COMPARATIVE STUDY ON ESSENTIAL ELEMENTS DISTRIBUTION IN CARROTS AND JUICE CARROTS

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Abstract. *The paper is a comparative study on the distribution of some essential mineral elements in carrots and carrot juice. The total concentrations of K, Ca, Mg, Fe, Mn, Zn and Cu from the carrot samples sold in markets in Timisoara and from the juices obtained by processing them in laboratory conditions were determined by the flame atomic absorption spectrometry method. The obtained results show that the carrot samples taken in the experiment contain different amounts of essential macro and microelements, depending on their origin and the nature of the analyzed element: 2710 - 3560 mg/kg K, 235 - 282 mg/kg Ca, 81.5 - 142 mg/kg Mg, 2.12- 3.52 mg/kg Fe, 3.12 - 4.68 mg/kg Mn, 1.87 - 3.06 mg/kg Zn and 0.31 - 0.56 mg/kg Cu. Lower concentrations, but significant enough to be considered in terms of mineral intake were determined in carrot juice: 1890 - 2425 mg/kg K, 65.8 - 80.2 mg/kg Ca, 118 - 156 mg/kg Mg, 2.86 - 3.72 mg/kg Fe, 0.53 - 1.36 mg/kg Mn, 1.78 -2.91 mg/kg Zn and 0.45 - 1.10 mg/kg Cu. The obtained results show that fresh carrots and their juices contain important and appreciable quantities of mineral essential elements for the normal functioning of the human body. Adequate consumption of fresh carrots or carrot juice could cover a significant part of the daily mineral requirement and could be considered as sources of essential minerals.*

Keywords*: carrot and carrot juice, essential minerals element, mineral intake.*

INTRODUCTION

Carrots (*Daucus carota L.*) among the most important root vegetables of the *Apiaceae* family, are cultivated all over the world (QUE et all., 2019). Carrot roots is a multi-nutrient food source, rich in natural bioactive compounds, which are known for their nutraceutical effects and health benefits (AHMAD et al., 2019). Carrot root contains increased amounts of carotenoids, carbohydrates and dietary fiber and is also rich in minerals (K, Na, Ca, Mg, P, S, Mn, Fe, Cu and Zn) vitamins (A, B, C, E, H) and antioxidants (AHMAD et. all., 2019; QUE et all., 2019; SURBHI et all., 2018; BYSTRICKÁ et all., 2015; PUSHPA, 2020).

Carrots are consumed either raw or cooked and processed into value added products viz. canned carrots, chips, candy, kheer, halvah, powder, juice, beverages, preserve and intermediate moisture products (RAEES-UL and PRASAD, 2015). Carrots classify tenth in terms of their nutritional value among 38 other fruits and vegetables and seventh for their contribution to nutrition (OLALUDE et al., 2015). Carrot juice, obtained by processing carrots is a rich source of vitamins, minerals and fiber with low energy value (ADERINOLA and ABAIRE, 2019; RAEES-UL and PRASAD, 2015). The complexity of the compounds present in carrots or carrot juice gives them many beneficial effects.

Carrot roots helps to protect eyesight, especially night vision, and provides protection against macular degeneration and cataract development, the leading cause of blindness in the elderly (KASALE et all., 2019). Fresh carrot also has a number of antioxidant, anticancer properties (BOADI et all., 2021; AHMAD et all., 2019). Many antidiabetic benefits, cholesterol

reduction and cardiovascular disease, anti-hypertensive, liver-protective, kidney protective and wound healing are associated with a consumption of carrot or carrot juice (PUSHA, 2020; DA SILVA DIAS, 2014; AHMAD et. all., 2019; BYSTRICKÁ et. all., 2015; SURBHI et all., 2018).

Carrot roots is a good supplier of essential mineral elements necessary for metabolic function of human body: K, Ca, Mg, P, Na, Fe, Mn, Cu, Zn, unevenly distributed, depending on the variety of carrot, culture conditions etc. (AHMAD T. et al., 2019). According to the FRIDA database.dk, 100 g fresh carrots contain 40-94.7 mg Na, 225-3380 mg K, 21.2-27.5 mg Ca, 7.3-11.9 mg Mg, 21.3-43.5 mg P, 0.14-0.48 mg Fe, 0.016-0.086 mg Cu, 0.11-0.27 mg Zn, 0.2-0.9 µg I, 0.15-0.69 mg Mn, 0.0-3.2 µg Cr, 0.0-0.9 µg Se, 0.0-3.15 g Ni (Frida database.dk. Carrot raw). Similar values were reported by BUTNARU and BUTU, which showed that according to U.S. Department of Agriculture, Food Central Data, 100g fresh carrot contains 33 mg Ca, 0.30 mg Fe, 12 mg Mg, 35 mg P, 320 mg K, 69 mg Na and 0.24 mg Zn (BUTNARIU and BUTU, 2014).

