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Availability of essential elements in Indian and US tea brands

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Abstract

Fifteen different brands of Indian tea leaves and seven US brands of flavoured tea were analysed for Na, K, Mn, Cu and Br by thermal neutron activation analysis (TNAA). Mn was also analysed by spectrophotometric and atomic absorption spectrometry (AAS) methods. In Indian tea, Mn concentration was found to be in the range 371–758 μg/g with a mean concentration of 575 ± 96 μg/g whereas in US tea it was in the range 79–768 μg/g with a mean concentration of 329 ± 231 μg/g. Na and Cu contents were also widely different in tea leaves from India and the USA but K contents were similar in the two tea leaves. Bromine was absent in tea leaves from the USA. Several standard or certified reference materials (SRMs/CRMs), including two tea leaves standards, were also analysed for data validation.

Keywords: Thermal neutron activation analysis; Tea leaves; Essential elements; Manganese; Indian and US tea brands

1. Introduction

Many elements, in trace amounts, play a vital role in metabolic processes and are essential for the general well being of humans. It is now well established that their deficiency or excess may cause disease and/or be deleterious to health (O'Dell & Sunde, 1997). Therefore, determination of trace element composition of foods and related products is essential for understanding their nutritive importance. Fermented dried leaves of the evergreen shrub, *Camellia sinensis*, family *Theaceae*, is called tea, the most common beverage world wide (Jha, Mann, & Balachandran, 1996). It is originally from China and one of the oldest known refreshing beverages. India is the largest producer of tea, though Sri Lanka, China and Japan also produce their own brands. The chemical composition of tea leaves and manufactured tea is very complex and consists of tanning substances, flavonols, alkaloids, proteins and amino acids, enzymes, aroma-forming substances, vitamins, minerals and trace elements (Jha et al., 1996). Several elements, such as Ca, Na, K, Mg and Mn, are present at mg/g level, whereas elements such as Cr, Fe, Co, Ni, Cu, Zn and Cd are present at a few μg/g. Also some rare earth elements have been reported at the ng/g level (Cao, Zhao, Yin, & Li, 1998). Tea leaves have been reported to contain 350–900 μg/g of Mn, an essential element for plants, microorganisms and higher animals, including man. The recommended range of daily dietary intake for an adult is 2–5 mg of Mn. Although intake of tea has good and bad effects, it can be a good Mn provider if one takes a few cups of tea daily (Heydorn, 1988).

The trace elements in food items can be determined by different analytical techniques, such as atomic absorption spectrometry (AAS) (Herber & Stoeppler, 1994), inductively-coupled plasma atomic emission spectrometry (ICP-AES) (Lamble & Hill, 1995; Zhang, Zhang, Zhou, & Wang, 1997), inductively-coupled plasma mass spectrometry (ICP-MS) (Cao et al., 1998), charged particle activation analysis (CPAA), cathode stripping voltammetry (Zhang, Liu, Zhang, & Li, 1996), total reflection X-ray fluorescence (Xie, Von Bohlen, Klockenkoemper, Jian, & Guenther, 1998), EDXRF (Salvador, Lopes, Nascimento, & Zucchi, 2002) and ion chromatography (Lu & Mou, 2000). Thermal neutron activation analysis (TNAA) is one of the most favoured

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techniques for determination of major, minor and trace elements in biological samples of plants as well as living tissues (Iyengar, 1989; Serfor-Armah, Akaho, Nyarko, Kyere, & Oppon-Boachie, 2003). The technique involves irradiation of the sample with thermal neutrons, resulting in the formation of radionuclides whose activity is measured by high resolution gamma ray spectrometry. It has the advantage of being highly sensitive and blank free, with a multielemental and nondestructive character, besides requiring only a small sample size (Landsberger, 1994).

