

FRESH ROOT VEGETABLES AS MINERALIZING FOODS

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Abstract Vegetables occupy an important place in the diet of modern man, these being rich sources of phytonutrients: vitamins (C, A, B1, B6, B9, E), minerals, dietary fiber and phytochemicals. Fresh root vegetables are a rich source of minerals, some of which are essential for the proper functioning of the human body. This paper aims to determine the mineral profile of some root vegetables and evaluate their mineral intake in the daily diet. The concentrations of some essential elements were determined: K, Ca, Mg, Fe, Mn, Zn, Cu and toxic: Pb and Cd, from fresh root vegetables (parsley, carrot and celery) sold in the local market. The results obtained from the analysis of mineral elements show that the fresh root vegetables studied contain significant amounts of unevenly distributed essential elements, depending on the species, the nature of the analyzed element and their origin: 1524 - 3375 mg/kg K, 308 - 352 mg/kg Ca, 181 - 331 mg/kg Mg, 5.75 - 8.27 mg/kg Fe, 1.20 - 2.87 mg/kg Mn, 2.97 - 7.67 mg/kg Zn, 0.70-1.29 mg/kg Cu. Lead and cadmium, heavy metals with pronounced toxicity, have been identified in very small quantities, below the toxicity limits provided by law (0.1 and 0.05 mg/kg for Pb and Cd, respectively). To evaluate the mineral intake, it was found that a consumption of 200 g fresh vegetable covers a large part of the recommended mineral requirement for people aged 19-50 years: 6.48 – 14.36% K, 6.16 - 7.05% Ca, 8.62 – 15.75% Mg, 14.38 – 20.67% Fe, 10.43 – 24.93% Mn, 5.39 - 13.94% Zn and 15.63 – 28.67% Cu – for men and 6.48 – 14.36% K, 6.16 – 7.05% Ca, 16.98 – 20.67 % Mg, 6.39 – 9.19% Fe, 13.33 – 31.85% Mn, 7.42 – 19.17% Zn, 15.63 – 28.67 % Cu – for women. These data confirm that fresh root vegetables can be considered as sources of essential elements and could be considered as additional sources of macro and microelements.

Keywords: fresh vegetable root, parsley, carrot, celery, mineral intake, mineralizing foods

INTRODUCTION

It is well known that regular consumption of vegetables along the fruits in detriment of foods rich in fat and sugar play an important role, in maintaining human health. Due to the natural intake of vitamins, minerals, fiber, enzymes, phytochemicals compounds, regular consumption of vegetables and fruits brings many benefits to the human body. Especially antioxidant vitamins (A, C, E, B group, etc.) and dietary fiber content have important roles in human health. A diet rich in fresh vegetables is associated with good overall health, improved gastrointestinal health and vision, reduced risk for some cancers, heart disease, stroke, diabetes, anemia, gastric ulcer, rheumatoid arthritis and other chronic diseases as well as a lower risk of cardiovascular disease (ULGER T.G., et al, 2016).

Fresh root vegetables are a rich source of minerals, some of which are essential for the proper functioning of the human body. Carrot is one of the important vegetables root with many qualities and benefits for the optimal functioning of the human body due to its special nutritional constituents. The beneficial effects on the body and maintaining good health are due to the

chemical composition of carrots: 80% water, 1% protein, 6% carbohydrates, a series of mineral salts (Na, K, Ca, P, Fe) and a number of vitamins (A B1, B2, B6, C). (GOGOASA et AL., 2014).

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 et al., 2019).

Parsley is a vegetable distinguish oneself for its nutritional and aromatic qualities, being a true accumulation of vitamins, minerals and other active ingredients, with remarkable therapeutic properties. Chemical composition of parsley - root: 85% water, 3% protein, 6% carbohydrates, volatile oil, important amounts of minerals (Na, K, Ca, P, I, Fe, Mg, Mn, S, Cu) as well as a series of vitamins (A, B, C).

