provide. The tea consumption in Iran is about one hundred thousand tons annually, which is about half the value of domestic production. The amount of tea produced in Iran is about 35,000 acres of land in north of the country (mainly in Gilan and the narrow strip of the West Mazandaran) comes into operation.

Estimation of chemical compounds particularly elemental contents in tea plant are necessary because the regular consumption of tea may contribute to nutrition, health, and pollution perspectives. Due to the importance of elemental contents present in tea, the aim of this study was to determine the level of elements (K, Mn, Cu, Ni, Na, Cd and Pb) in black tea from north Iran.

MATERIALS AND METHODS

From each tea factories in land north of Iran (10 Region: Foman, Rasht, Shaft, Lahijan, Siahkal, Langerud, Rudsar, Amlash and Tonkabon), samples of black tea were accumulated. An atomic absorption spectrophotometer (AAS) (shimadzu, Japan) with flame and graphite furnace was used for the analysis of Na, K, Cu, Mn, Ni, Cd, and Pb contents in the samples of tea leaves.

Total samples of tea leaf were accurately weighed, Exactly 1 g of he dried tea leaf sample was taken in a 100 ml beaker and then by adding 10 ml nitric acid and perchloric acid (5:1) and then heating it up to completely combine insoluble particles with acid. Again half of previous mixed acids were used and solution consistently agitated till to removal total fumes. While heating continue, a mixture of white gelatinous was produced, then mixture with adding 10 ml water and on further heating, lessened to 2 ml. Again, 10 ml of water were applied and for removing turbidity or suspended matter Whatman No.42 filter was used for filtration. Afterward 2-3 drops HCl were used and finally the volume of solution increased to 50 ml. The whole solutions were kept in polythene bottles. Every sample of tea leaves was prepared in triplicate and three repeat determinations were carried out by the AAS.

RESULTS AND DISCUSSION

The results of seven elements content (Na, K, Cu, Mn, Ni, Cd and Pb) of black tea leaves are presented in Table 1. The results demonstrated that the concentration of elemental contents in tea samples from various regions of north Iran were different. There were wide variation in the amounts of Na, K, Cu, Mn, Ni, Cd and Pb of black tea samples from several agroclimatic regions. In various regions of Iran, the geochemical characteristics of the soil and also the application number and timing of fertilizers and fungicides are different therefore the content of elements are conditional. The elemental contents of tea samples are discussed as follows:

Sodium (N) and Potassium (K)

As shown in Table 1, the wide level concentrations of Na (32.3–74.3 µg/g) were detected in Iranian tea samples. The highest and the lowest level of N were belonged to Lahijan (sample 4) and Rasht (sample 2) region respectively.

However, the K contents in experimental samples varied between 17.3–23.2 mg/g. The highest being farm of Ramsar and the lowest in farm of Siahkal. Wang et al., (1993) were determined the concentrations of Na and K in tea leaves of china in the range of 29.4–78.1 µg/g and 16.9–20.3 mg/g, respectively.

This finding was the range of values observed by other authors for K concentration in tea plans, such as: Marschner, (1995) claimed that more focal elements like K, N, P, Mg and S in tissues of tea plant are portable and moved to young tissues, therefore higher amount of K in tea leaves were reported by this author [16], and also in another research Powell studied on tea leaves and determined a high level of K in tea samples and suggested that it may be specifically incorporated within a binding ligand of the tea leaves. In fact, “both the monovalent non-hydrolytic ions are completely absorbed in the small bowel, being kinetically active and very weakly bound, both to polyelectrolytes in gastrointestinal muscles and tea polyphenols” [8].

Manganese (Mn) and copper (Cu)

The results reported in Table 1, revealed that the level of manganese in black tea was found in the range of 682 and 731 mg kg⁻¹. The Mn content in Shaft (682±8.74) and Siahkal black tea (682±7.51) was the minimum and while Mn level was maximum in Amlash.