A large variation in the trace element composition of tea leaves has been observed and the results discussed with reference to existing literature values, country of origin and processing methodology (Powell, Burden, & Thompson, 1998). It is reported that, under simulated intestinal conditions, a single serving of tea contributes about 40% of the average daily dietary intake of manganese in a potentially bioavailable form. Wang, Ke, and Yang (1993) determined thirteen elements (Zn, Mn, Ca, Cu, Ni, Al, K, Mg, Cd, Pb, Na, Co and Sc) in Chinese tea by AAS, NAA and ICP-AES. Also, extraction of elements in tea was studied by simulating the common Chinese style. Chute, Weginwar, and Garg (1990) reported Mn concentration of 802 ± 4 and 707 ± 2 μg/g in two Indian brands of tea leaves by a substoichiometric isotope dilution (IDA) method. Dutta and Basu (1997) developed an IDA method for the determination of Mn in tea leaves. Liu, Zhang, Liu, and Wang (1995) determined Mn in Chinese tea leaves by a catalytic kinetic spectrophotometric method. Lu, Lu, Hang, and Wang (1996) determined Se in tea leaves polarographically using a dropping mercury electrode. Jiang, Liu, Zhao, and Mo (1997) determined traces of Fe in tea by a novel photochemical voltammetric method. Liang and Li (2000) reported phosphorus and manganese in tea by microwave plasma torch atomic emission spectroscopy. Lozak, Soltyk, Ostapczuk, and Fijalek (2002) determined several trace elements, including Fe and Co, in tea bags and infusions. Ozdemir and Gucer (1998a, 1998b) determined speciation of Mn in tea leaves and infusions, employing solvent extraction into five fractions: residue, total cationic, total anionic, Mn (II) and organic bound Mn. In a recent study, Matsuura, Hokura, Katsuki, Itoh, and Haraguchi (2001) have used size exclusion chromatography for speciation of major to trace elements in black tea leaves. Okamoto and Fuwa (1987) reported 700 μg/g Mn in Japanese tea leaves and developed a certified reference material (NIES, 1986). Recently, a new Polish standard reference material of tea leaves, INCT-TL-1 has been developed (Dybczanski, 2002).

We have analysed 15 different Indian brands of tea leaves and 7 brands of flavoured tea samples from United States of America for Na, K, Mn, Cu and Br by TNAA. Also, Mn was determined by spectrophotometry and AAS. Measurements were validated by analysing several SRMs/CRMs of plant leaves.

2. Materials and methods

Different brands of tea leaves were procured from the local market. Seven brands of flavoured US tea samples were procured from a store in California, USA. These had their origins in India, Sri Lanka and China including some herbal infusions with flavouring additives. Six standard reference materials were procured from NIST (USA), NIES (Japan) and INCT (Poland). Accurately weighed samples (30–40 mg) of each tea were packed in high-density polythene bags. Elemental standard of Mn was prepared by depositing 25–40 μg of Mn as $KMnO_4$ on to an Al foil and packed. These samples, along with the elemental standard and SRMs, were irradiated for 2 h at a thermal neutron flux of 10^{11} $n\,cm^{-2}\,s^{-1}$ in the APSARA reactor at BARC, Mumbai. Each irradiation batch contained 4 samples and 3 standards. After appropriate cooling for 2 h, γ-activities of activation products were measured by high resolution gamma ray spectrometry, using a 22% relative efficiency HPGe detector (γ-PGT, Princeton Gamma-Tech, Germany) and a PC-based 4k channel analyzer. Its resolution was 1.9 at 1332 keV of ^{60}Co. Peak areas under 1369, 1525, 511, 847 and 554 keV γ-rays of the radionuclides ^{24}Na ($t_{1/2} = 15$ h), ^{42}K ($t_{1/2} = 12.4$ h), ^{64}Cu ($t_{1/2} = 12.7$ h), ^{56}Mn ($t_{1/2} = 2.58$ h) and ^{82}Br ($t_{1/2} = 35.3$ h), respectively, were corrected for decay during counting and dead time losses. These were counted three times for 5, 5 and 15 min at intervals of 2, 5 and 20 h, respectively. The concentrations of Na, K, Mn, Cu and Br were calculated by a comparator method.

