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Determination and Comparison of Some Elements in Different Types of Orange Juices and Investigation of Health Effects

F. Demir, A. S. Kipcak, O. Dere Ozdemir, E. Moroydor Derun, S. Piskin

***Abstract*—**Fruit juices play important roles in human health as being a key part of nutrition. Juice and nectar are two categories of drinks with so many variations for consumers, regardless of age, lifestyle and taste preferences, which they can find their favorites. Juices contain 100% pulp when pulp content of 'nectar' changes between 25%-50%. In this study, potassium (K), magnesium (Mg), and phosphorus (P) contents in orange juice and nectar is determined for conscious consumption. For this purpose inductively coupled plasma optical emission spectrometry (ICP-OES) is used to find out potassium (K), magnesium (Mg), and phosphorus (P) contents in orange juices and nectar. Furthermore, the daily intake of elements from orange juice and nectar that affects human health is also investigated. From the results of experiments K, Mg and P contents are found in orange juice as 1351; 73,25; 89,27 ppm and in orange nectar as 986; 33,76; 51,30 respectively.

***Keywords*—**Orange juice, nectar, ICP-OES, element.

I. Introduction

FRUIT juices are widely consumed drinks across the world and its enormous commercial and social importance is obvious. Today, in the quest to get healthy, more and more people choose fruit juices, being recognized as a source of nutrient compounds, including essential elements [1]. They are widely accepted as good sources of vitamins and minerals, including vitamin C, folate, potassium, magnesium and antioxidants. [2].

Different types of fruit juices are preferred due to positive effects on the health and nutrition. Juice, nectar and still drinks are three categories of drinks with so many variants that all consumers, regardless of age, lifestyle and taste preferences whom they can find their favorite type [3].

The term of "fruit juice" is restricted to beverages that are 100% pure juice, whereas a "nectar" may be diluted (to a degree limited by regulations) with water and contain additives besides fruit juice, including natural and artificial sweeteners, and preservatives [4]. The fruit juice content in nectar can vary between 25 and 99 per cent [3]. Today a wide variety of fruit juices are consumed.

Botanically; orange is the citrus fruit belonging in the *Rutaceae* family, of the genus; *Citrus*. The genus citrus also includes other related species of oranges such as pomelo, tangerine (mandarin orange), lemon, and grapefruit. Scientific name of orange is *Citrus sinensis* [5], [6].

Orange juice (Fig. 1) is one of the most popular beverages in the world, important for health and nutrition. Health benefits of orange juice are well known, such as a way to naturally enhance body's resistance to various diseases. Delicious and juicy orange fruit contains an impressive list of essential nutrients, vitamins, minerals for normal growth and development and overall well-being [6].

Fig. 1 Orange juice [7]

Orange juice contains various elements such as calcium, potassium, sodium, iron, manganese and magnesium. These elements which are in the structure of orange juices have various effects on human health.

Potassium (K) 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 heart beat [8].

Magnesium (Mg) is a physiologically essential constituent playing an important role in different vital processes occurring in the human body. Being a cofactor in almost all phosphorylation reactions involving ATP, Mg is considered as an indirect antioxidant. It is not only a major component of the bones, but furthermore it influences the nervous system and muscle activity. Habitually low intakes of Mg are associated

F. Demir, , is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (e-mail: demirfunda1@hotmail.com).

A. S. Kipcak, O. Dere Ozdemir, F. Demir, and S. Piskin are with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (e-mail: skipcak@ yildiz.edu.tr, odere@ yildiz.edu.tr, demirfunda1@hotmail.com, piskin@yildiz.edu.tr).

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 (phone: 0090-212-3834776; fax: 0090-212-3834725; e -mail: moroydor@yildiz.edu.tr / moroydor@gmail.com).

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

with etiologic factors in cardiovascular and nervous diseases, bone deterioration and stress [9], [10].

Phosphorus (P) is an essential element for all forms of life on earth. It is a primary constituent of deoxyribonucleic acid (DNA) and adenosine triphosphate (ATP) which is responsible for the encoding of genetic instructions and intracellular energy transfer within living cells [11].

There are various studies about element contents of orange juice. Dehelean and Magdas determined 13 elements (Na, Mg, K, Ca, Cr, Mn, Co, Ni, Cu, Zn, As, Cd, Pb) in different types of orange juices [1]. Simpkins et al. studied on several elements' (Al, Ba, B, Ca, Co, Cu, Fe, Li, Mg, Mn, Mo, Ni, P, K, Rb, Si, Na, Sr, Sn, Ti, V, Zn) amounts in orange juices [12]. Krejpcio et al. determined 4 elements (Pb, Cd, Cu, Zn) in various fruit juices [13]. Magdas et al. determined apple juice elements by using ICP-OES method. ICP-OES is very often applied in the elemental analysis of fruit juice samples [14]. Chuku and Chinaka investigated 4 major elements (K, Mg, Fe, Ca) in grapefruit, lime, orange and lemon fruit [15].

