Elemental Analysis Of Indian Green and Black Tea leaves using Hand Held X-ray Fluorescence Spectrometer

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Abstract

Green and black tea samples available in Indian markets were analyzed for their elemental composition using Hand held X-ray Fluorescence spectrometer. Twenty eight elements were analyzed in the tea leaves. Macronutrients detected in major proportions were K and Ca, while Zn, Fe, Cu, Mn, and Mg were the micronutrients detected in all the samples. Si, P and S were the nonmetals detected in the tea leaves. The samples also showed presence of rare earth metals like Ag, Sr, Rb, Nb and Mo..

Keywords: Green tea, black tea, X-ray fluorescence,Trace elements

Introduction:

Tea leaves are used in many diverse ways, not only as extracts, but also as a constituent of medicines and cosmetics (green tea)(2,3,4,5). Thus, chemical components present in this type of materials have received great interest because they are related to the human's health. Chemical constituents present in plants are responsible for their medicinal as well as toxic properties. These constituents include different organic compounds *e.g.* vitamins, flavonoids, alkaloids *etc.* Trace elements play a very important role in the formation of these compounds. Also, the concentration of certain elements is a good indicator of the origin of samples. Tea turns Darker as it Oxidizes.Hence it is necessary to see tracelements in both green and black tea samples. All plants contain chemical called chlorophyll. In the most basic sense, this is what gives plants their "green" color. As the process of oxidation occurs, chlorophyll breaks down so the color becomes less "green."In the present study a few tea leaves were selected both from green tea category and black tea to understand their differences and also for a comparison.

Experimental

Tea samples were analysed by hand Held X-ray spectrometer (HHXRF). Hand held XRF (HHXRF) is the need of the hour to analyze metals, powders and alloys, as other conventional XRF techniques are found to be cumbersome and difficult to handle. . The tea powders was placed in a cubical box for irradiation by X-ray tube. Rhodium tube was used for irradiation. The spectrum was obtained in 60 seconds. A Typical spectrum of the tea powder is shown in Fig

1. The beam lines were of (Beam 1 from 12 to 36 keV) and Beam 2 from 0-12 KeV).

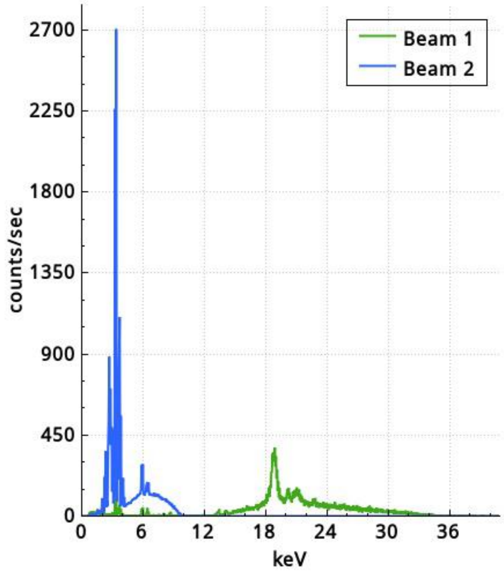

Figure 1: X-ray spectrum of a tea sample (green tea) by HHXRF

Fig 2 gives the X-ray spectrum in a black tea. Figure 3 gives the image of HHXRF instrument