For the analysis by AAS and spectrophotometric methods, about 1 g of each sample was accurately weighed and taken in a 100 ml beaker to which 10 ml of a 5:1 mixture of nitric acid and perchloric acid were added and heated up to slurry formation. Then another 5 ml of acid mixture were added dropwise. It was continuously stirred until all the fumes ceased. On further heating, a white gelatinous mass was observed, after which 10 ml of water were added and the contents reduced to 2 ml by heating. Again, 10 ml water were added and the solution was filtered through Whatman No. 42 filter paper to remove any turbidity or suspended matter; 2–3 drops of HCl were added and the solution made up to 50 ml. All the solutions were stored in tightly capped polythene bottles. An atomic absorption spectrophotometer (GBC Avanta, Australia) was used for the analysis of Mn in all the tea samples at 279.5 nm.

Mn was also determined spectrophotometrically using KIO_4 as an oxidant. In this method, Mn^{2+} was oxidised to MnO_4^- in nitric acid and sulphuric acid solution by a slight excess of KIO_4 as per reaction (Christian, 2001).

$$2Mn^{2+} + 5IO_4^- + 3H_2O \rightarrow 2MnO_4^- + 5IO_3^- + 6H^+$$

MnO_4^- absorbs at 525 and 544.5 nm and the pink colour so formed is stable for a long period of time. All absorbances were measured at 525 nm using a Shimadzu model UV-1601 UV–Vis spectrophotometer. A calibration plot was made by using standard solutions of $MnCl_2$ in the concentration range 1–10 μg/g Mn and oxidized in a similar manner. Mn concentrations in tea samples were calculated using the calibration plot. SRMs were also analysed for Mn content by AAS and spectrophotometry.

3. Results and discussion

3.1. General

Analytical data for Na, K, Mn, Cu and Br in six SRMs are given in Table 1. In most cases, our values were within ±10% agreement with those of certified values except in the case of Cu for SRM-1573 and SRM-1575 where the differences were much larger. In the case of copper, we have not corrected for the contribution to 511 keV from higher energy gamma rays, both in samples and standards. In the case of Na, the values will be affected by $^{27}Al(n,\alpha)^{24}Na$ reaction. Since we used a comparator method, corrections were not incorporated essentially because Al content of tea leaves is small (<0.1%) (Lamble & Hill, 1995; Matsuura et al., 2001). Also, the relative standard deviations (RSDs) in all the cases were <10% suggesting precision of our measurements. Mean values of calculated concentrations of Na, K, Cu and Br in fifteen Indian and seven US tea brands are given in Table 2. Standard deviation was calculated on the basis of replicate measurements/multiple countings/counting statistics. Also included in the table are mean values in tea from both the countries, taking into account all the determinations. Mn was also analysed by AAS and spectrophotometric methods and the concentration data in all the Indian and US brands are listed in Table 3. A typical γ-ray spectrum of tea leaves irradiated for two hours and cooled for 2 h is shown in Fig. 1, where photopeaks of ^{24}Na, ^{42}K, ^{56}Mn and ^{82}Br have been identified.

It is known that many organic and inorganic materials can be dissolved from tea leaves during the digestion or percolation process. Therefore, a direct method of INAA is most suitable for the determination of elements to eliminate the matrix interferences compared to AAS and spectrophotometric methods. In view of the good agreement with the certified values and smaller standard deviations for various SRMs/CRMs in Table