According to Kumar et al. (2005) Turkey and Japan tea samples as compare to this study had higher Mn concentration (1100–2678 mg/kg). Mn amount has been certificated average level 1585±40 mg kg⁻¹ in Turkey standards of black tea [3]. Mn level in Japan tea standard was also determined in level 700 ± 25 mg kg⁻¹ by Okamoto and Fuwa (1987) [17]. It was claimed by Dang (2005), that by increasing in plant the element contents raised [18]. AL-Oud (2003) also reported high Mn concentrations (390-900 mg kg⁻¹) in the plants of tea [19]. Heydorn (1988) have reported 2–5 mg of Mn amount in daily intake will be supplied by using up 1-2 cups of tea [20]. Changes of degenerative bone were found in deficiency of Manganese [21].

A perusal of copper level in experimental samples of black tea (Table 1) showed that copper ranged was between 23.43 and 33.60 mg kg⁻¹. Next to Al and Zn, copper is one of the major elements in tea and also is central metal to polyphenol oxidase enzyme. The copper level was detected at minimum level (23.43mg kg⁻¹) in Ramsar tea leaves and at the maximum level (33.60 mg kg⁻¹) in samples of Langerud. Xie et al., (1998) and Ferrara et al., (2001) were reported the Cu content in black tea samples. According to their results lower than 30 mg kg⁻¹ Cu level was found in all samples of black tea [22,23], while according to international standards Cu limit is below of 150 mg kg⁻¹ in United kigdam, India and Kenya [24]. Wang et al. (1993), who found that the Cu content in Chinese tea samples was varied between 9.6 and 20. 9 mg kg⁻¹ [9].

Lead (Pb) and cadmium (Cd)

The concentration of Pb in Siahkal tea leaves was the maximum at 0.43 mg kg⁻¹, although Pb amount was the minimum at 0.20 mg kg⁻¹ in Rasht. After Siahkal the level of pb in Ramsar and Tonkabon samples with 0.37 mg kg⁻¹ and 0.36 mg kg⁻¹ were higher respectively. The higher lead concentration was found in Ramsar and Tonkabon samples. According to Franklin et al., (2005) zinc sulphate is necessary for growing tea plants because deficiency of zinc is greatly discerned on the other hand this compound contaminated with lead. Several sources with lead impurities are phosphatic fertilizers, potassic fertilizers, N–P–K blends, zinc, manganese, boron and magnesium [25]. Semu & Singh claimed that the accumulation of Pb and Cd in tea may be increased by using of copper fungicides and copper oxychloride with heavy metal contamination [26]. Lagerwerff (1972) have been reported that another lead contamination source is minute particles of inorganic Pb mixtures in the atmosphere; therefore fields in the roadside have higher level of pb content [27]. Xie et al., (1998) also repoted 1.42 mg kg⁻¹ Pb content in the samples of Chinese tea leaves [22].

The results of the current study also revealed that the Pb level in all tea samples was less than 10 mg kg⁻¹. This finding is in agreement with the acceptable limit of international standards in United Kingdom, India and Kenya [24].

Fortunately, the concentrations of Cd in the tea leaf samples were below to be determined by the technique used in this research. Although, in several research the content of cadmium in tea samples were different for example: According to AL-Oud, (2003) research the Cd concentration varied between 0-0.18 mg kg⁻¹ [19]. Ferrara et al. (2001) also reported that Cd content in black tea was lower from different tea samples of other countries [23]. According to the research of Mengel and Kirby (1987) rock phosphate is applied annually in tea fields and this compound is a main source that increase Cd amount in tea plants [28]. Concentration of Cd in phosphatic fertilizers and zinc sources were determined in the range 4.9-5.5 mg kg⁻¹ and 11.8–50.9 mg kg⁻¹ respectively by Franklin et al. (2005). It was evident from this study that contaminated phosphatic and zinc fertilizers were the sources of Cd in tea [25].

