International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:6, No:11, 2012

Cr, Fe and Se Contents of the Turkish Black and Green Teas and the Effect of Lemon Addition

E. Moroydor Derun, A. S. Kipcak, O. Dere Ozdemir, and M. B. Piskin

***Abstract*—**Tea is consumed by a big part of the world's population. It has an enormous importance for the Turkish culture. Nearly it is brewed every morning and evening at the all houses. Also it is consumed with lemon wedge. Habitual drinking of tea infusions may significantly contribute to daily dietary requirements of elements.

Different instrumental techniques are used for determination of these elements. But atomic and mass spectroscopic methods are preferred most. In these study chromium, iron and selenium contents after the hot water brewing of black and green tea were determined by Optical Emission Spectroscopy (ICP-OES). Furthermore, effect of lemon addition on chromium, iron and selenium concentration tea infusions is investigated.

Results of the investigation showed that concentration of chromium, iron and selenium increased in black tea with lemon addition. On the other hand only selenium is increased with lemon addition in green tea. And iron concentration is not detected in green tea but its concentration is determined as 1.420 ppm after lemon addition.

***Keywords*—**Black tea, green tea, ICP-OES, lemon

I. Introduction

TEA is the agricultural product of the leaves, leaf buds, and internodes of the Camellia sinensis plant, prepared and cured by various methods. (Fig. 1 (a)). There are at least six varieties of tea: white, yellow, green, oolong, black, and pu-erh. The three most popular types of tea (green, oolong, and black) are distinguished on the basis of degree of fermentation [1]. To produce green tea, freshly harvested leaves are immediately steamed to prevent fermentation, yielding a dry product. The steaming process destroys the enzymes responsible for breaking down the colour pigments in the leaves and allows tea to maintain its green colour during the subsequent rolling and drying process.

Black tea is generally processed by a fermentation method that allows for effective action of polyphenol oxidase enzymes and this process causes the leaves to blacken. Drying is applied to stop the oxidation process thereby resulting in a long-lasting, stable tea product [2]. Lemon wedge or lemon juice addition to tea is very widely used in Turkey. Therefore the affect of lemon addition was investigated by other researchers for different kind of teas [3].

Fig. 1 (a) Black tea [4], (b) green tea [5], (c) Turkish tea serving [6]

Chromium is known to enhance the action of insulin, a hormone critical to the metabolism and storage of carbohydrate, fat, and protein in the body. Chromium is widely distributed in the food supply, but most foods provide only small amounts such as less than 2 ppm per serving. Meat and whole-grain products, as well as some fruits, vegetables, and spices are relatively good sources. In contrast, food high in simple sugars such as sucrose and fructose are low in chromium [7].

Iron, one of the most abundant metal on Earth, is essential to most life forms and to normal human physiology. Iron is an integral part of many proteins and enzymes that maintain good health. In human metabolism, iron is an essential component of proteins involved in oxygen transport. It is also essential for the regulation of cell growth and differentiation. A deficiency of iron limits oxygen delivery to cells, resulting in fatigue, poor work performance, and decreased immunity. On the other hand, excess amounts of iron can result in toxicity and even death [8].

Selenium is a trace mineral that is essential to good health but required only in small amounts. Selenium is incorporated into proteins to make selenoproteins, which are important antioxidant enzymes. The antioxidant properties of selenoproteins help prevent cellular damage from free radicals. Free radicals are natural by-products of oxygen metabolism that may contribute to the development of chronic

A. S. Kipcak, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834751; fax: 0090-212-3834725; e-mail: skipcak@ yildiz.edu.tr / seyhunkipcak@gmail.com).

O. Dere Ozdemir, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (e-mail: odere@ yildiz.edu.tr).

E. Moroydor Derun, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (e-mail: moroydor@yildiz.edu.tr / moroydor@gmail.com).

M. B. Piskin, is with the Yildiz Technical University, Department of Bioengineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (e-mail: meburp@hotmail.com).

diseases such as cancer and heart disease. Other selenoproteins help regulate thyroid function and play a role in the immune system [9].

The aim of this study is to investigate Cr, Fe and Se concentration in Turkish black and green teas. The secondary aim is to determinate this element concentrations in teas with lemon addition.

