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Influence of brewing pots on mineral content of black tea infusions

[Demleme kaplarının siyah çay demlerindeki mineral içeriğine etkisi]

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ABSTRACT

Purpose: The objective of this study is to analyze the minerals of different black tea infusions brewed in different pots.

Material and Methods: Eight different samples of black tea were used in this study. Six mineral contents (Fe, Cu, Mn, Zn, Na and K) obtained by duplicate analysis of 64 samples (8 different samples – 4 pots – 2 infusions each) that were brewed two times under the same conditions in different pots (stainless steel, aluminum, porcelain and glass) were analysed. Fe, Cu, Mn and Zn contents in infusions were determined by atomic absorption spectrometer; Na and K contents were determined by flame photometer. The differences in mineral contents of infusions brewed in different pots were analyzed by analysis of variance (F-test) for randomized block design.

Results: Fe, Mn, Zn and Na contents of infusions were found to be significantly different whereas no statistically significant differences were observed in Cu and K contents between brewing pots. The highest amount of mineral found in infusions was K. Fe contents were found to be similar in infusions brewed in stainless steel and glass pots which is less than the tea brewed in aluminum and porcelain pots. There was no significant difference in the Zn content of infusions brewed in aluminum and porcelain pots, however these were significantly higher than those in stainless steel and glass pots. The Mn content of tea brewed in glass pot was significantly lower as compared to the other three pots. The Na content was found highest in tea brewed in porcelain pot, and lowest in glass pot.

Conclusion: Tea is an important source of some minerals especially for K. The mineral content of tea may differ according to the pot in which it is brewed. This is especially important in order to regulate the tea consumption of patients in illnesses where there should be restrictions on some mineral consumption.

Key words: Black tea, Atomic spectrometry, Tea infusion, Mineral composition, Mineral intakes

Conflict of Interest: Authors have no conflict of interest.

ÖZET

Amaç: Bu çalışma, farklı kaplarda demlenmiş farklı çay örneklerinin mineral içeriklerini belirlenmek amacıyla yürütülmüştür.

Gereç ve Yöntemler: Araştırmada 8 farklı tür siyah çay örneği kullanılmıştır. Her çayın, aynı koşullar altında, 4 farklı demlikte (paslanmaz çelik, aluminyum, porselen ve cam) ikişer kez demlenmesiyle elde edilen 64 örneğin 6 mineral içeriği (Fe, Cu, Mn, Zn, Na ve K) ikili olarak analiz edilmiştir. Demlerdeki Fe, Cu, Mn ve Zn miktarları; atomik absorpsiyon spektrometresi, Na ve K miktarları ise; flame fotometre ile belirlenmiştir. Çay demlerindeki mineral miktarlarının demleme kapları arasındaki farkları; rasgele blok düzeni için varyans analizi yöntemi ile araştırılmıştır.

Bulgular: Paslanmaz çelik, aluminyum, porselen ve cam olmak üzere 4 farklı kapta demlenen çayların Fe, Mn, Zn ve Na miktarları arasındaki farkların istatistiksel olarak önemli, Cu ve K miktarları arasındaki farkların ise önemsiz olduğu belirlenmiştir. Demlerde en yüksek miktarda bulunan mineral K'dur. Paslanmaz çelik ve cam kaplarda demlenen çayların Fe miktarları benzer olup diğer iki kapta (alüminyum ve porselen) demlenen çaylardakinden daha düşüktür. Buna karşılık alüminyum ve porselen kaplarda demlenen çayların Zn miktarları benzerdir ve diğer iki kapta (paslanmaz çelik ve cam kap) demlenenlerden önemli düzeyde yüksektir. Mn miktarı; cam kapta demlenen çaylarda, diğer 3 kapta demlenenlerden daha düşük bulunmuştur. Na; porselen kapta demlenen çayda en yüksek, cam kapta demlenen çayda ise en düşük miktardadır.

Sonuçlar: Siyah çay, başta potasyum olmak üzere bazı mineraller açısından zengin bir içecektir. Çayın demlendiği kaba göre bileşimindeki mineral içeriği değişebilmektedir. Bu değişikliklerin bilinmesi; özellikle bazı minerallerin sınırlanması gereken hastalıklarda, çay tüketim miktarlarının düzenlenmesi açısından önemlidir.