Celery is one of the healthiest flavor root vegetables appreciated since ancient times rich in antioxidants and essential vitamins for its therapeutic values. Being a precious source of vitamins, antioxidants, pigments, flavors, organic acids, tanning substances, contains large amounts of minerals – macro- and micro-elements –Na, K, Ca, Mg, P, Fe, Zn, Cu, is considered a medicine-food (VICENTE et al., 2009; YASER et al., 2014). This study aims to determine the mineral profile of some root vegetables and evaluate their mineral intake in the daily diet

MATERIALS AND METHODS

In order to carry out this experiment, fresh root vegetables samples (parsley, carrot and celery) have been collected, from the local markets, Timisoara. These fresh root vegetables bought from the local fresh market were used to compose the samples for analysis. For each vegetable assortment, three homogeneous samples were prepared, previously cleaned by washing and drying by wiping with filter paper. In the analysis of the essential and toxic mineral elements concerned, 5 grams of fresh sample were taken into consideration.

Instrumentation

Nabertherm thermo-adjustable calcination oven model 6/11, was used for calcining vegetable samples. Varian 280 FS Atomic Flame Absorption Spectrophotometer, used to measure the absorbance of mineral elements in standard solutions and sample solutions obtained after mineralization. Also, the Reagents used are Nitric acid Merck, 65% ($\rho = 1.39 \text{ g/cm}^3$) to prepare the nitric acid solution 0.5 N; Multi-element concentrated standard solution (1g/L) Merck-Germany used to prepare working standards for K, Ca, Mg, Fe. Mn, Zn, Cu, Pb and Cd

Method

The determination of the mineral elements concentrations in the vegetable samples was performed by the method of atomic absorption spectrometry in the air-acetylene flame according to the procedure described by Gogoasa et al., 2014. This protocol involves the mineralization of vegetable samples through calcination, followed by the solubilisation of ashes in acid HNO_3 0.5 N and measuring the absorbance of mineral elements in the acid solution.

Basically, $5 \pm 0.0002 \text{ g}$ of each fresh vegetable root was dried (in an electric oven for 4-6 hours at 105°C) and calcined at 550°C until a grayish-white residue appeared. The ashes resulting from calcination was then mixed with 20 ml solution of HNO_3 0.5 N, and then evaporated on an electric stove until almost dry. This operation was repeated two more times, and the solution was brought up to 50 ml with small portions of 15 ml HNO_3 0.5 N each and distilled water, through filtering. Measuring element absorbance in clear solution of 50 ml was done with the flame atomic absorbance spectrometer Varian 280 FS, in air-acetylene flame. The working parameters of the apparatus – wave length, air pressure, acetylene pressure, burner

height, etc. – were decided in accordance with the recommendations of the apparatus supplier. Parallel with the measuring of sample absorbance and under the same working conditions, were determined the absorbances of the calibration solutions. All the mineral composition analyses were performed in triplicate.

In order to evaluate the mineral intake of the root vegetables taken in the experiment, the results obtained from their analysis were used, as well as the daily mineral requirement recommended by the Food and Nutrition Board, Institute of Medicine, National Academies. [https://www.nal.usda.gov/sites/default/files/fnic_uploads/recommended_intakes_individuals.pdf] (table 1).

Table 1

Dietary reference intakes (DRIs): Recommended dietary allowances and elements tolerable upper intake levels elements for the man and women 19-50 ages

Specification	People range	Mineral element, mg/day						
		K	Ca	Mg	Mn	Fe	Zn	Cu
Recommended values	Man	3400	1000	420	2.3	8	11	0.9
	Women	2600	1000	310	1.8	18	8	0.9
Tolerable values	Man	ND*	2500	350	11	45	40	10
	Women	ND*	2500	350	11	45	40	10

* Not determinable owing to a lack of a specific toxicological effect.

The mineral intake (MI) corresponding to each essential element was determined using the relation:

$$MI (\%) = \frac{c}{a} \cdot 100$$

where: MI - mineral intake, c- the amount of elements (mg) contained in the mass from fresh vegetable taken for consumption; a - the recommended amount of element (mg/day).

RESULTS AND DISCUSSION

The experimental results obtained from the mineral essential elements analysis in the samples studied are presented in Table 2.

Table 2.