Nickel (Ni)

The Nickel amount in all the samples of tea was in the range of 2.30 and 3.68 mg kg⁻¹ with the highest value in Lahijan and lowest value in Rodsar. Marcos et al. (1998) determined in the range of 2.89 and 22.6 mg kg⁻¹ nickle in the sample of tea leaves [28]. According to research of Franklin, et al.,(2005) the Nickel amount in commercial phosphatic fertilizers, potassic fertilizers, manganese sources and zinc sources was in the range of 19 to 24 mg kg⁻¹, 2.7 to 16 mg kg⁻¹, 340 to 613 mg kg⁻¹ and 241 to 2,399 mg kg⁻¹ respectively. The important result from this study prove that main source for this heavy metal poisoning is soil with low micro nutrient and fertilizers therefore determining the geochemical characteristics of the tea fields is necessary for contamination of heavy metal [25].

Table 1- Elemental content in black teas from north Iran¹

Region	Elemental contents						
	Na ($\mu\text{g g}^{-1}$)	K (mg g^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	Pb (mg kg^{-1})	Ni (mg kg^{-1})	Cd (mg kg^{-1})
Foman	56.33 \pm 5.51 ^e	18.13 \pm 0.67 ^{ab}	692 \pm 7.64 ^{ab}	28.80 \pm 0.62 ^f	0.30 \pm 0.01 ^{cd}	3.30 \pm 0.02 ^d	ND
Rasht	32.33 \pm 3.51 ^a	21.87 \pm 0.45 ^{ef}	704 \pm 8.54 ^{abc}	29.50 \pm 0.51 ^g	0.20 \pm 0.02 ^a	2.70 \pm 0.06 ^b	ND
Shaft	52.33 \pm 2.52 ^{de}	20.10 \pm 0.75 ^{cd}	682 \pm 8.74 ^a	26.80 \pm 0.57 ^e	0.25 \pm 0.02 ^b	2.67 \pm 0.07 ^b	ND
Lahijan	74.33 \pm 4.04 ^f	18.60 \pm 0.61 ^{ab}	701 \pm 10.15 ^{abc}	29.30 \pm 0.71 ^g	0.33 \pm 0.01 ^{de}	3.68 \pm 0.05 ^e	ND
Siahkal	44.33 \pm 3.79 ^{cd}	17.33 \pm 0.65 ^a	682 \pm 7.51 ^a	32.40 \pm 0.32 ^h	0.43 \pm 0.01 ^f	3.10 \pm 0.05 ^c	ND
Langerud	51.67 \pm 2.52 ^{de}	20.90 \pm 0.46 ^{de}	710 \pm 6.81 ^{bcd}	33.60 \pm 0.54 ⁱ	0.32 \pm 0.02 ^d	2.60 \pm 0.08 ^b	ND
Rudsar	34.00 \pm 3.00 ^{ab}	18.13 \pm 0.35 ^{ab}	715 \pm 5.00 ^{cd}	24.30 \pm 0.43 ^b	0.32 \pm 0.01 ^d	2.30 \pm 0.03 ^a	ND
Amlash	41.67 \pm 2.08 ^{bc}	19.27 \pm 0.55 ^{bc}	731 \pm 6.56 ^d	26.20 \pm 0.35 ^d	0.27 \pm 0.01 ^{bc}	3.20 \pm 0.01 ^{cd}	ND
Ramsar	67.67 \pm 3.21 ^f	23.20 \pm 0.75 ^f	728 \pm 10.41 ^d	23.43 \pm 0.47 ^a	0.37 \pm 0.01 ^e	3.64 \pm 0.08 ^e	ND
Tonekabon	37.50 \pm 2.04 ^{abc}	20.47 \pm 0.55 ^{cde}	712 \pm 12.58 ^{bcd}	25.38 \pm 0.59 ^c	0.36 \pm 0.02 ^e	2.34 \pm 0.01 ^a	ND

¹: Note: The results are represented as Mean \pm SD (n = 3)

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significant difference within column at confidence level of $P < 0.05$.

ND: Not detected

CONCLUSION

A perusal of data in this study showed that contents of element were significant different in tea leaves from regions of north Iran. Results showed that the levels of Na, K, Mn, Ni, Cu and Pb were less than acceptable limit according the international standards and also tea has a large amount of manganese. The level of cadmium in tea leaves from the different region of north Iran was below the detection limit.

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