II. Experimental Methods

A. Preparation and Hot Water Brewing of Teas

Black tea and green tea are purchased from the local market in Istanbul, Turkey. Tea solutions are prepared by the brewing method of infusion. The brewing method of infusion is used according to the ISO standarts numbered 3103.

Teas, which are black and green, are purchased from the Local market in Istanbul, Turkey. For the experiments ISO standarts numbered 3103 is used for the hot water brewing process in which 50 mL of hot water (90-100°C) was poured to 2 grams of tea in the beaker and stirred. After the 6 minutes, the extract was filtered into a 100 mL volumetric flask and filled up to volume of 100 ml with pure water. The brewing process is shown in Fig. 1 [10]-[12].

For the lemon added experiment, lemon is squeezed (pH~4) then lemon juice is added to teas with 1:6 ratio at the instance of Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) experiments 15 minutes prior to measurements. Also used lemons are purchased from local market in Istanbul, Turkey too.

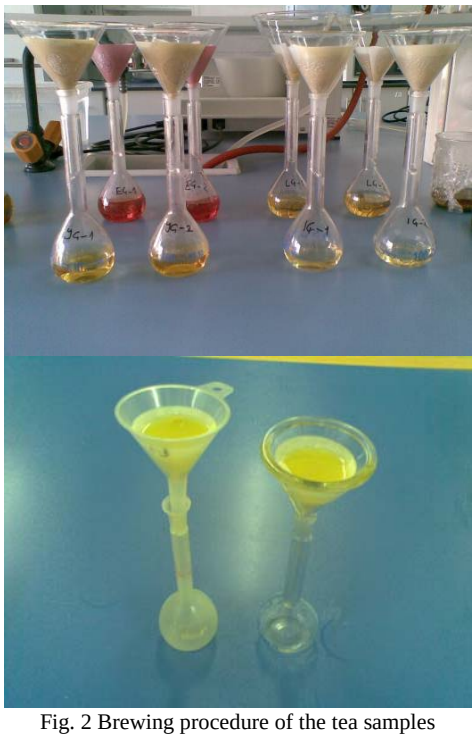

Fig. 2 Brewing procedure of the tea samples

B. Calibration Sets Set-up and Elemental Analysis of the Tea Samples

Calibration sets are set-up by using Cr, Fe and Se standard solutions [12].

In the technique of ICP-OES, samples are subjected to high temperatures that cause excitation and/or ionization of the sample of atoms. These excited and ionized atoms are then decayed to a lower energy state through the emission. The intensity of the light emitted at a specific wavelength to the element of interest is measured [13].

Perkin-Elmer Optima 2100 DV model Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) equipped with an AS-93 autosampler was used in the experiments (Fig. 3). Measured sample images are given in Fig. 4.

Fig. 3 Perkin-Elmer Optima 2100 DV, ICP-OES

Fig. 4 Measured tea samples

Measurement conditions were adjusted to a power of 1.45 kW, plasma flow of 15.0 L min^{-1}, auxiliary flow of 0.8 L min^{-1} and nebulizer flow of 1 L min^{-1}.

III. Results

A. Calibration Set Results

Calibration results are given in Table I. From the results, it can be seen that the coefficient of determination (R^2) values fit with the linear regression.

TABLE I
Calibration Results

Element	Slope	Intercept	R^2
Cr	$4.013x10^6$	$-2.442x10^3$	0.9997
Fe	$8.422x10^5$	$-4.510x10^3$	0.9997
Se	$1.325x10^4$	-11.5	0.9995

B. Element Contents of the Teas and Lemon Addition Effect

Chromium (Cr), iron (Fe) and selenium (Se) contents and lemon addition effects of the black and green teas are shown in Fig. 5 through Fig. 7 and Table II respectively.

