International Journal of Chemical, Materials and Biomolecular Sciences
ISSN: 2415-6620
Vol:10, No:1, 2016

Determination of the Element Contents in Turkish Coffee and Effect of Sugar Addition

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***Abstract*—**Coffee is a widely consumed beverage with many components such as caffeine, flavonoids, phenolic compounds, and minerals. Coffee consumption continues to increase due to its physiological effects, its pleasant taste, and aroma. Robusta and Arabica are two basic types of coffee beans. The coffee bean used for Turkish coffee is Arabica. There are many elements in the structure of coffee and have various effect on human health such as Sodium (Na), Boron (B), Magnesium (Mg) and Iron (Fe). In this study, the amounts of Mg, Na, Fe, and B contents in Turkish coffee are determined and effect of sugar addition is investigated for conscious consumption. The analysis of the contents of coffees was determined by using inductively coupled plasma optical emission spectrometry (ICP-OES). From the results of the experiments the Mg, Na, Fe and B contents of Turkish coffee after sugar addition were found as 19.83, 1.04, 0.02, 0.21 ppm, while without using sugar these concentrations were found 21.46, 0.81, 0.008 and 0.16 ppm. In addition, element contents were calculated for 1, 3 and 5 cups of coffee in order to investigate the health effects.

***Keywords*—**Health effect, ICP-OES, sugar, Turkish coffee.

I. Introduction

COFFEE is one of the most popular drinks in the world. It is obvious that coffee is commercially and socially important [1]. Coffee is an agricultural product that plays an important role in the international trade [2]. The word Coffee has originated from the Arabic word Quahweh. Today its popularity is identified by various terms in several countries such as café (French), caffe (Italian), kaffee (German), koffie (Dutch) and coffee [3].

Consumption of coffee continues to increase because of its physiological effects, pleasant taste, and aroma [1]. It is suggested by recent researches that drinking two to four cups of coffee per day provides a number of health benefits like decrease of mortality risk, colorectal cancer development, hepatic injury and cirrhosis, degenerative, progressive and chronic diseases such as Alzheimer's and Parkinson's disease, type 2 diabetes and coronary heart disease [4].

The coffee plant belongs to the family Rubiaceae and genera Coffea. It is usually a woody perennial tree which grows at higher altitudes [5]. In the food industry, fruits (berries), which are some parts of the coffee plant, are used for the production of coffee [6]. A typical coffee plant can be seen in Fig. 1. 70 different species of genera Coffea are being reported but most important are *Coffea arabica* (arabica coffee) and *Coffea canephora* (robusta coffee). These two varieties differ in their taste, appearance, and between caffeine contents. A hedonic trend of consumers falls in favor of Arabica coffee as compared to Robusta coffee [5].

Fig. 1 Coffee Plant

The type of coffee bean used for Turkish coffee is *Coffea arabica*. Ground beans are pounded to the finest possible powder. These are finer than the beans in any other way of preparation. Grinding of the beans is either done by using a burr mill or by pounding in a mortar, which is the original method [7]. In Turkey, the cultural behavior of Turkish coffee consumption comes from Ottoman Empire and it has been consumed by every day by people [8].

Chemical composition of coffee, namely the presence of essential, non-essential, and toxic elements, has to be known because of its habitual consumption. These elements have to be kept under control in terms of its safety and to assist its quality, nutritional value, and certain sensorial properties [6]. Turkish coffee contains various elements such as Na, B, Mg, Fe, Ca, and K. These elements have various effects on human health such as Na helps to regulate the body's water balance. [3], [9]. Mg is a cofactor for enzyme systems [10]-[12]. Fe is important for normal human physiology and for most life forms [13] and Boron (B) is consumed by oral intake of food and drinking water [8].

Although limited information is available on the levels of trace element contents in coffee beans of different origins in the literature, a number of studies with different analytical techniques have been carried out to determine the level of minerals (major, minor and toxic metals) in green (raw) and

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roasted coffee types in different parts of the world (such as Brazil, Nigeria, India, etc.) [14].

There are various studies about element contents of coffees. Grembecka et al. [1] determined 14 elements (Ca, Mg, K, Na, P, Co, Mn, Fe, Cr, Ni, Zn, Cu, Cd, Pb) in coffee. Oliveira et al. [4] studied on soluble powdered instant coffees. Ozdestan [7] investigate the profile and levels of bioactive amines (polyamines and biogenic amines), the levels of five minerals (Mg, Mn, Zn, Na, K), total dry matter content, total ash content, pH values in ground and brewed Turkish coffees.