Table 1
Comparison of elemental concentrations in SRMs by NAA

SRM	Na (mg/g)	K (mg/g)	Mn (μg/g)	Cu (μg/g)	Br (μg/g)
Citrus leaves (SRM-1572)	0.16 ± 0.02 (0.16 ± 0.02)	19.5 ± 1.3 (18.2 ± 0.6)	21.3 ± 0.8 (23 ± 2)	13.8 ± 1.9 (16.5 ± 1.0)	7.9 ± 1.5 (8.2)
Tomato leaves (SRM-1573)	0.50 ± 0.19 [0.52]	46.7 ± 0.4 (44.6 ± 0.3)	268 ± 15 (238 ± 7)	13.1 ± 3.8 (11 ± 1)	24.4 ± 1.8 (26)
Pine needle (SRM-1575)	0.22 ± 0.08 [0.26]	3.71 ± 0.28 (3.7 ± 0.2)	670 ± 42 (675 ± 15)	5.21 ± 1.0 (3 ± 0.3)	8.3 ± 2.4 (9)
Tea leaves (NIES) Japan	0.015 (0.015 ± 0.001)	17.4 ± 1.3 (18.6 ± 0.7)	725 ± 23 (700 ± 25)	7.3 ± 1.2 (7.0 ± 0.3)	2.86 ± 0.30 (–)
Tobacco leaves (CTA-OTL-1)	0.35 ± 0.01 (0.345)	15.6 ± 0.1 (15.6 ± 0.5)	414 ± 26 (412 ± 14)	14.8 ± 0.8 (14.1 ± 0.5)	8.96 ± 1.07 (9.28 ± 1.06)
Tobacco leaves (CTA-VTL-2)	0.332 ± 0.170 (0.312)	9.97 ± 0.30 (10.3 ± 0.4)	77.0 ± 4.9 (79.7 ± 2.6)	19.8 ± 1.2 (18.2 ± 0.9)	15.3 ± 1.3 (14.3 ± 1.4)

Concentrations in parentheses ( ) are certified and in [ ] are from the literature.

Table 2
Concentrations of Na, K, Cu and Br in tea leaves by NAA

Sample	Na (μg/g)	K (mg/g)	Cu (μg/g)	Br (μg/g)
Indian brands				
Agni tea	27.0 ± 0.7	24.0 ± 1.8	22.5 ± 1.2	9.16 ± 1.21
A-one	21.4 ± 0.2	18.5 ± 1.0	1.60 ± 0.9	–
Green label (Lipton)	118 ± 1	20.0 ± 0.8	20.4 ± 8.0	3.78 ± 0.92
Kesri tea	56.0 ± 0.6	20.1 ± 0.9	8.92 ± 2.60	3.00 ± 0.39
Mohani	52.7 ± 0.8	22.3 ± 0.8	13.5 ± 3.1	3.28 ± 0.44
Rajdhani gold tea	47.2 ± 0.6	19.4 ± 1.4	7.25 ± 2.1	5.96 ± 0.77
Red label (Brooke Bond)	88.0 ± 3.8	21.8 ± 2.3	19.0 ± 1.2	3.98 ± 0.81
Sargam pure city tea	34.6 ± 0.6	22.2 ± 0.8	8.34 ± 1.9	4.85 ± 0.65
Sugandh tea	50.3 ± 0.9	22.4 ± 0.8	11.0 ± 2.6	3.79 ± 0.51
Tajmahal tea	42.7 ± 1.1	23.0 ± 0.8	15.8 ± 0.8	6.71 ± 0.89
Tata tea	95.2 ± 4.7	18.7 ± 0.6	21.8 ± 1.2	4.10 ± 0.92
Tea queen	38.3 ± 0.7	22.8 ± 1.8	35.0 ± 1.9	13.9 ± 1.45
Tez	27.4 ± 0.9	23.6 ± 1.1	17.6 ± 0.8	9.21 ± 1.22
Tea bags				
Tajmahal	62.0 ± 8.9	17.7 ± 1.6	10.5 ± 4.2	2.49 ± 0.41
Twinings	41.7 ± 1.1	20.1 ± 0.7	9.41 ± 2.2	–
Mean ± SD[a]	53.5 ± 27.4	21.1 ± 2.0	14.8 ± 8.2	5.71 ± 3.29
US brands				
Awake (black tea)	796 ± 28	23.7 ± 1.2	12.0 ± 0.5	–
Calm (herbal infusion)	194 ± 4	19.4 ± 1.3	17.0 ± 0.8	–
Earlgrey (scented black tea)	135 ± 2	19.5 ± 1.0	10.4 ± 0.4	–
Passion (herbal infusion)	114 ± 3	13.1 ± 0.6	4.4 ± 0.2	–
Refresh (herbal infusion)	705 ± 21	19.5 ± 1.0	16.1 ± 0.7	–
Tezo Chai (spiced black tea)	174 ± 3	15.8 ± 0.8	8.9 ± 0.3	–
Zen (green tea and herbal infusion)	248 ± 8	15.5 ± 0.8	17.3 ± 0.5	–
Mean ± SD[a]	338 ± 286	18.1 ± 3.5	12.3 ± 4.8	