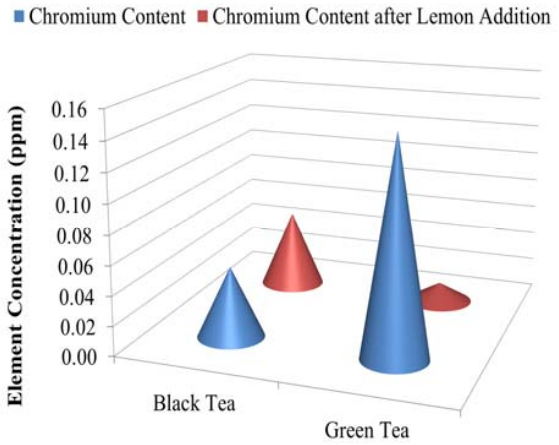

Fig. 5 Chromium contents of the brewed tea samples

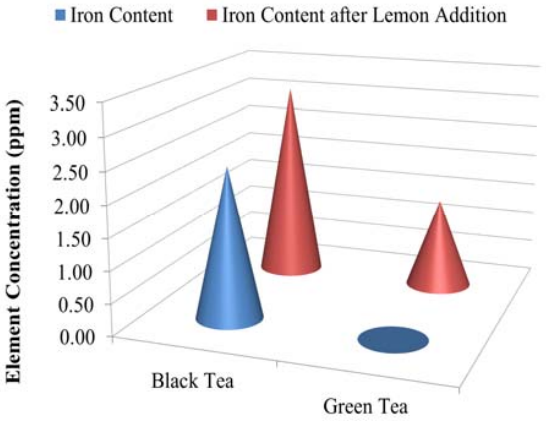

Fig. 6 Iron contents of the brewed tea samples

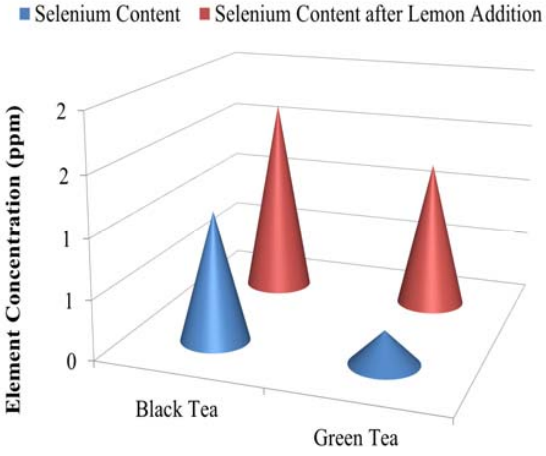

Fig. 7 Selenium contents of the brewed tea samples

TABLE II
ELEMENT CONTENTS OF THE TEAS AND LEMON ADDED TEAS

Tea Type	Element	Concentration (ppm)	Lemon Added Concentration (ppm)
Black Tea	Cr	0.048 ± 0.004	0.053 ± 0.001
	Fe	2.396 ± 0.040	3.114 ± 0.264
	Se	1.093 ± 0.045	1.668 ± 0.279
Green Tea	Cr	0.148 ± 0.009	0.013 ± 0.001
	Fe	-*	1.420 ± 0.025
	Se	0.280 ± 0.001	1.250 ± 0.134

* Out of the detection limit of ICP-OES

It is seen in the results that the maximum element concentrations in the black and green teas are iron and selenium, respectively. Lemon addition increased all the element concentration in the black teas, on the contrary in green teas chromium concentration is decreased despite the increasing iron and selenium. The change in percentage of concentration in the teas are calculated and given in Table III. In green tea the iron element is beyond the detection limit of ICP-OES.

TABLE III
ELEMENT CONTENTS CHANGES OF THE TEAS AFTER LEMON ADDITION

Tea Type	Element	Change in Concentration (%)
Black Tea	Cr	~ 10.4
	Fe	~ 29.9
	Se	~ 52.7
Green Tea	Cr	~ -91.2
	Fe	-
	Se	~ 346.4

In black and green tea selenium element is increased by 52.7% and 346.4%, respectively by the lemon addition. In green teas the chromium content is decreased by the lemon addition with a value of 91.2%.

IV. Discussion and Conclusion

Daily adequate intake for human is given in Table IV.

TABLE IV
ADEQUATE INTAKE FOR HUMAN [7-9]

Daily consumption (ppm)	Cr	Fe	Se
0-6 months	0.2	270	15
7-12 months	5.5	11000	20
1-3 years	11	7000	20
4-8 years	15	10000	30
9-13 years	21-25	8000	40
14-18 years	24-35	11000	55
19-50 years	25-35	8000-18000	55
> 50 years	20-30	8000	55
Pregnancy	29-30	27000	60
Lactation	44-45	9000-10000	70

According to the literature iron is the most required element for human body according to these three elements. Then selenium and chromium follows. Chromium and selenium adequate intakes are increasing from infantry to an age 50.