Analyzing the mineral profile of some fresh vegetables, GOGOASA et all. showed that carrot root contains important amounts of mineral bioelements: 364 mg / kg Ca, 121 mg / kg Mg, 3250 mg / kg K, 8.51 mg / kg Fe, 2.45 mg / kg Zn and 0.29 mg / kg Cu (GOGOASA et all., 2014). The increased contents of the mineral elements in the carrot root are found in the juice obtained from the fresh carrot. The consulted literature provided very little information for the concentration of mineral elements in carrot juice (DOMAGAŁA-ŚWIATKIEWICZ and GASTOŁ, 2012; OLALUDE et all., 2015).

Values of the mineral content are reported for juice mixtures (EL-DAKAK et al., 2016; ADERINOLA T.A. and ABAIRE K.E., 2019) or for carrot juices preserved or obtained only under certain special conditions (KHOMICH et al, 2020). According to the FRIDA fooddata.dk database, canned carrot juice has the following mineral profile: 29.0 mg /100g Na, 292 mg / 100g K, 14.2 mg /100g Ca, 14.0 mg /100g Mg, 24.4 mg /100g P, 0.46 mg Fe, 0.046 mg /100g Cu, 0.18 mg / 100g and 0.13 mg / 100g Mn (FRIDA database.dk. Carrot juice, canned). Important data on the distribution of essential and potentially toxic mineral elements in organic and conventional carrot, celery and red beet juices were also reported by DOMAGAŁA-ŚWIATKIEWICZ and GATOŁ, 2012, which showed that unclarified juices obtained with cold press juicer have the following mineral profile (mg/kg fresh matter): Ca (64.8), K (2306), Mg (135.6), P (378.0), S (153.3), Fe (3.48), Zn (2.05), Cu (0.56), Mn (0.63) , B (0.76), Na (363.9), Sr (0.17), Cd (0.06), Pb (0.009) and Ni (0.18) (DOMAGAŁA-ŚWIATKIEWICZ and GASTOŁ, 2012). Increased concentrations of essential elements in root carrots are also cited by RAEES and PRASAD, which show that 100 g fresh carrots contain 9 - 12 mg Mg, 25 - 280 mg P, 240 - 320 mg K and 40 - 69 mg Na and 2-80 mg Ca (RAEES-UL and PRASAD, 2015). From analysis of the composition of some vegetable juices it was found that the carrot juice obtained by pressing, filtering and pasteurization (at 750 ℃, for 15 min) contains different amounts of calcium (3.20 mg /100 ml), magnesium (1.10 mg /100 ml), phosphorus (4.83 mg /100ml) and potassium (32.10 mg/100ml), (ADERINOLA and ABAIRE, 2019).

Analyzing the nutritional profile of industrially produced carrot juice, KHOMICH et all., found that the analyzed juices contain significant amounts of mineral elements K (139.0 - 400.7), Ca (8.3 - 47.8 mg / 100 cm3), Mg (8.4 - 31.5 mg / 100 cm3), P (19.6 - 25.1 mg / 100 cm3), Fe (0.29 - 0.66 mg / 100 cm3), Mn (0.074 - 0.133 mg / 100 cm3) and Cu (0.04- 0.06 mg / 100 cm3) (KHOMICH et all., 2020). It can be observed that the fresh carrot and the juices obtained by its processing contain important quantities of unevenly distributed essential mineral elements, depending on the origin, the nature of the analyzed element and the way the juice is prepared (COZMA et al, 2020).

MATERIAL AND METHODS

It can be seen that compared to fresh carrots, the distribution of mineral elements in carrot juice shows significant differences. This can be explained by the way of obtaining the juice, the physico-chemical properties of the elements and the way of linking them to the matrix of the carrot from which it was extracted.

The purpose of this experiment is to determine the total concentrations of K, Ca, Mg, Fe, Mn, Zn and Cu from the carrot samples sold in markets in Timisoara and from the fresh juices obtained by processing them in laboratory conditions. The obtained results allow a comparative analysis of the mineral intake between carrot and carrot juice. In order to carry out the experiment, fresh carrot samples were taken from three different markets in Timisoara, from which samples were prepared for the analysis of mineral elements and for the preparation of carrot juice. Carrots were washed, sorted, trimmed in the usual manner and consequently crushed with peel. Unclarified juices were in normal conditions obtained with juicer.

Mineral elements (K, Ca, Mg, Fe, Mn, Zn and Cu) content from carrot and carrot juice, previously dried at 80-90 ℃, was assessed using flame atomic absorption spectrometry method recommended by Gogoasa et all (GOGOASA et all., 2014).

RESULTS AND DISCUSSION

The experimental results obtained in determining the mineral elements from the carrots taken in the experiment and from their juice are presented in table 1. The determinations were made in triplicate for each sample.