[a] The quoted SD is the value on the range of elemental concentrations determined in different tea brands.

1, the experimental values of concentrations in tea leaves are reliable. Large variations in concentrations for most of the elements in various brands from the two countries could be attributed to their origin and processing methodology. In this regard, granular tea leaves, powder and tea bags show widely different elemental contents, suggesting the effect of processing methodology. Out of the five elements analysed in this study, two are alkali metals, two are transition elements and Br is a halogen. Their elemental contents are discussed separately.

3.2. Alkali metals

A perusal of data in Table 2 shows that Na content in Indian tea brands is in a wide range 21–118 μg/g, with mean value of 53.5 ± 27.4 μg/g. On the other hand, Na content in US tea brands is in a much wider range, 114–796 μg/g with a mean value of 338 ± 286 μg/g. The much higher Na content in US brands may be partly due to flavouring additives. Three of the US brands are not tea leaves but herbal infusions (Calm, Passion and Refresh, Table 2). However, K contents in Indian and US tea brands are in a narrow range 17.7–24.0 and 13.1–23.7 mg/g with mean contents of 21.1 ± 2.0 and 18.1 ± 3.5 mg/g respectively. Surprisingly, K contents in tea leaves from India and US, as well as in NIES standard tea sample (18.6 ± 0.7 mg/g), are comparable. Wang et al. (1993) reported Na and K contents in the range 29.4–78.1 μg/g and 16.9–20.3 mg/g, respectively, in three Chinese tea samples. Thus, K content in tea leaves is not only higher, by an order of magnitude compared to Na, but is independent of the brand. However, Na content shows large variability. Na and K seem to be inversely correlated as shown in Fig. 2. Powell et al. (1998) have also reported a higher concentration of K 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 (Powell et al., 1998).

3.3. Manganese and copper

The Mn contents in various tea brands, by three different methods, show comparable values (Table 3), though in some cases large differences have been observed. In most of the cases, standard deviations of the mean of three methods are small, suggesting good agreement within the three values by different analytical

Table 3
Comparison of Mn concentrations (μg/g) in Indian and US tea brands by AAS, spectrophotometry and NAA