In [15], coffee and tea elements are determined by using inductively coupled plasma optical emission spectrometry (ICP-OES) method. In most of the studies ICP-OES has been used as the analytical technique. The reasons for using ICP-OES as the analytical technique are its multi-element capability, its good sensitivity, wide linear dynamic range, relatively high freedom from non-spectral interferences and its precision. Therefore, ICP OES could offer considerable advantages for the quantitative analysis of food and has been applied repeatedly for the analysis of coffee [16].

The purpose of this study is to determine the content of Na, B, Mg and Fe of the Turkish coffee sold in Turkey. Also in this study the element concentrations after the sugar added Turkish coffee are investigated for the health effects and compared with the element concentrations of pure infusions. As an addition, the element concentrations of Turkish coffee without sugar and with sugar, intake percentage for humans between the ages of 19-50 in one, two and five cups of coffee are given and discussed for conscious consumption.

II. Experimental

A. Preparation and Infusion of the Coffee Samples

Turkish coffees were purchased from the local market in Istanbul, Turkey (Fig. 2).

Fig. 2 Coffee Samples

Infusions of coffees are prepared by brewing method according to ISO 3103 [17]. In this method, 2 g of coffee which is the average value in a cup of coffee, was weighed and brewed with 100 mL distilled water. In the sugar added experiments, 2,61 g of sugar which is the average sugar amount in a cup of coffee consumed, was weighed and added into the coffee.

After the brewing, the infusions were filtered through Macherey-Nagel blue ribbon filter paper. Filtered coffees are shown in Fig. 3.

B. Preparation of the Calibration Sets and Elemental Analysis of the Coffee Samples

Calibration sets conducted by using Na, B, Mg, Fe and Ca standard solutions.

ICP-OES is one of the most powerful and popular analytical tools for the determination of trace elements in a myriad of sample types. In ICP-OES technique, the sample is subjected to enough high temperatures for causing excitation and/or ionization of the sample of atoms [18]. It has high sensitivity for detecting the major trace elements [19].

Perkin-Elmer Optima 2100 DV model ICP-OES equipped with an AS-93 auto sampler was used in the experiments (Fig. 4).

Fig. 3 Filtered coffees

Fig. 4 Perkin-Elmer Optima 2100 DV, ICP-OES

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}.

C. Daily Element Intakes for Human Body

The addicted person consumes daily at least 5 cup coffees

(1 cup is equal to 100 ml). The intake of Mg, Na, B and Fe elements from 5 cups is calculated with (1).

$$m(mg) = C\left(\frac{mg}{l}\right) \times \frac{l}{1000ml} \times 100ml \times 5 \quad (1)$$

where ‘m’ is the element contents of five cups of tea, “C” is the element concentration.

Daily essential element requirements for human body in 19-50 ages for both of men and women, in Mg; maximum 420 mg day^{-1} for men and maximum 320 mg day^{-1} for women, in Na; maximum 1500 mg day^{-1} for both of men and women, in B; maximum 13 mg day^{-1} for both of men and women, in Fe; maximum 8 mg day^{-1} for men and maximum 18mg $day^{-1}$for women [20].

These elements of intake percentages were calculated by using (2) and the values of daily requirements for human body.

$$DMI = m \times 100 / DRI \quad (2)$$

where ‘DRI’ is recommended dietary reference intakes and ‘DMI’ is daily main intakes.

III. Results and Discussion

A. Analysis Results

Elemental analysis results for Turkish coffee and sugar added Turkish coffeeare presented in Table I in mg/L. From the results obtained, the Mg amount is the highest and it is followed by Na, B and Fe amounts.

TABLE I
SOME ESSENTIAL ELEMENT CONTENTS OF THE TURKISH COFFEE AND THE SUGAR ADDED TURKISH COFFEE

	Elements	Pure Concentration (ppm)	Sugar Added Concentration (ppm)
Turkish Coffee	Mg	21,45	19,83
	Na	0,81	1,04
	B	0,16	0,21
	Fe	0,008	0,02

As can be seen from both Table I and Fig. 5, with sugar addition to Turkish coffee, the Na, B and Fe concentrations were increased to 1,04, 0,21 and 0,02 ppm respectively. However, Mg concentration was decreased to 19,83ppm.