Today orange juice is widely consumed beverage not only in Turkey but also all-around of the world.

The purpose of this study is to determine the content of Mg, P and K of 100% orange juice and nectar of orange juice that are sold in Turkey. Also the health effects are investigated.

II. Experimental Procedure

A. Preparation of the Orange Juice Samples

100% orange juice and orange nectar were purchased from the local market in Istanbul, Turkey. In this method, 5 ml of orange juice was digested with 10 mL of HNO_3 in microwave digestion system (Fig. 2), according to the digestion program presented in Table I.

TABLE I
Operating Conditions

Operating conditions for the microwave digestion system			
Step	Temperature (°C)	Ramp Time (min)	Hold Time (min)
1	150	10	5
2	160	10	5
3	190	10	10
4	100	3	2

Fig. 2 Microwave digestion system

The resulting solutions were cooled and diluted to 25 mL with distilled water. The resulted solutions were analysed by ICP-OES. Solutions are shown in Fig. 3.

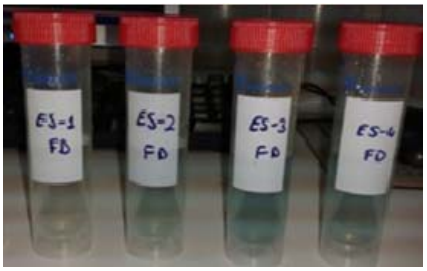

Fig. 3 Resulted solutions

B. Preparation of the Calibration Sets and Elemental Analysis of the Orange Juice Samples

Calibration sets conducted by using K, Mg and P standard solutions. Prepared solutions are shown in Fig. 4.

Fig. 4 Calibration solutions

ICP-OES is a trace-level, elemental analysis technique that uses the emission spectra of a sample to identify, and quantify the elements present [16]. In ICP-OES technique, the sample is subjected to enough high temperatures for causing excitation and/or ionization of the sample of atoms [17]. It has high sensitivity for detecting the major trace elements [18].

Perkin-Elmer Optima 2100 DV model ICP-OES equipped with an AS-93 auto sampler was used in the experiments (Fig. 5). The measured samples are given in Fig. 6.

Fig. 5 Inductively coupled plasma optical emission spectrometry (ICP-OES)

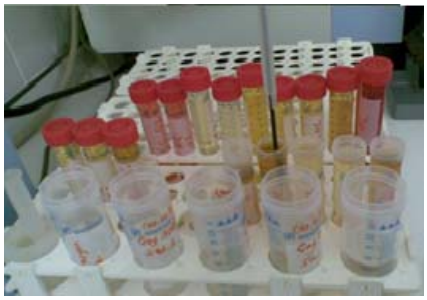

Fig. 6 Measured solutions

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. Analysis Results

Elemental analysis results are shown in Table II. From the results obtained, the maximum element contents are seen in the 100% orange juice and followed by orange nectar. The average Mg, P, K contents in 100% orange juice calculated as 73,25 ppm, 89,27 ppm, 1351 ppm respectively and in orange nectar calculated as 33,76 ppm, 51,30 ppm, 986 ppm respectively.

TABLE II
The Contents of Elements

Element Contents of Orange Juice and Nectar (ppm)			
	Mg	P	K
100% Orange Juice	73,25	89,27	1351
Orange Nectar	33,76	51,30	986

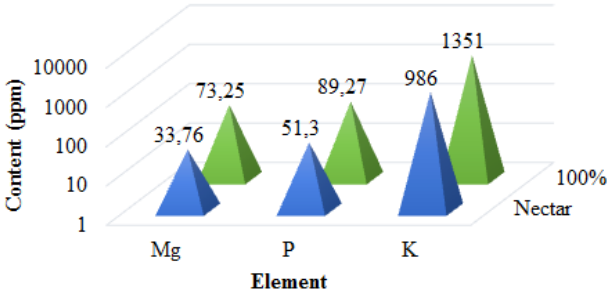

Fig. 7 Elements contents of 100% orange juice and nectar

As can be seen from both Table II and Fig. 7, the K amount in two types of orange juices is the highest and it is followed by P amount and Mg amount.