Tea sample	NAA	AAS	Spectrophotometry	Mean ± SD
Indian brands				
Agni tea	567 ± 18	570	620	586 ± 24
A-one	381 ± 7	625	731	579 ± 146
Green label (Lipton)	343 ± 5	390	380	371 ± 20
Kesri	575 ± 25	568	650	598 ± 37
Mohani	878 ± 35	655	740	758 ± 92
Rajdhani gold tea	700 ± 30	571	527	599 ± 73
Red label (Brooke Bond)	555 ± 63	522	685	587 ± 70
Sargam pure city tea	511 ± 21	490	481	494 ± 13
Sugandh tea	565 ± 38	677	680	641 ± 53
Tajmahal tea	563 ± 32	550	540	551 ± 9
Tata tea	630 ± 38	620	630	627 ± 5
Tea queen	442 ± 12	410	441	431 ± 15
Tez	705 ± 52	603	680	663 ± 43
Tea bags				
Tajmahal	370 ± 42	583	542	498 ± 92
Twinings	685 ± 50	615	612	637 ± 34
Mean ± SD[a]	565 ± 140	563 ± 82	596 ± 107	575 ± 96
US brands (flavoured)				
Awake (black tea)	412 ± 42	347	361	373 ± 28
Calm (herbal infusion)	139 ± 9	122	117	126 ± 9
Earlgrey (scented black tea)	328 ± 39	354	338	340 ± 11
Passion (herbal infusion)	208 ± 12	208	207	208 ± 1
Refresh (herbal infusion)	78 ± 3	80	80	79 ± 1
Tezo chai (spiced black tea)	396 ± 21	466	367	410 ± 42
Zen (green tea and herbal infusion)	756 ± 25	751	797	768 ± 21
Mean ± SD[a]	331 ± 226	332 ± 230	323 ± 239	329 ± 231

[a] The quoted SD values are on the basis of range of Mn values determined in different brands.

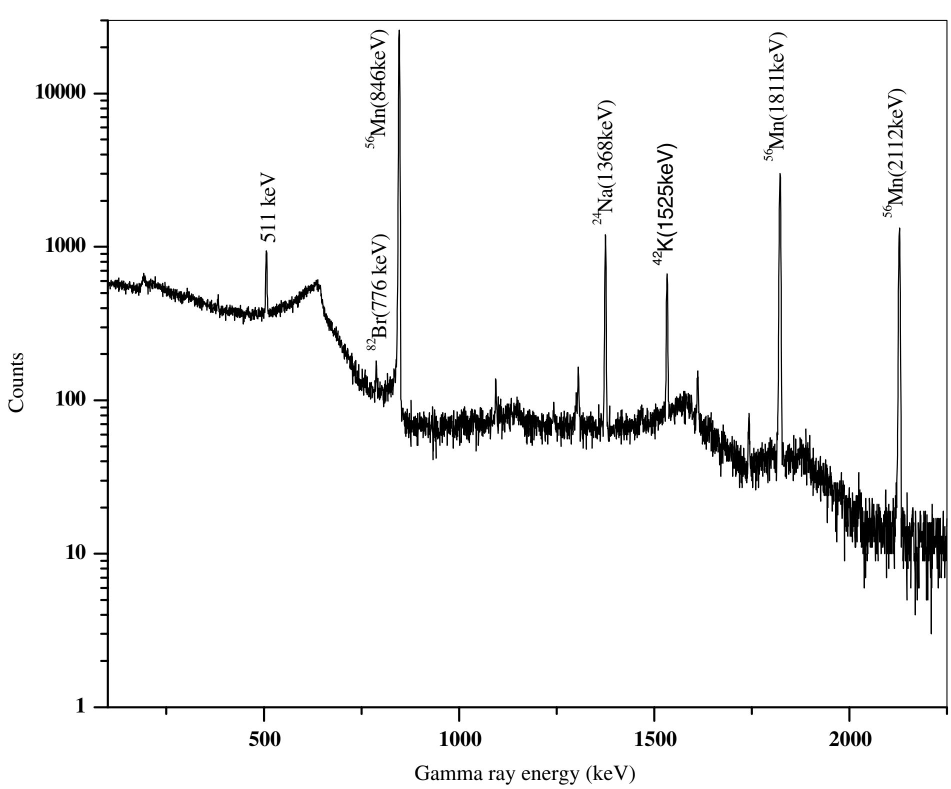

Fig. 1. Gamma ray spectrum of typical tea leaves after a 2 h irradiation.