The distribution of essential and toxic elements (mean values) in some fresh root vegetables

Vegetable	Mineral elements, mg/kg fresh vegetable								
	K	Ca	Mg	Fe	Mn	Zn	Cu	Pb	Cd
Parsley	3375±	352±	331±	8.27±	2.87±	7.67±	1.29±	0.02±	0.03±
	561	99	127	3.02	1.29	4.62	0.76	0.00	0.01
Carrot	1524±	314±	272±72	5.75±	2.47±	3.20±	0.70±	0.02±	0.02±
	649	41		1.90	0.94	0.78	0.31	0.00	0.00
Celery	2265±	308±	181±43	6.17±	1.20±	2.97±	0.88±	0.03±	0.02±
	523	76		1.50	0.29	0.66	0.45	0.01	0.01

As can be seen from Table 2, the concentration of the analyzed mineral elements shows obvious non-uniformity, presenting values between 0.02 mg/kg (for Pb and Cd) and 3375 mg/kg (for K in parsley), depending on the type and origin of the vegetables, as well as the nature of the analyzed element. The best represented of the mineral elements are the macroelements, which represent over 99% of the analyzed mineral elements. Of these, potassium stands out, determined in the highest concentrations in all the analyzed samples. Calcium and magnesium have been identified in relatively comparable concentrations, but much lower than potassium. The essential microelements were determined in much smaller quantities than the macroelements (COZMA A., et al, 2020). Toxic mineral elements: Pb and Cd were determined at very low concentrations, at the device limit detection and below the levels of toxicity.

Potassium, an essential macro-element for humans, whose deficiency causes a series of severe dysfunctions (cardiac arrhythmias, muscle weakness, glucose intolerance) or moderate (high blood pressure, increased risk of kidney stones, stroke etc.) (FAIRWEATHER-TAIT, CASHMAN, 2015), was determined in concentrations between 1524 - 3375 mg/kg (in carrot, respectively in parsley). The highest amounts of potassium were determined in parsley (3375 ± 561 mg/kg); lower concentrations were determined in celery (2265 ± 523 mg/kg) and carrot (1524 ± 649 mg/kg).

Calcium, an essential macroelement for the human body, constituent of bones and teeth, helps regulate nerve and muscle function and is important for blood clotting, blood pressure regulation, immune system health (SOETAN, 2010). It has been determined in lower concentrations than potassium and relatively close to magnesium: 352 ± 99 mg/kg in parsley, 314 ± 41 mg/kg in carrot and 308 ± 76 mg/kg in celery. It can be seen that the distribution of calcium in the three assortments is in relatively close limits, between 308 - 352 mg/kg.

Magnesium, essential macroelement with many biological functions, which regulates various biochemical reactions in the body including protein synthesis, muscle and nerve function, blood glucose control and blood pressure regulation was determined at concentrations ranging from 181 to 331 mg/kg (in celery, respectively in parsley). Richer in magnesium is parsley root (331 ± 127 mg/kg), followed by carrot and celery root with concentrations of 272 ± 72 and 181 ± 43 mg/kg, Mg.

Iron, an essential component of myoglobin, but also necessary for growth, development, normal cell function and the synthesis of hormones and connective tissue (AL-FARTUSIE, MOHSSAN, 2017). This element was determined in the highest concentration compared to the rest of the analyzed microelements. The Fe concentration in the analyzed vegetables shows relatively close values between 5.75 mg/kg, in carrot and 8.27 mg/kg in parsley. However, it can be said that richer in Fe is parsley (8.27 ± 3.02), followed by celery and carrot, with close Fe concentrations (6.17 ± 1.50 , respectively 5.75 ± 1.90 mg/kg).

Manganese, essential microelement which helps the body to form connective tissue, bones, blood clotting factors, which also plays a role in fat and carbohydrate metabolism, calcium absorption, and blood sugar regulation, normal brain and nerve function (AL-FARTUSIE, MOHSSAN, 2017) was determined within concentration limits between 1.20 mg/kg (celery) – 2.87 mg/kg (parsley). Close Mn concentrations were identified in parsley and carrot (2.87 ± 1.29 mg/kg), respectively 2.47 ± 0.94 mg/kg; compared to these, the Mn content in celery is significantly lower (1.20 ± 0.29 mg/kg).