But iron element intake is changing from age to age and at the pregnancy iron elements adequate intake is at a maximum value of 27000 ppm daily.

Assuming that a person who drinks one cup of black tea and green tea and one tea bag weights two grams, the element concentrations are recalculated and listed in Table V.

TABLE V
ELEMENT CONTENTS IN ONE BAG OF TEA (~2 GRAMS)

Tea Type	Element	Pure Concentration (ppm)	Lemon Added Concentration (ppm)
Black Tea	Cr	$9.60x10^{-5} \pm 8.49x10^{-6}$	$1.06x10^{-4} \pm 2.83x10^{-6}$
	Fe	$4.79x10^{-3} \pm 8.06x10^{-5}$	$6.23x10^{-3} \pm 5.28x10^{-4}$
	Se	$2.19x10^{-3} \pm 8.91x10^{-5}$	$3.34x10^{-3} \pm 5.57x10^{-4}$
Green Tea	Cr	$2.96x10^{-4} \pm 8.49x10^{-6}$	$2.60x10^{-5} \pm 2.83x10^{-6}$
	Fe	-	$2.84x10^{-3} \pm 4.95x10^{-5}$
	Se	$5.60x10^{-4} \pm 2.83x10^{-6}$	$2.50x10^{-3} \pm 2.69x10^{-4}$

Also it can be assumed that for a person who is addicted to tea, can be drink ten cups of tea daily. According to this chromium, iron and selenium element concentrations are recalculated for ten bags of tea and listed in Table VI.

TABLE VI
TEA ADDICTED PERSON DAILY ELEMENT INTAKE FROM TEA

Tea Type	Element	Pure Concentration (ppm)	Lemon Added Concentration (ppm)
Black Tea	Cr	$9.60x10^{-4} \pm 8.49x10^{-5}$	$1.06x10^{-3} \pm 2.83x10^{-5}$
	Fe	$4.79x10^{-2} \pm 8.06x10^{-4}$	$6.23x10^{-2} \pm 5.28x10^{-3}$
	Se	$2.19x10^{-2} \pm 8.91x10^{-4}$	$3.34x10^{-2} \pm 5.57x10^{-2}$
Green Tea	Cr	$2.96x10^{-3} \pm 8.49x10^{-5}$	$2.60x10^{-4} \pm 2.83x10^{-5}$
	Fe	-	$2.84x10^{-2} \pm 4.95x10^{-4}$
	Se	$5.60x10^{-3} \pm 2.83x10^{-5}$	$2.50x10^{-2} \pm 2.69x10^{-3}$

According to the Table IV and Table VI, tea addicted adult daily tea dietary percentages are calculated and shown in Table VII.

TABLE VII
TEA ADDICTED ADULT DAILY (19-50 YEARS) TEA DIETARY

Tea Type	Element	Pure (%)	Lemon Added (%)
Black Tea	Cr	$2.7x10^{-3} – 3.8x10^{-3}$	$3.0x10^{-3} – 4.2x10^{-3}$
	Fe	$2.7x10^{-4} – 6.0x10^{-4}$	$3.5x10^{-4} – 7.8x10^{-4}$
	Se	$4.0x10^{-2}$	$6.1x10^{-2}$
Green Tea	Cr	$8.5x10^{-3} – 1.2x10^{-2}$	$7.0x10^{-4} – 1.0x10^{-3}$
	Fe	-	$1.6x10^{-4} – 3.6x10^{-4}$
	Se	$1.0x10^{-2}$	$4.5x10^{-2}$

As a conclusion it is seen that the chromium, iron and selenium concentrations are much more lower than the required daily allowance, even if a person is tea addicted or not.

Lemon addition increased the chromium, iron and selenium contents in the black teas but in the green tea chromium is decreased and iron and selenium is increased.

As can be seen that both two types of teas and does not reach the maximum daily dosage of the elements but the element concentrations should be considered at other drinks or foods consumed daily.

ACKNOWLEDGMENT

We would like to thank Prof.Dr. Sabriye Piskin for her great contribution to our study.