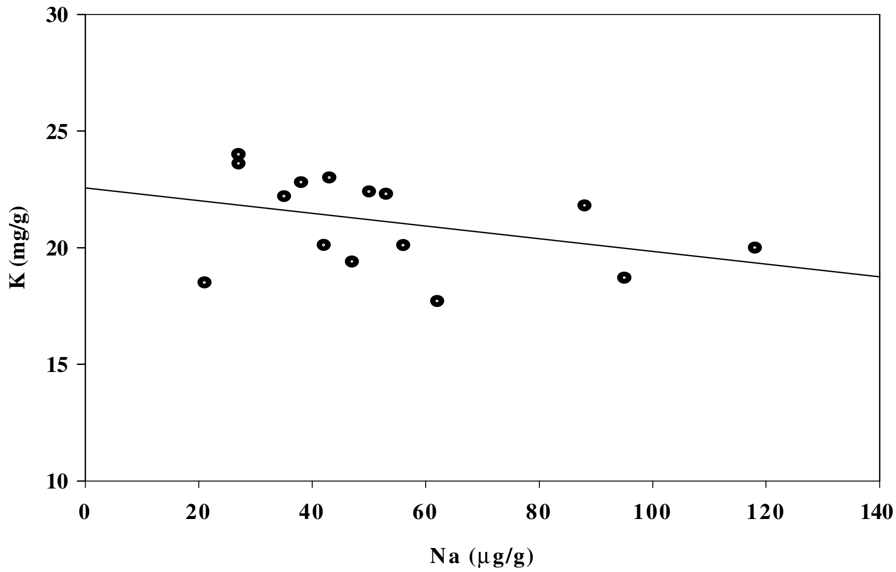

Fig. 2. Correlation of Na and K contents in tea leaves of Indian brands.

methods. It may be noted that, for AAS and spectrophotometric methods, dried tea leaves were dissolved and both the methods were employed on the same aliquots, whereas in the NAA method, a separate aliquot of dried tea leaves was analyzed. Therefore, large differences in analytical data by the three methods, in some cases, may be due to sample inhomogeneity. The tea leaves of US brands analysed in this study were derived from India, Sri Lanka and China, including herbal infusions with several flavouring additives, before being marketed. Therefore, elemental contents in US tea leaves are likely to be altered. Mn concentrations in US tea brands were found in a much wider range with lowest (79 μg/g) and highest (768 μg/g) values for Refresh and Zen brands, respectively. On the other hand, Mn content in various Indian brands is in a much narrow range, 371–758 μg/g, with a mean value of 575 ± 96 μg/g.

Because of its biochemical importance, Mn has been the most analysed element in tea leaves from various countries. A comparison of Mn concentrations in tea leaves from different countries is given in Table 4. It is observed that most tea leaves from various countries have Mn content in the range 300–900 μg/g, except those from Turkey and Japan where much higher Mn contents (1100–2678 μg/g) have been reported. Mn content of a recently developed tea leaves standard, INCT-TL-1 has been found to be much higher 1585 ± 40 μg/g, which, however, is comparable with its certified value of 1570 ± 110 μg/g. However, certified Mn content of another tea SRM from NIES, Japan is 700 ± 25 μg/g (Okamoto & Fuwa, 1987), which is comparable with that of Indian tea. Therefore, it may be presumed that average Mn content of tea leaves is likely to be ~600 μg/g. Matsuura et al. (2001) have suggested Mn to be moderately extracted whereas Powell et al. (1998) have

Table 4
Comparison of Mn contents in tea leaves from various countries

Country	Concentration range (μg/g)	No. of samples analysed	Reference
India	700–800	2	Chute et al. (1990)
	550–730	2	Lamble and Hill (1995)
	371–758	15	This work
China and Taiwan	930–1064	3	Wang et al. (1993)
	370–510	4	Liu et al. (1995)
	730–880	4	Lamble and Hill (1995)
Sri lanka	310	1	Lamble and Hill (1995)
Africa	842	1	Lamble and Hill (1995)
Japan	2678	1	Lamble and Hill (1995)
UK	350–900	1	Powell et al. (1998)
USA	80–770	7	This work
Turkey	1107–2205	5	Ozdemir and Gucer (1998a)
Tea leaves (INCT-TL-1) (Poland)	1570 ± 110	2	Dybcznski (2002)