Zinc, an essential microelement that functions as a cofactor for many enzymes involved in metabolism and cell growth, being involved in the metabolism of proteins, carbohydrates, lipids and energy (FAIRWEATHER-TAIT, CASHMAN, 2015) were determined in concentrations comparable to the Fe concentration and slightly higher than the Mn concentration. Zn distribution in the analyzed vegetables shows values between 2.97 mg/kg (celery) - 7.67 mg/kg (parsley).

Copper, essential constituent of several enzymes: cytochrome oxidase, monoamine oxidase, catalase, peroxidase, ascorbic acid oxidase, lactase, and which, due to its presence in a wide variety of enzymes, is involved in many metabolic reactions (AL-FARTUSIE, MOHSSAN, 2017) was determined in the lowest concentrations of all essential elements. The copper concentration in the three varieties of vegetables analyzed shows close values between 0.70 - 1.29 mg/kg (in carrot and parsley, respectively).

Lead and cadmium, elements with pronounced toxic properties for the human body, cause both acute and chronic poisoning, adverse effects on the kidney, liver, heart, vascular and immune systems. European legislation limits the concentrations of lead and cadmium in vegetable oils to a maximum of 0.1 mg/kg for Pb and 0.05 mg/kg for Cd (RADA et al., 2020). The concentrations of these heavy metals in the analyzed vegetable assortments show very low values, between 0.020 - 0.03 mg/kg, below the limit allowed by European legislation. From the results presented above it can be stated that the fresh varieties of root vegetables studied contain increased amounts of macroelements (potassium, calcium and magnesium) and important contents of microelements (iron, zinc, manganese and copper). In addition, these vegetables contain very small amounts of toxic elements, excluding the possibility of contamination with lead and cadmium (DA SILVA DIAS, J.C., 2014; MEHRI A., 2020).

The concentration of essential mineral elements has the following decreasing trend: K> Ca> Mg> Fe> Zn> Mn> Cu. Regarding the total content of essential analyzed elements, it can be seen that in parsley root is concentrated the largest amounts of essential elements (4078 mg/kg). Celery and carrot root accumulate lower mineral contents (2765 and 2122 mg/kg respectively). As a result, the quality of the mineralizing food for these vegetables increases in the order: carrot< celery < parsley. Increased concentrations of essential elements from vegetable roots suggested the evaluation of their mineral intake.

The coverage level of the daily mineral requirement was determined, corresponding to a consumption of 200 g of fresh vegetables. The quantities of essential minerals contained in 200 g of fresh vegetables are presented in table 3.

Table 3.

The essential element contents from 200 g fresh vegetables

Vegetables	Element, mg						
	K	Ca	Mg	Fe	Mn	Zn	Cu
Parsley	675.00	70.47	66.13	1.65	0.57	1.53	0.26
Carrot	304.73	62.87	54.33	1.15	0.49	0.64	0.14
Celery	453.07	61.60	36.20	1.23	0.24	0.59	0.18
Average values	453.07	61.60	36.20	1.23	0.24	0.59	0.18

The evaluation of the mineral intake for a consumption of 200 g fresh vegetable, respectively the coverage percentage of the daily mineral requirement recommended K, Ca, Mg, Fe, Mn, Zn and Cu are presented in table 4.

Table 4.

The mineral intake corresponding to 200g fresh vegetable for men and women aged 19-50 years

Vegetable	Specification	Mineral intake %						
		K	Ca	Mg	Fe	Mn	Zn	Cu
Parsley	Men	14.36	7.05	15.75	20.67	24.93	13.94	28.67
	Women	14.36	7.05	20.67	9.19	31.85	19.17	28.67
Carrot	Men	6.48	6.29	12.94	14.38	21.45	5.82	15.63
	Women	6.48	6.29	16.98	6.339	27.41	8.00	15.63
Celery	Men	9.64	6.16	8.62	15.42	10.43	5.39	19.56
	Women	9.64	6.16	11.31	6.85	13.33	7.42	19.56
Average values	Men	10.16	6.50	12.43	16.79	18.84	8.36	21.48
	Women	10.16	6.50	16.32	7.46	24.07	11.50	21.48