Key words: siyah çay, atomik spectrometry, Tea infusion, Mineral composition, Mineral intakes

Çıkar çatışması: Yazarların; konuyla ve/veya herhangi başka bir yazar ile ilgili maddi veya manevi bir çıkar ilişkisi yoktur.

Introduction

Tea is prepared from the young tender shoots of Camellia sinensis [1-3]. Tea has been one of the most consumed non-alcoholic drink aside from water for over 4000 years for its desirable taste, refreshing and mildly stimulant effect [3-7]. It is one of the safest beverages since it is prepared with boiling, sterile water. As an estimated amount, 18-20 billion teacups are consumed daily in the world (8). The annual tea consumption is about 2.3 kg per capita in Turkey, higher than world average [1]. Black tea is consumed often with sugar and lemon [6]. Tea varies by type (black, green, oolong, pu'er, blended, unblended) and processing methods (conventional; cut, tear, curl) [9]. Black tea is prepared as stick-shaped, granular, paper bagged, and canned or bottled in beveraged forms [10].

Health benefits have been well documented and emphasized the therapeutic action of tea. Tea is a good source for some essential minerals. Tea is recently considered a healthy drink with bioactive molecules and high antioxidant capacity [11-13]. Infusion methods vary considerably among countries in the world. Preferred infusion strength and infusion time for tea brewing differ among tea drinkers [9, 14]. Because of the importance of minerals contained in tea, many studies have been carried out to determine their levels in tea leaves and their infusions [4, 7, 12, 15]. Tea is an essential part of the human diet in Turkey. However the mineral content of tea infusion brewed in different pots is not known. This study was designed to analyze minerals of black tea infusion brewed in different pots.

Materials and methods

Samples: Eight brands of powdered Turkish black tea leaves were selected for this study. These samples were bought from markets as 1 kg package. Six mineral contents (Fe, Cu, Mn, Zn, Na and K) obtained by duplicate analysis of 64 samples (8 different samples – 4 pots – 2 infusions each) that were brewed two times under the same conditions in different pots (stainless steel, aluminum, porcelain and glass) were analyzed.

Apparatus: Elemental concentrations of Fe, Cu, Mn and Zn in the tea infusion samples by atomic absorption spectrometer (AAS), (Perkin-Elmer model 1100, Perkin-Elmer Corp., Norwalk, CT), Na and K concentrations; flame photometer (Corning model 410, Halstead, UK) by were analyzed.

Reagents: Nitric and perchloric acids (Merck, Darmstadt, Germany) were analytical grade. Stock standards (1000mg L^{-1}) for all the analyzed minerals were purchased from Merck. Working standard solutions were prepared by serial dilutions of the standards. All aqueous solutions and dilutions were prepared with de-ionized water (Milli-Q, Millipore, Bedford, MA).

Preparation of tea infusions: All glassware used for analysis, was washed with de-ionized water [9, 16, 17]. Tea infusion samples were prepared as dublicated according to drinking habits of Turkish people. De-ionized water was heated on hot plate. Two grams of each black tea sample was added to 100 mL at 95°C de-ionized water, infusions were waited for 5 minutes on the hot plate [15, 18, 19]. The temperature of de-ionized water was measured by a laboratory thermometer. Infusion procedures of each tea samples were performed in stainless steel, aluminum, porcelain and glass pots separately. Following cooling procedure at room temperature, the tea infusions were filtered by Whatman No 42 filter paper. Filtrates were measured with volumetric flasks. Samples of tea infusion (10 mL) were transferred in a beaker and dried for 24 hours in a stable at 60°C in drying cabinet [10].

Analysis of minerals in tea infusions: A solution containing HNO_3 and $HCLO_4$ (1/1, v/v), was added separately to each infusion residue. This procedure was performed in a 100 mL of beaker. The mixtures were heated on a hot plate at 80°C until a clear colorless solution was obtained. Following the cooling procedure at room temperature, the solutions were filtered (Whatman No 42) into a volumetric flasks. The volumes of filtered samples were complemented to 50 mL by deionized water. Each type of filtered and diluted infusion sample was stored in a clean, labeled and tightly capped polyethylene bottle. Iron, copper, manganese, zinc, contents were detected by atomic absorption spectrometer, natrium and potassium contents were determined by flame photometer. The samples were analyzed in duplicate [8, 12, 20, 21].