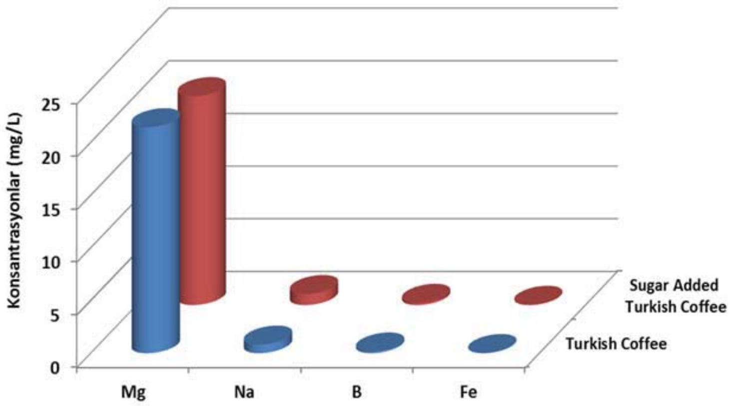

Fig. 5 Element contents of the brewed coffee samples

B. Health Effects

Daily maximum element intake for humans is shown in Table II. Recommended maximum daily Mg, Na, B and Fe intake amount can be seen between 400-420, 1500, 13 and 8 mg for adults respectively. Also the Table II shows us that the recommended Fe amount for females is higher than the recommended amount for males. B and Na amounts are the same for men and women but recommended Mg amount for males is higher than the recommended amount for females.

TABLE II
RECOMMENDED MAXIMUM DAILY ELEMENT INTAKE FOR ADULTS

Daily Consumption	Mg (mg/day)	Na (mg/day)	B (mg/day)	Fe (mg/day)
19-30 years man	400	1500	13	8
19-30 years woman	310	1500	13	18
31-50 years man	420	1500	13	8
31-50 years woman	320	1500	13	18

The element contents of the analyzed coffees were calculated for 1, 3, 5 cups respectively. Analysis data were shown us percentage element intake for adults (%). Results of Mg, Na, B and Fe analysis are shown in the Table III through Table V.

TABLE III
DAILY MAGNESIUM INTAKE FOR ADULTS

Mg Intake for	Turkish Coffee (%)	Sugar Added Turkish Coffee (%)
1 Cup	0,512	0,472
3 Cups	1,536	1,416
5 Cups	2,560	2,360

Magnesium, an abundant mineral in the body, is naturally present in many foods, added to other food products, available as a dietary supplement, and present in some medicines. Magnesium amounts of Turkish coffees are shown in Table III.

TABLE IV
DAILY SODIUM INTAKE FOR ADULTS

Na Intake for	Turkish Coffee (%)	Sugar Added Turkish Coffee (%)
1 Cup	0,005	0,007
3 Cups	0,015	0,021
5 Cups	0,027	0,035

TABLE V
DAILY BORON INTAKE FOR ADULTS

B Intake for	Turkish Coffee (%)	Sugar Added Turkish Coffee (%)
1 Cup	0,123	0,161
3 Cups	0,369	0,483
5 Cups	0,615	0,807

TABLE VI
DAILY IRON INTAKE FOR ADULTS

Fe Intake for	Turkish Coffee (%)	Sugar Added Turkish Coffee (%)
1 Cup	0,004	0,011
3 Cups	0,012	0,033
5 Cups	0,022	0,055

Sodium's role in the human body is being a systemic electrolyte and the co-regulation of ATP [21]. Sodium amounts of Turkish coffees are shown in Table IV.

Boron stimulates brain function and together with other minerals, such as calcium and magnesium and vitamin D it helps to prevent [15]. Boron amounts of Turkish coffees are shown in Table V.

Iron plays critical role in red blood cell formation and function. It is also important for brain function. Fe is a component of hemoglobin and numerous enzymes. It also prevents microcytic hypochromic anemia [13]. Iron amounts of Turkish coffees are shown in Table VI.

As it is seen that daily element intake from Turkish coffee showed differences according to consumption amount.From the results obtained in this study it can be said that element contents of Turkish coffees in 1 cup, 3 cups and 5 cups lower than daily maximum element intake for adults.

As a result, the investigated Turkish coffee and sugar added Turkish coffee don't reach the maximum daily dosage of element concentration.

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