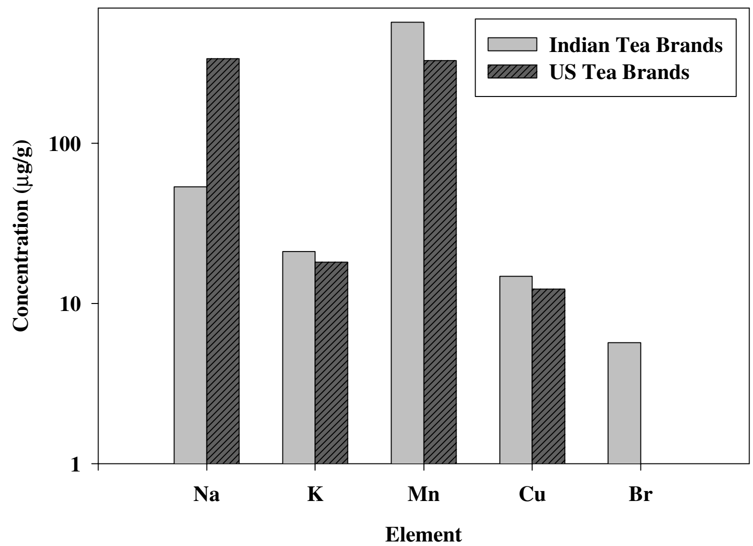

Fig. 3. Comparison of elemental contents in Indian and US tea brands.

found 40% of Mn content in bioavailable form under simulated intestinal conditions. Therefore, considering consumption of a few cups of tea per day, the daily dietary intake of 2–5 mg of Mn may be provided (Heydorn, 1988). Manganese deficiency may cause degenerative bone changes and altered pancreatic function (Hurley & Keen, 1987), although its deficiency in humans is unusual.

Cu contents in Indian and US tea brands are in a large range, 1.60–35.0 and 4.4–17.3 μg/g, with mean values of 14.8 ± 8.2 and 12.3 ± 4.8 μg/g, respectively, which are comparable. However, Cu content in Indian tea brands is in a much wider range compared to that in US brands. Wang et al. (1993) reported Cu content in the range 9.6–20.9 μg/g in three Chinese tea brands. Therefore, our values are comparable.

Br content in Indian tea brands is in the range 2.49–13.9 μg/g, with a mean content of 5.71 ± 3.29 μg/g. However, Br was not detected in US tea brands and two Indian brands (A-One and Twinings, Table 2). Br is reported to be an environmental contaminant (Manahan, 1984). Our earlier studies indicated that certain plant leaves contain Br, which could have been derived from soil (Balaji et al., 2000). It is likely that Indian tea leaves might have become contaminated with Br during processing, whereas processing of US tea leaves might have been carried out in a much cleaner atmosphere.

A histographic comparison of mean elemental contents of Na, K, Mn, Cu and Br in Indian and US tea brands is shown in Fig. 3. It is observed; in general, that Indian tea is rich in mineral contents compared to US brands. Even though US tea is from India, Sri Lanka and China (but possibly due to various flavouring additives and herbal infusions) its mineral contents are lower. Powell et al. (1998) demonstrated that tea is not a rich dietary source of essential metals for humans, except manganese.

4. Conclusion

Fifteen different brands of Indian tea and seven brands of US tea were analysed for Na, K, Mn, Cu and Br by thermal neutron activation analysis. Manganese was also analyzed by spectrophotometry and AAS methods. It was observed that the Na content varies within a large range but K contents were similar in the two types of samples. Mn concentration in Indian tea is 575 ± 96 μg/g compared to 329 ± 231 μg/g in US tea brands. Tea is a rich source of manganese.

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