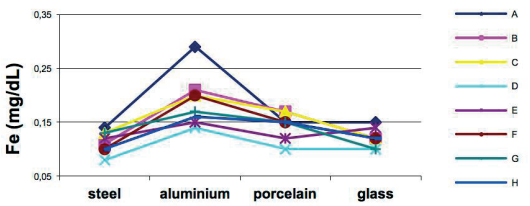
Statistical Analysis: Analysis of variance (F-test) for randomized block design is used for significance testing. The pots were regarded as treatments and samples as blocks, respectively. Post-hoc tests were used in order to establish a significant difference between types of pots for element content. SPSS 12.0 is used for the analysis and significance level is set at 0.05.

Results and Discussion

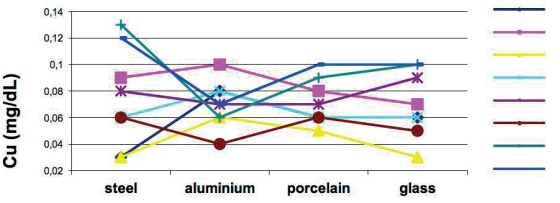
Tea is one of the famous beverages all around the world. Tea is known as one of the best source of the minerals, flavonoids and polyphenols in terms of its leaves and brew. However, the amount of substances within its composition alters depending on in which area it is grown, the processes applied, the procedures of packaging, the amount of tea used in brewing, the time of brewing, the heat and the pot used [2, 5, 15, 19, 21]. In this study, 8 different black tea samples were used, brewed under the same condition in different pots and Fe, Cu, Mn, Zn, Na and K minerals were analyzed from the solutions obtained. The mineral content of the solutions and comparisons brewed in different pots made up of steel, aluminum, porcelain and glass are shown in Table 1. The average mineral content of the brews are also displayed graphically in Figure 1 (1A-1D). There were no statistically significant differences in Cu and K contents regarding to brewing pots ($p>0.05$). Those two

Table 1. Mineral contents of infusion in different pots (mg/dL)

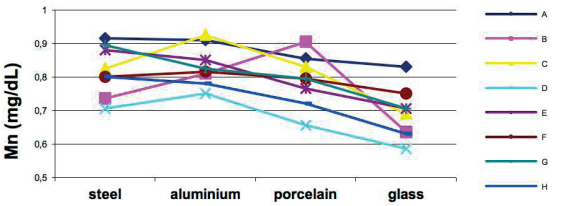
Minerals	Stainless steel[a] $\bar{x}$ ±SD	Aluminum[b] $\bar{x}$ ±SD	Porcelein[c] $\bar{x}$ ±SD	Glass[d] $\bar{x}$ ±SD	p	Pots which are not statistically different
Fe	0.011±0.002	0.019±0.005	0.015±0.002	0.012±0.002	<0.001	*a, d*
Cu	0.008±0.004	0.007±0.002	0.007±0.002	0.007±0.003	>0.05	*a, b, c, d*
Mn	0.819±0.075	0.833±0.060	0.790±0.078	0.691±0.077	<0.001	*a, b, c*
Zn	0.018±0.003	0.029±0.005	0.029±0.008	0.015±0.001	<0.001	*b, c*
Na	0.099±0.013	0.115±0.022	0.131±0.024	0.079±0.013	<0.001	*a, b; b, c*
K	28.975±2.676	30.375±1.598	28.613±1.099	28.563±1.106	>0.05	a, b, c, d



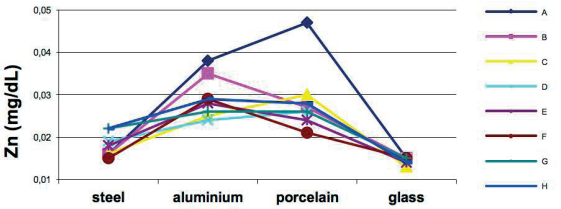
1A. Fe contents of eight infusion samples in four different pots



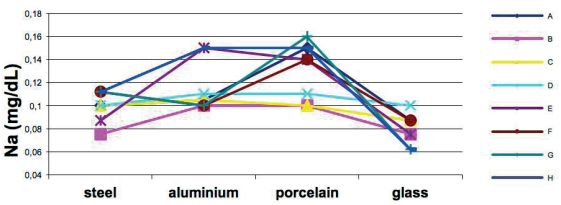
1B. Cu contents of eight infusion samples in four different pots