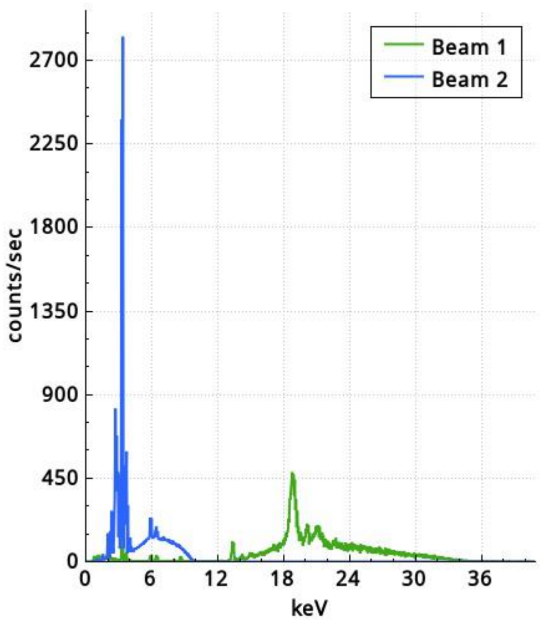

Figure 2: X-ray spectrum of a tea sample (black tea) by HHXRF

Figure 3: Image of HHXRF instrument

Different tea samples in the form of tea bags were procured directly from various distributors in India. Tea samples analyzed were 1) Duncans Double Diamond green tea manufactured by Duncans Tea Limited, Kolkata, India. 2) Koranganigreen tea manufactured by Korangani Tea Co. Pvt. Ltd., Guwahati, Assam, India. 3) Cambridge Tea Party green tea manufactured by Snowlan Epicure Pvt. Ltd., Pune, India. 4) Typhoo green and black tea manufactured by Apeejay Tea Limited, Kolkata, India. 5) Tea-a-me green and black tea manufactured by MadhuJayanti International Pvt. Ltd., Kolkata, India. 6) Octavius black tea manufactured by LMJ International Ltd., Kolkata, India. 7) Tata Agni black tea manufactured by Tata Global Beverages, Bengaluru, India. 8) Brook Bond Red Label black tea manufactured by Hindustan Unilever Limited, India.Each tea sample was dried at 110^{o}C for 3 hours in a vacuum oven to remove moisture content. The dried tea leaves were ground to fine powder using a mortar and pestle and stored in airtight bags till analysis.

Results and discussion

Among the macronutrients the analyzed tea samples showed high amounts of K and Ca. Analysis also revealed presence of metal micronutrients like Mn,Zn,Fe,Cu,Mg and nonmetals like P, Sion and S. Rare earth metals like Ag, Sr, Rb,Nb and Mo were also present in small amounts. Toxic metals like Cd, As and Pb were detected in traces in one or two tea samples only, while Hg was found to be absent in all the samples. Metals like Al, Ti, V, Cr, Co, Ni, Se, and Bi could not be detected in any of the analyzed samples. Results of the elemental analysis have been shown in **Table 1**.

Table 1: Elemental analysis of green and black tea samples using X-ray fluorescence technique

	Element content in ppm															
	K	**Ca**	**P**	**Si**	**Mn**	**S**	**Zn**	**Fe**	**Cu**	**Nb**	**Mo**	**Ag**	**Sr**	**Rb**	**Cd**	**Mg**
Green Tea																
Double Diamond	33800	14060	3020	1870	1398	4759	96	773	59	11	13	30	29	35	15	6700
Korangani	25080	25080	3036	130	615	2689	46	745	23	5	ND	54	21	72	41	8900
Cambridge	27670	7460	3450	490	1846	2968	50	627	16	6	ND	35	21	54	29	ND
Tea-a-me	24670	9630	2499	350	1767	2651	63	462	34	10	5	72	20	21	29	ND
Typhoo	39800	13870	4770	180	1352	4069	123	2590	82	16	ND	60	26	48	ND	ND
Mean content	**30204**	**14020**	**3355**	**604**	**1396**	**3427**	**75.6**	**1039**	**43**	**9.6**	**9**	**50.2**	**23.4**	**46**	**28.5**	**-**
Black Tea																
Tata	29610	9590	2586	750	1776	2749	54	2943	28	13	13	33	33	79	14	5500
Red label	38710	11380	3430	420	2142	3523	70	1386	43	9	10	ND	28	86	27	ND
Octavius	40540	6720	6300	390	1117	4269	124	507	47	11	9	41	22	77	ND	ND
Tea-a-me	39320	11880	3190	990	3340	3071	40	4010	32	6	12	45	27	64	43	ND
Typhoo	29120	5441	4600	700	690	2787	84	594	25	11	7	16	17	99	ND	ND
Mean content	**35460**	**9002**	**4021**	**650**	**1813**	**3280**	**74.4**	**1888**	**35**	**10**	**10.2**	**26.2**	**25.4**	**81**	**28**	**-**

Black tea samples showed about 5000 ppm more average K content as compared to green tea samples. However, content of Ca showed an opposite trend. Green tea samples showed almost 5000 ppm higher average Ca content than black tea samples.Zn metal was almost similar in the samples. Cu content was slightly higher in green tea samples than in black tea samples. Average Fe content was higher in black tea samples than green tea samples by almost 800 ppm. Tea-a me showed highest Fe content with about 4010 ppm, followed by Tata tea at 2943 ppm, both of which are black tea samples. A similar trend was observed in case of Mn content where black samples showed an average 400 ppm more concentration than the green tea samples. Tea-a-me once again showed maximum Mn content at 3340 ppm among all tea samples, followed by Red Label at 2142 ppm. Only three tea samples Double Diamond and Korangani among green tea samples and Tata among the black tea samples exhibited the presence of Mg.