As can be seen from Table 4, a daily consumption of 200 g vegetable root contributes differently to ensuring the daily requirement of essential elements, depending on the variety of vegetables, the content of the concentration of the essential element in the mass of vegetables consumed, the mineral needs recommended and category of consumers (men or women, age). Under the conditions of the present experiment, the percentage of coverage of the daily mineral requirement has the following values: 6.48% with K (men and women) for carrot- 14.36% with K (men and women) for parsley; 6.16% with Ca (men and women) for celery - 7.05% with Ca (men and women) for parsley; 8.62% with Mg (men) for celery - 20.67% with Mg (women) for parsley; 6.39% with Fe (women) for carrot - 20.67% with Fe (men) for parsley; 10.43% with Mn (men) for celery - 31.85% with Mn (women) for parsley; 5.39% with Zn (men) for celery - 19.17% with Zn (women) for parsley; 15.63% with Cu (men and women) for carrot - 28.67% with Cu (men and women) for parsley. It can be seen that parsley root ranks first in terms of the contribution of essential elements. Taking into account the average values of the concentrations of the mineral elements analyzed in the three varieties of vegetables, a consumption of 200g of fresh vegetables (such as salads, nectar, etc.) would cover the following percentages of the daily mineral requirement: 10.16% from K, 6.50% from Ca, 12.43% from Mg, 16.79% from Fe, 18.84% from Mn, 8.36% from Zn and 21.48% from Cu – for men and 10.16% from K, 6.50% from Ca, 16.32% from Mg, 7.46% from Fe, 24% from Mn, 11.50% from Zn and 21.48% from Cu – for women.

Therefore, under the conditions of the present experiment, the average mineral intake shows the following decreasing trend: Cu (21.48) > Mn (18.84%) > Fe (16.79%) > Mg (12.43%) > K (10.16%) > Zn (8.36%) > Ca (6.50%) – for men and Mn (24.07%) > Cu (21.48) > Mg (16.32%) > Zn (11.52%) > K (10.16%) > Fe (7.46%) > Ca (6.50%) – for women. A possible supplementation of the vegetables consumption in order to increase the mineral intake may be possible, but with caution in accordance with tolerable upper intake levels for each bioelement. Any supplementation of vegetable root brings with it other compounds that exceed certain limits, so the concentrations may have harmful side effects. These data confirm that fresh root

vegetables represent a sources of essential elements and could be considered as additional sources of macro and microelements.

CONCLUSIONS

The assortments of the fresh root vegetables (parsley, carrot and celery) studied contain increased amounts of macroelements (potassium, calcium and magnesium) and important contents of trace elements (iron, zinc, manganese and copper). In addition, these vegetables contain very small amounts of toxic elements (Pb and Cd), below the limits of toxicity imposed by European legislation, so that a possible contamination with lead and cadmium is excluded.

The distribution of the analyzed essential elements shows obvious non-uniformity, their concentration presenting values between 0.70 mg / kg (for Cu in carrot) - 3375 mg / kg (for K in parsley), depending on the assortment and origin of vegetables, as well as the nature of the analyzed element. The concentration of the essential elements analyzed in the varieties of vegetables taken in the experiment follows the following decreasing trend: K > Ca > Mg > Fe > Zn > Mn > Cu.

Parsley, concentrates the largest amounts of essential elements (4078 mg/kg) while roots of celery and carrot accumulate lower contents of essential minerals (2765 and 2122 mg/kg respectively). As a result, the quality of the mineralized food of these vegetables increases in the order: carrot < celery < parsley.

The results obtained from the evaluation of the monthly intake show that a consumption of 200 g fresh vegetable, covers a good part of the daily requirement recommended by K, Ca, Mg, Fe, Mn, Zn and Cu, depending on the vegetable assortment, the element content in mass of vegetables taken for consumption, the mineral requirement recommended by the category of consumers (men or women and age).

The average mineral intake shows the following decreasing trend: Cu (21.48) > Mn (18.84%) > Fe (16.79%) > Mg (12.43%) > K (10.16%) > Zn (8.36%) > Ca (6.50%) – for men and Mn (24.07%) > Cu (21.48) > Mg (16.32%) > Zn (11.52%) > K (10.16%) > Fe (7.46%) > Ca (6.50%) – for women.

In conclusion, it can be said that fresh root vegetables can be considered as sources of essential elements being additional sources of macro and microelements.

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