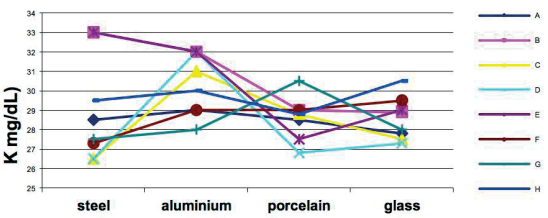
1C. Mn contents of eight infusion samples in four different pots



1D. Zn contents of eight infusion samples in four different pots



1E. Na contents of eight infusion samples in four different pots



1F. K contents of eight infusion samples in four different pots

Figure 1. Mineral content of infusion samples in different pots

Figure 1. Mineral content of infusion samples in different pots.

minerals were not affected from brewing pots. It was found that Cu content of the tea brewed in steel pot, and K content of the tea brewed in an aluminum pot though not statistically significant slightly higher than the others ($p>0.05$).

Fe content of tea infusion brewed in stainless steel, and glass pots was lower than those brewed in aluminum and porcelain pots ($p<0.001$). Although there was no statistically significant difference between steel and glass pots' Fe contents in the brewing, the Mn content of tea brewed in glass pot as compared to 3 other pots was significantly lower ($p<0.001$). There was no significant difference in

the Zn content in tea infusions brewed in aluminum and porcelain pots ($p>0.05$). On the other hand, Zn content of tea brewed in steel and glass pots was less than the other pots ($p<0.001$). The Na content of tea was found highest in porcelain pot, and the lowest in glass pot.

In general, Mn, Zn, Na and K contents were lower in tea brewed in glass pots. Fe contents were found lower in steel and glass pots but no statistical significance was achieved. The Cu content wasn't statistically different between types of pot used to brew tea. In the light of our findings, it can be thought that the lowest leaching of minerals was seen in tea which was brewed in glass pots.

Gurses and Artık [22] brewed Turkish tea samples in porcelain pot and analysed some minerals in brewed tea. Among the minerals Fe and Cu contents were higher, and Na and K contents were similar to our results. Arslan ve Togrul, [23] investigated minerals in Turkish black tea samples brewed at different conditions. Compared to their results Fe and Zn levels in our study are lower, Mn level is higher.

Most of the studies carried out on tea samples were generally concentrated on tea leaves [15, 20, 21, 24, 25]. However, the studies made on the analysis of mineral quantities passing to the brew were limited [14, 18, 19, 21]. Some results obtained from these studies are summarized in Table 2. No comparison was made regarding the brewing pots in these studies. Since the analyses were conducted in standard laboratory conditions, our results were compared with the results of minerals brewed in glass pots. According to this, when 5 minutes brewing data was taken into consideration which we have obtained from our study, Cu was lower where other minerals were higher compared to Natesan and Ranganathan [19] brewing results at different time intervals. Our findings on Cu content compared to the results obtained from the study of Wrobel et al [21] were a little lower and Fe and Mn levels were higher. With respect to these research results, it can be concluded that Cu content in tea produced in Turkey is low. The reason could be the difference in the area where tea is grown, the production processes, packaging methods and packages. However, if USDA [25] data is considered, Fe and Cu results showed similarities. It has been observed that Zn, Na and K were a little high and Mn, is obviously high.

Drinking tea contributes to dietary mineral intake [12, 21, 26]. Depending on the quantity of tea daily consumed and the hardness of tea the mineral contents show alterations in individuals [2]. If the tea composition consumed regionally is known, the mineral intake can be controlled in the intended way based on the diet [27].

Among the various elements present in the tea infusion, only K is present in high amounts [19]. Tea is known as a good source for K and Mn, in addition to the flavonoids in its composition or other beneficial components [7, 20, 26].

