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Lemon Effect on Some Elements in Turkish Teas

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***Abstract*—**Tea has several types of essential elements. Potassium, magnesium and phosphorus are some examples of these elements. Tea is widely used drink in Turkey, also some people puts a lemon wedge to tea for different taste. In this study potassium, magnesium and phosphorus contents after the hot water brewing of black and green tea were determined by Optical Emission Spectroscopy (ICP-OES). Furthermore, how the lemon addition to teas affects the concentrations of the potassium, magnesium and phosphorus amount are investigated.

From the results, potassium, magnesium and phosphorus concentrations are found as 3003.3, 597.1, 1167.2 ppm in black tea and 3718.0, 3830.5, 376.4 ppm in green tea, respectively. After lemon addition potassium, magnesium and phosphorus concentrations are changed to 14930, 830.4, 1113.5 ppm in black tea and 15460.0, 909.5, 1152.5 ppm in green tea, respectively.

It is seen that lemon addition affects some essential elements in black and green Turkish teas.

***Keywords*—**Hot water brewing, ICP-OES, lemon**,** tea

I. Introduction

TEA is made from steeping the processed leaves, buds, or twigs of the tea bush (Camellia sinensis) in water (Fig. 1 (a)). Turkish tea is a form of black tea, which is produced on the eastern Black Sea coast at around Rize region. Turkish tea is typically prepared by using two stacked kettles (Fig. 1 (b)) especially designed for tea preparation. Water is brought to a boil in the larger lower kettle and then some of the water is used to fill the smaller kettle on top. Tea is drunk from small glasses to enjoy it hot in addition to showing its colour (Fig. 1 (c)), with lumps of sugar. Also a lemon wedge or lemon juice addition to tea is very widely used in our country. In Turkey different than in other Mediterranean countries, tea replaces both alcohol and coffee as the respectful beverage [1]-[3].

Tea has several types of essential elements to human body. Such as calcium, cobalt, chromium, copper, iron, potassium, magnesium, manganese, sodium, phosphorus, vanadium and zinc. In this study the potassium, magnesium and phosphorus content of the black and green teas are investigated.

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Fig. 1 (a) Camellia sinensis [4], (b) two stacked kettle [5], (c) small glass [6]

Potassium is fundamentally involved in a massive amount of body processes, such as fluid balance, protein synthesis, nerve conduction, energy production, muscle contraction, synthesis of nucleic acids and control of heartbeat [7].

The majority of phosphorus found in the body is bound up with calcium in the bones as calcium phosphate, accounting for around 80% of the bodily total. The remainder is distributed throughout the body as inorganic phosphate and in all cells as ATP (Adenosine Tri-Phosphate), which is the main "energy" chemical in the body, as well as being a main component of the genetic materials DNA and RNA, which are found in every cell [8].

Along with phosphorus, magnesium follows a close second behind calcium as the most common mineral in the body. Around 86% of all the magnesium is found in the bones (60%) and muscles (26%), with the rest being distributed between the other soft tissues (especially brain, heart, liver and kidney) and bodily fluids [9].

The element concentrations in tea is a popular issue for the researchers due to health effects. Different tea samples and different elements were investigated by the lots of researchers. Ferna´ndez et al. (2002) were analyzed eleven metals in tea beverages, infusions, instants and tea soft drinks by ICP-OES [10]. About 40 elements concentrations in black tea infusions were determine by Matsuura and his friends [11]. Salahinejad and Aflaki was reported twelve toxic metals and essential minerals in black tea which are cultivated in Iran and imported [12].

The purpose of this study is to determine the content of potassium, magnesium and phosphorus after the brewing process of the two types of Turkish teas that are black and green tea. Also how is the lemon addition to tea effects the potassium, magnesium and phosphorus content are investigated, since a lemon wedge or lemon juice addition to tea is very widely used in our country.

II. Experimental Procedure

A. Preparation and Brewing of the Tea Samples

Black tea and green teas 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.

In this method, 50 mL of hot water (90-100°C) was poured to 2 grams of tea in the beaker and stirred. After 6 minutes, the extract was filtered into a 100 mL volumetric flask, which is shown in Fig. 1 and filled up to volume of 100 ml with pure water [13]-[15].

Lemons are bought from local market and 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.

Fig. 2 Brewing procedure of the tea samples

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

Calibration sets are conducted by using K, Mg, P standard solutions [15].

In ICP-OES technique, the sample is 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 [16].