Table 1

Comparative distribution of essential elements in fresh carrots and carrots juice

Sample	Values	Mineral elements [mg/kg fresh weight]						
		K	Ca	Mg	Fe	Mn	Zn	Cu
Carrot	*Average*	3100±151	261±19.51	105± 26.48	2.74±0.58	3.72± 0.69	2.24± 0.58	0.42± 0.10
	Limits	2710 - 3560	235 - 282	81.5 - 142	2.12- 3.52	3.12 - 4.68	1.87 - 3.06	0.31 - 0.56
Carrot juice	*Average*	2110±229	72.4±5.94	131±17.68	3.21± 0.37	0.84± 0.51	2.22± 0.49	0.68± 0.30
	Limits	1890 - 2425	65.8 - 80.2	118 - 156	2.86 - 3.72	0.53 - 1.36	1.78 -2.91	0.45 - 1.10

As can be seen from Table 1, the analyzed native carrots contain significant amounts of mineral elements, which variation depending on the origin of the sample and the nature of the analyzed element. The best represented among the analyzed elements are the macroelements that have been determined in certain concentration limits depending on their sampling location: the concentration limits show the following average concentrations: 2710-3560 mg/kg K, 235-282 mg /kg Ca as well as 81.5 - 142 mg /kg Mg. Potassium predominates (determined in an average concentration of 3100 mg /kg), followed by calcium and magnesium, which were determined in much lower and different average concentrations (261, respectively 105 mg /kg). Compared to macroelements, the microelements were determined in much lower concentrations but high enough considering their need in the human body. Concentrations of microelements: 2.12-3.52 mg / kg Fe, 3.12-4.68 mg / kg Mn, 1.87-3.06 mg / kg Zn, 0.31-0.56 mg / kg Cu, shows that fresh carrot has significant amounts of microelements. The best represented of the microelements are Mn, Fe and Cu determined in relatively close

average concentrations (3.72, 2.74 and 2.24 mg/kg). Copper, the essential microelement was determined in much lower concentrations (0.42 mg/kg, mean value), but sufficient given the necessary for copper recommended in the daily diet.

The concentration of the mineral elements in the carrot juice is different from the concentration determined in the carrots. Concentration limits of mineral elements in carrot juice: 1890 - 2425 mg / kg K, 65.8 - 80.2 mg / kg Ca, 118 - 156 mg / kg Mg, 2.86 - 3.72 mg / kg Fe, 0.53 - 1.36 mg / kg Mn, 1.78 -2.91 mg / kg Zn, 0.45 - 1.10 mg / kg Cu, shows that an important part of the minerals present in carrots are found in its juice so that the carrot juice contains sufficiently important quantities necessary for the metabolic processes in the body. Also, in this case, the best represented of the investigated elements are potassium, magnesium and calcium, determined in average concentrations of 2210, 131 and 72.4 mg/kg. The rest of the elements were identified in lower concentrations than macroelements except Mg (0.84 mg / kg), in concentrations close to the average concentrations determined in fresh carrots (3.21 mg / kg Fe, 2.24 mg / kg Zn, 0.68 mg / kg Mn. The concentration of trace elements in carrot juice shows the following decreasing trend: Fe > Zn> Mn≅ Cu.

The concentrations of mineral elements, determined in the samples of carrots and their juices fall within the concentration ranges for this type of vegetable foods (FRIDA database.dk. Carrot raw; FRIDA database.dk. Carrot juice). Analyzing the average concentrations of the essential elements determined in the carrot compared to those identified in the carrot juice, noticeable differences are observed. The largest differences were in potassium, calcium and manganese which were identified in much lower concentrations in carrot juice: 2110 versus 3100 mg/kg K, 72.4 versus 261 mg/kg Ca, 0.84 versus 3.72 mg/kg Mn. Comparing the concentrations of iron, zinc and copper determined in carrots with those identified in carrot juice: 3.21 compared to 2.74 mg/kg Fe, 2. 22 compared to 2.24 mg/kg Zn and 0.68 compared to 0.42 mg/kg Cu, no notable differences are observed. We mention a slight increase of the Fe and Cu content in the carrot juice.

The differences between the mineral content of fresh carrot and carrot juice can be attributed to the different way of binding the analyzed element to the carrot matrix, as well as to the physico-chemical properties of the analyzed element. Therefore, it is difficult to correlate the concentrations of the elements present between the two forms: fresh carrot and carrot juice. Taking into account the average concentrations of the essential elements analyzed in the carrot samples and in the carrot juice, as well as the recommended mineral requirement it can be estimated that adequate consumption of fresh carrots or carrot juice could cover a significant part of the daily mineral requirement and could be considered as sources of essential minerals (DOMAGAŁA-ŚWIATKIEWICZ and GASTOŁ, 2012; GOGOASA et all., 2014).

CONCLUSIONS

The experimental results show that native fresh carrots sold in the local market and their juices contain high amounts of K, Ca, Mg and significant amounts of Fe, Mn, Zn and Cu, unevenly distributed depending on the origin and nature of the element analyzed.

The average concentrations of the essential elements determined in carrot compared to those identified in carrot juice show notable differences.

The largest differences were in potassium, calcium and manganese which were identified in much lower concentrations in carrot juice. Comparing the concentrations of iron,

zinc and copper determined in carrots with those identified in carrot juice, no notable differences are reported.

Taking into account the average concentrations of K, Ca, Mg, Fe, Mn, Zn and Cu in the carrot and in the carrot juice samples, as well as the recommended mineral requirement, it can be stated that adequate consumption of carrots or carrot juice could cover a significant part of the daily mineral requirement.

Therefore, fresh carrots analyzed and their juice could be considered as sources of essential minerals.

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