The amounts of different elements present in tea beverages had been reported in previous studies [11]. The differences observed in the content or range of some elements may be due to differences in geographic characteristic, origin and nature of soils, and agronomic and cultural practices among the various tea-producing areas [19]. The percentage of elements leached into the tea infusions depends on preparing process, so standard techniques should be used for preparing tea infusions in order to compare different element contents of different tea types [21]. The quality of black tea has traditionally been assessed by a tea taster who has developed a language of his own to describe various quality attributes of a tea infusion [14, 19]. The determined amount of the elements in tea beverages and in tea infusions can be used in the calculation of the amount of the element consumed through drinking tea [19]. It has been reported that some of the elements present in tea brew are quite good for human health [11, 28].

Data should be provided for each country, since tea types consumed and tea brewing techniques differ traditionally. Large variations in the amounts of the elements in the brands grown in different countries could be attributed to their origin and processing methodology. In this regard, granular tea leaves, powder and tea bags show

Table 2. Mineral contents of infusions reported different studies

	Natesan and Ranganathan, 1990 (19)	Wrobel, 2000 (21)	USDA Data (25)
Mineral	$\bar{x}$ ±SD	$\bar{x}$ ±SD	
Fe	0.00588±0.0051	0.0019±0.00022	0.010
Cu	0.0459±0.0043	0.00908±0.00022	0.008
Mn	0.089±0.0070	0.172±0.01008	0.219
Zn	0.0117±0.0009	-	0.010
Na	0.029±0.0025	-	0
K	14.48±1.427	-	21

widely different elemental contents suggesting the effect of processing methodology [20, 27].

On average, 1 L tea is consumed per person per day, which as a percentage of average daily dietary intake, can provide 2% of Cu and 35.5% of Mn. [28]. Since most of the elements present in tea are unlike food items which are consumed in their entirety it is only the fraction soluble during infusion which is consumed [19]. Hakim and et al [2] found a correlation between the reported strength of the tea and actual infusion time was highly significant. It was advised to use infusion time as a surrogate for the tea beverage, and hence its mineral content. Determination of trace elements in tea infusion is important for their nutritional value. Hence, tea drinking may be regarded as a major source of some essential dietary elements. Our results show that amounts of elements transferred into the tea infusions varied widely for the different pots samples used. The present study suggests that tea is a rich source of dieatary potassium and manganese tea infusions. Tea could be an important source of manganese and the large amount of potassium in that could be beneficial for human health. In the present study Mn, Zn, Na and K contents determined were lower tea infusions prepared in glass pots than other pots. The comparison of total elemental content in stainless steel, and porcelain pots showed concentrations of Mn, Zn, Na were considerably higher in the glass pots. Although Al content of the tea drink prepared in different pot was not analyzed**,** it may be speculated that Al content could be high since content of most mineral is high than tea infusion prepared in aluminum pots. The present study suggests that tea is a rich source of dieatary potassium and manganese tea infusions. Especially among patients who suffer from renal disease whose dietary K intakes need to be restricted because of their elevated high blood K levels, tea consumption should be restricted. If wanted, tea brewed in glass pot, in short period and light tea should be preferred seldomly.

Lack of specific information on the type and amount of tea consumed, duration of tea intake, method and type of container used for preparation of tea have limited to set up similarities between all studies. Therefore, more specific information about qualitative and quantitative aspects of tea consumption should be gathered from epidemiological studies for standardization as the type and the amount of tea and the infusion techniques affect estimates of mineral intake. In the present study, tea infusions were prepared using deionized water. However, tea for consumers may be prepared with water from various sources containing different elemental concentrations and this may affect elemental concentrations in the tea infusion. The results obtained from our research and various results from other articles show that while determining the nutrition status of the societies, international nutrient content should be used to calculate the quantities in taken correctly.

Conclusion

In this study we investigated the amounts of minerals in different brands black tea infusion brewed in different pots. Infusion procedures of each tea samples were performed in different pots (stainless steel, aluminum, porcelain and glass). The infusions were analyzed to estimate the amounts of Fe, Cu, Mn, Zn, Na and K leached into the liquor. The results indicated that mineral content with the exception of Cu and K, significantly differed with the type of pots used for brewing. The tea is an important source of K and Mn. Especially among patients who suffer from renal disease whose dietary K intakes need to be restricted because of their elevated high blood K levels, tea consumption should be restricted. If wanted, tea brewed in glass pot, in short period and light tea should be preferred seldomly. The accurate determination of the amounts of trace elements and minerals in tea infusion is important for health as regular consumption of tea beverages contributes to the daily dietary requirements of them.

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