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 samples are given in Fig. 4.

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

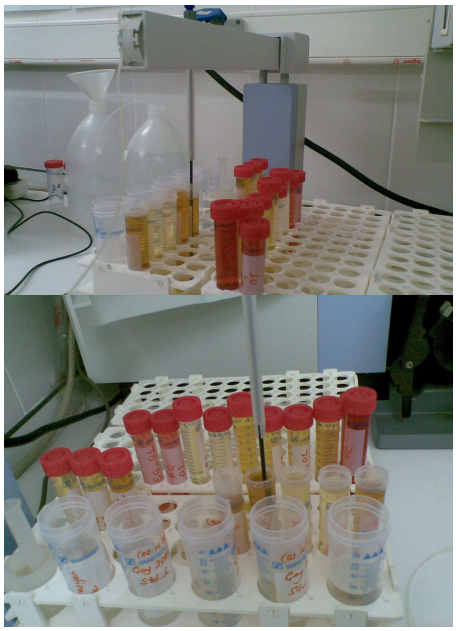

Fig. 4 Measured tea samples

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 Results

Calibration results are shown in Table I. From the results, it is seen that coefficient of determination (R^2) value fits with the linear regression.

TABLE I
CALIBRATION RESULTS

Element	Slope	Intercept	R^2
K	$2x10^6$	$-3x10^6$	0.9998
Mg	$1x10^6$	$-3x10^6$	0.9997
P	$23.32x10^3$	$-11.90x10^3$	0.9999

B. Some Essential Element Contents of the Teas and Lemon added Teas

Potassium (K), magnesium (Mg) and phosphorus (P) contents and lemon addition results of the black and green teas are shown in Fig. 5 through Fig. 7 and Table II respectively.

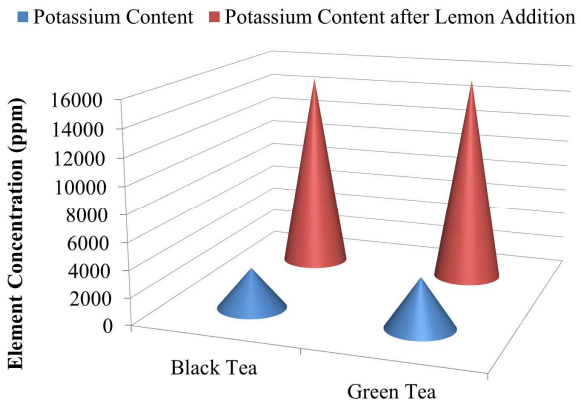

Fig. 5 Potassium contents of the brewed tea samples

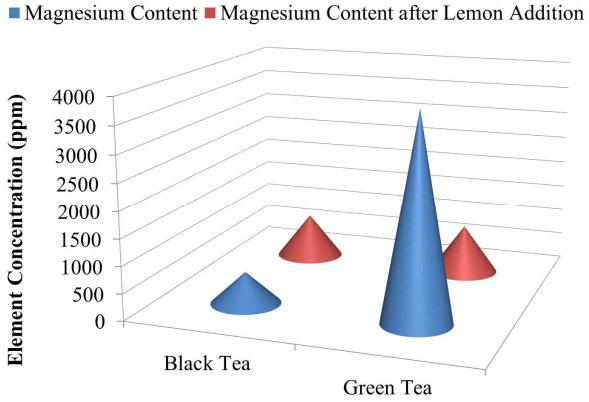

Fig. 6 Magnesium contents of the brewed tea samples

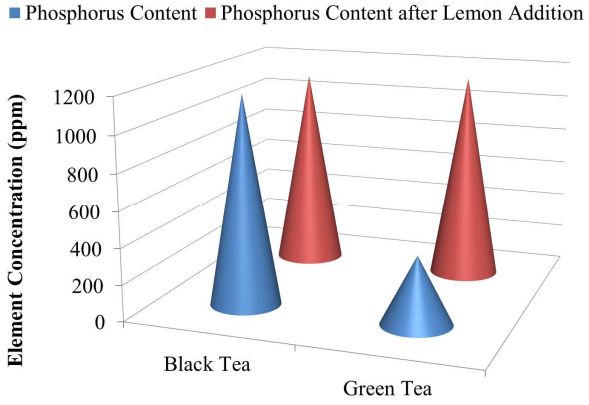

Fig. 7 Phosphorus contents of the brewed tea samples

TABLE II
SOME ESSENTIAL ELEMENT CONTENTS OF THE TEAS AND LEMON ADDED TEAS

Tea Type	Element	Pure Concentration (ppm)	Lemon Added Concentration (ppm)
Black Tea	K	3003.0 ± 402	14930.0 ± 890.9
	Mg	597.1 ± 10.4	830.4 ± 93.8
	P	1167.2 ± 19.5	1113.5 ± 23.3
Green Tea	K	3718.0 ± 82.0	15460.0 ± 381.4
	Mg	3830.5 ± 437.7	909.5 ± 48.9
	P	376.4 ± 11.7	1152.5 ± 38.9