Among the rare earth metals the green tea samples showed higher Ag content in green tea samples, the precious metal being almost double the concentration than that in the black tea samples. The metal was not detected in the Red Label tea sample. Differences in Mo was very distinct among the tea samples analyzed. Double Diamond and Tea-a-me showed some traces, whereas all five black tea samples showed presence of Mo metal in comparable amounts. The average Nb content was similar among green tea and black tea samples, the highest being observed in Typhoo green tea sample. Black tea samples showed almost twice the Rb content than green tea samples, with Typhoo showing highest and Tea-a-me showing the least content of the alkali metal. Average Sr contents in black and green tea samples were similar with minor differences among all ten samples.

Octavius showed the highest P content, making the average content of this metabolically important non metal in black tea almost 650 ppm higher than the green tea samples. Average Si content was higher in black tea samples than the green tea samples. However it was the silicon content in the green tea Double Diamond which was very high as compared to all other samples taken in this study. Average sulphur content in green tea was just about 200 ppm higher than the black tea samples, indicating no significant difference among the two types of tea.

Among the toxic metals the average Cd content was comparable among the green tea and black tea samples. Octavius and Typhoo did not contain detectable cadmium content on analysis. As was detected only in Double Diamond green tea. Two green tea samples Cambridge and Typhoo showed traces of Sn metal, which was not detected in any of the black tea samples. On the contrary Pb content was detected in two black tea samples Tata and Octavius, but absent in all green tea samples.

A comparison of green and black tea samples of the same brand also yielded variations. Green tea sample of Typhoo showed higher K, Ca, Zn, Fe, Cu, P, Mn, S, Sr, Nb and Ag contents than the black tea sample of the same brand. However the black tea sample showed higher Si, Rb and Mo content than the green tea sample. In case of Tea-a-me elements K, Ca, Fe, Mo, Sr, S, P, Si, Rb and Ca were found to be higher in black tea sample than in green tea sample, whereas Ag, Zn, Nb, Mn and Cu contents were higher in the green tea sample than in the black tea sample.

Zn is an essential cofactor in a number of enzymes responsible for growth and metabolism in the body. It helps in cell division, synthesis of DNA and protein, as well as for production of insulin.
Iron is in important component of haemoglobin and myoglobin, both responsible for transfer of oxygen in the body. It is required for synthesis if hormones, cell functions and growth.
Cu is an integral part of number of enzymes such as cytochrome oxidase, peroxidase, lactase, catalase, superoxide dismutase and ascorbic acid oxidase. It also helps in absorption of Fe metal from food. It helps in formation of myelin sheath in nerves and in bone formation.
Mn plays an important role in absorption of Ca, regulation of blood sugar, and metabolism of carbohydrate and fat in body. It helps in formation of bones, clotting of blood and synthesis of sex hormones. It is also an important cofactor for enzymes in redox reactions involving free radicals. (Falah and Mohssan, 2017)

The observed differences in the concentrations of some elements in the tested teas were attributed to the following factors: preferential absorbability by particular kinds of the tea plant for selected elements; age of the plant; mineral composition of the soil, in which the plant grows; season, when the samples were collected; climatic conditions. Hence, there is an interest in monitoring the content of major, minor, and trace elements present in the extracts from tea leaves. We have shown that HHXRF is a powerful analytical tool and can serve well for multi-elemental analysis of tea leaves. The data obtained in this study should prelude a detailed multielemental analysis of tea extracts. Although metals and other elements are present in beverages at generally low concentrations, they may significantly contribute to their dietary intake because of the potentially large quantities of the consumed infusions.

Conclusion:

It is seen that the trace elements present in the tea leaves are mostly useful for the human consumption and it is safe to drink green as well as black tea . HHXRF provides a convenient technique to analyze tracelemnts in Tea samples requiring no cumbersome sample preparation.

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