REFERENCES

[1] L. K. Mandiwana, N. Panichev, S. Panicheva, "Determination of chromium (VI) in black, green and herbal teas", Food Chem. Vol. 129, pp. 1839-1843, 2011.
[2] D. Desideri, M.A. Meli, C. Roselli, L. Feduzi, "Polarized X ray fluorescence spectrometer (EDPXRF) for the determination of essential and non essential elements in tea", Microchemical Journal, Vol. 98, pp. 186–189, 2011.
[3] B. Kralj, I. Krizaj,P. Bukovec, S. Slejko, R. Milacic, "Speciation of alumimium in tea infusions by use of SEC and FPLC with ICP-OES and ES-MS-MS detection", Anal. Bioanal Chem. , Vol. 383, pp. 467-475, 2005.
[4] http://www.equiteas.com/index.php?main_page=index&cPath=1 retrieved on 10.05.2012
[5] http://www.teacuppa.com/Bai-Pian-Green-Tea.asp retrieved on 10.05.2012
[6] http://173.192.107.190/~anjam/gabispics/turkishtea.html retrieved on 10.05.2012.
[7] http://ods.od.nih.gov/factsheets/Chromium-HealthProfessional/ retrieved on 10.05.2012
[8] http://ods.od.nih.gov/factsheets/Iron-HealthProfessional/ retrieved on 10.05.2012.
[9] http://ods.od.nih.gov/factsheets/Selenium-HealthProfessional/ retrieved on 10.05.2012.
[10] A. Krejcova, T. Cernohorsky, "The determination of boron in tea and coffee by ICP–AES method", *Food Chem*, vol. 82, pp. 303–308, August 2003.
[11] A. S. Kipcak, O. Dere Ozdemir, S. Hafizoglu, E. Moroydor Derun, M. B. Piskin, "Determination of some essential element concentrations in turkish teas", in *Proc. Abstract Index Book, 12th Mediterranean Congress in Chemical Engineering*, Barcelona, Spain, November 2011, pp. 58, poster 23_015_P.
[12] O. D. Ozdemir, A.S. Kipcak, E. M. Derun, N. Tugrul, M. B. Piskin, "The analysis of the boron amounts in coffees by the method of ICP-OES", *International Review of Chemical Engineering Rapid Communications (IRECHE)*, Issue 2, Vol. 2, pp. 326-328, March 2010.
[13] C. Zhang, "Fundamentals of environmental sampling and analysis", Wiley-Interscience, 2007, pp.221.

Emek Moroydor Derun was born in Istanbul in 1976. Moroydor Derun graduated from B.Sc. in 1998, M.Sc. in 2000 and Ph. D. in 2005 from Chemical Engineering Department at Yildiz Technical University, Istanbul. She has been assistant professor since 2006.
Her research interest is in the area of waste management, lightweight concrete, semi conductive materials, boron technology and food technologies especially in teas and coffees. She has many articles and studies in international and national conference proceedings and articles.

Azmi Seyhun Kipcak was born in 1980 Istanbul, Turkey. He was graduated from Department of Chemical Engineering in Ege University in 2002. After completing the university studies he graduated from Bilgi University from the department of Master of Business Administration in 2004. He worked in Kultur University from 2003 to 2007 as a research assistant then he transferred to Yildiz Technical University at 2008, where he started his M.Sc. studies about Chemical Engineering in 2006. He completed his M.Sc. studies at Yildiz Technical University in 2009 and started to Ph.D. studies at the same year. He has been research assistant since 2008. He studied on neutron shielding with boron

minerals and the characterization of boron minerals by using XRD, XRF, FT-IR, Raman, DTA/TG, DSC and ICP-OES at the graduate studies now he is studying on the synthesis of magnesium borates from different raw materials and wastes. Also he is improving the neutron shielding studies with the synthesized materials and working on the element analysis of Turkish Teas and Coffees. Another research field about the studies is the fly ash characterization.

Ozgul Dere Ozdemir was born in Canakkale in 1982. Ozdemir graduated B.Sc. and M.Sc. in Chemical Eng. Department at Yildiz Technical University, Istanbul. She has been research assistant since 2006.

Her research interest is in the area of waste management, material characterization, chemical technologies and food technologies especially in teas and coffees.

Mehmet Burcin Piskin was born in Istanbul in 1976. Piskin graduated from B.Sc. in Department of Metallurgical and Materials Engineering, both M.Sc. and Ph.D. in Chemical Engineering Department at Yildiz Technical University, Istanbul.

His research interest is in the area of waste management, semi conductive materials, boron technology and food technologies especially in teas and coffees. He has many articles and studies in international and national conference proceedings and articles.