From the results obtained the maximum element concentrations are seen for potassium in black teas and magnesium in green teas. Also, the minimum element concentrations in black teas and green teas are magnesium and phosphorus, respectively. In black teas, potassium and magnesium amounts are increased by the lemon addition, on the contrary, the phosphorus amount is decreased. The potassium amount at the green tea is increased by the lemon addition likely at the black tea. Despite that the magnesium content is decreased by the lemon addition unlikely at the black tea.

Similarly the phosphorus content is increased by the lemon addition in the green teas, as opposed to the black teas.

IV. Discussion and Conclusions

Human daily element dietary is given in Table III.

TABLE III
RECOMMENDED DIETARY ALLOWANCE VALUES [17]

Daily consumption (mg)	K	Mg	P
Babies (Age<1)	400-700	30-75	100-275
Children (1<Age<9)	3000-3800	80-130	460-500
Grownup (9<Age<18)	4500 - 4700	240-410	1250
Adult (18<Age<70)	4700	310-420	700
Pregnancy (18<Age<50)	4700	350-360	700
Elder (Age>70)	4700	420	700

According to the literature potassium is the most required element for human body. Phosphorus follows the potassium element. The magnesium necessity for human body is lower than the others. Potassium element necessity increases from age 1 to 18 then become constant at the age greater than 18. Magnesium element necessity is increases to an age of 70 and after that age it become constant. Also magnesium necessity is increases at the pregnant women. Phosphorus necessity is increases from age 1 to 18 and after that age decreases and become constant.

Assuming that one black tea and green tea bag weights two grams, potassium, magnesium and phosphorus element concentrations are recalculated for one bag of tea and listed in Table IV.

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

Tea Type	Element	Pure Concentration (ppm)	Lemon Added Concentration (ppm)
Black Tea	K	6.01 ± 0.80	29.86 ± 1.78
	Mg	1.19 ± 0.02	1.66 ± 0.19
	P	2.33 ± 0.04	2.23 ± 0.05
Green Tea	K	7.44 ± 0.16	30.92 ± 0.76
	Mg	7.66 ± 0.88	1.82 ± 0.10
	P	0.75 ± 0.02	2.31 ± 0.08

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 situation potassium, magnesium and phosphorus element concentrations are recalculated for ten bags of tea and listed in Table V.

TABLE V
TEA ADDICTED PERSONS DAILY ESSENTIAL ELEMENT INTAKE FROM TEAS

Tea Type	Element	Pure Concentration (ppm)	Lemon Added Concentration (ppm)
Black Tea	K	~60	~300
	Mg	~12	~17
	P	~24	~23
Green Tea	K	~75	~310
	Mg	~77	~19
	P	~8	~23

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

TABLE VI
TEA ADDICTED ADULT DAILY TEA DIETARY

Tea Type	Element	Pure (%)	Lemon Added (%)
Black Tea	K	1.3	6.4
	Mg	2.8-3.9	4.0-5.5
	P	3.4	3.3
Green Tea	K	1.6	6.6
	Mg	18.3-24.8	4.5-6.1
	P	1.1	3.3

From the results obtained in this study it can be said that green tea contains the potassium and magnesium elements more than the black tea. Also black tea phosphorus content is greater than the green tea. Lemon addition increased the potassium and magnesium content of the black tea and decreased the phosphorus content. But in the green tea potassium and phosphorus content is increased with the lemon addition and magnesium is decreased.

For a tea addict person who drinks ten cups of black or green tea with lemon daily can satisfy 6.4–6.6% potassium, 4.0–6.1% magnesium and 3.3% phosphorus necessity from tea only. Similarly who drinks ten cups of black or green tea without lemon daily can satisfy 1.3–1.6% potassium, 2.8–24.8% magnesium and 1.1–3.4% phosphorus necessity from tea only. 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 foods consumed daily.

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