B. Daily Dosage Calculations

Fruit juices are sold in markets with various amounts such as 200 ml, 330 ml or 1 liters. The intake of Mg, P and K elements from 200 ml and 330 ml of 100% orange juice and nectar is calculated with (1) and (2) respectively.

$$m(mg) = C\left(\frac{mg}{l}\right) \times \frac{l}{1000ml} \times 100ml \times 200 \quad (1)$$

$$m(mg) = C\left(\frac{mg}{l}\right) \times \frac{l}{1000ml} \times 100ml \times 330 \quad (2)$$

where 'm' is the element contents of 200 ml and 330 ml of orange juice, "C" is the element concentration.

Daily essential element requirements for human body in 19-70 ages are in Mg; between 400-420 mg.day^{-1} for men and 310-320 mg.day^{-1} for women, in P; between 700-4000 mg.day^{-1} for both of men and women, in K; maximum 4700 mg.day^{-1} for both of men and women [19].

These elements of intake percentages were calculated by using (3) and the values of daily requirements for human body.

$$DMI = m \times 100 / DRI \quad (3)$$

where "DRI" is recommended dietary reference intakes.

IV. Discussion and Conclusions

Daily maximum element intake for humans is shown in Table III. In Table III, it can be seen that the recommended maximum daily Mg, P and K intake amount which are between 310-420, 700-4000 and 4500-4700 mg for adults respectively. Also the table shows the recommended P and K amounts are the same for men and women between 9-70 years but recommended Mg amount for males is higher than females.

TABLE III
Recommended Maximum Daily Element Intake [19]

	Years	Mg (mg/day)	P (mg/day)	K (mg/day)
Children	1-3	80	460-3000	3000
	4-8	130	500-3000	3800
Males	9-18	240-420	1250-4000	4500-4700
	19-70	400-420	700-4000	4700
Females	9-18	240-360	1250-4000	4500-4700
	19-70	310-320	700-4000	4700

The element contents of the analyzed orange juice were calculated for 200 and 330 ml respectively. Analysis data were shown the percentage element intake for adults (%). Results of Mg, P and K analysis are shown in Tables IV-VI.

Magnesium is a cofactor for enzyme systems. It provides activation of many enzymes. Mg is responsible for the regulation of muscle and nerve function and it also regulates blood pressure and heart rhythm [20]. Magnesium amounts of orange juices and nectars are shown in Table IV.

TABLE IV
Daily Magnesium Intake for Adults

Mg Intake (%)		
	100% Orange Juice	Nectar
200 ml	3,48-4,72	1,60-2,17
330 ml	5,75-7,79	2,65-3,59
1000 ml	17,44-23,62	8,03-10,89

Phosphorus works with Ca to develop and maintain strong bones and teeth; enhances the use of other nutrients. P also provides the storage and transfer of energy and nucleotide synthesis [20]. Phosphorus amounts of orange juices and nectars are shown in Table V.

TABLE V
DAILY PHOSPHORUS INTAKE FOR ADULTS

	P Intake (%)	
	100% Orange Juice	Nectar
200 ml	0,44-2,55	0,25-2,17
330 ml	0,73-4,20	0,42-2,41
1000 ml	2,23-12,75	1,28-7,32

Potassium regulates heartbeat. It maintains fluid balance and helps muscles contraction.

Potassium deficiency causes muscle lassitude and cramps, heart rhythm disturbances, slowing reflexes, and circulatory disorders [20]. Potassium amounts of orange juices are shown in Table VI.

TABLE VI
DAILY POTASSIUM INTAKE FOR ADULTS

	K Intake (%)	
	100% Orange Juice	Nectar
200 ml	5,74-6	4,19-4,38
330 ml	9,48-9,90	6,92-7,23
1000 ml	28,74-30,02	20,97-21,91

As can be seen that element content of orange juices showed differences because of the juice types because of fruit contents and additives.

From the results obtained in this study it can be said that both two types of orange juices element content in 200 ml, 330 ml and 1000 ml lower than daily maximum element intake for adults.

As a result the investigated Turkey brand of 100% orange juices and nectars do not reach the maximum daily dosage of element concentration.

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Funda Demir was born in İstanbul in 1990. Demir graduated B.Sc in 2013 and started M.Sc. in the same year on the Department of Chemical Engineering at Yildiz Technical University, Istanbul. She is interested in food technologies.

Azmi Seyhun Kipcak 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 in 2009 and his Ph.D. studies in 2013 year at Yildiz Technical University. 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.

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

Sabriye Piskin graduated from Istanbul Technical University on Chemical Engineering with M.Sc. degree in 1974. She completed a Ph.D. degree at the same department in 1983. Her research interests include boron minerals and compounds, hydrogen storage technologies, fuel cell applications, materials characterization, coal, waste management, corrosion, implants and synthetic materials production.