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Research of the mineral composition of freeze-dried plant powders

E N Demina^{1,4}, O V Safronova¹, I K Kuprina¹, I V Kochieva² and S K Abaeva³

¹ Orel State University named after I. S. Turgenev, 95, Komsomolskaya str., Orel, 302026, Russia

² North-Caucasian Mining and Metallurgical Institute, 44, Nikolaeva str., Vladikavkaz, RSO-Alania, 362021, Russia

³ North Ossetian State University after K. L. Khetagurov, 44-46, Vatutina str., Vladikavkaz, RSO-Alania, 362025, Russia

⁴E-mail: deminakate1@yandex.ru

Abstract. The article presents the results of studying the mineral composition of strawberry, raspberry, apricot, black currant and pumpkin powders. The powders under study were obtained by freeze-drying using an innovative resource-saving technology. The results of the determination of mineral substances indicate the full composition of vegetable powders. The level of satisfaction of the daily requirement for basic macronutrients varies from 1.3 % in terms of sulfur content to 64.4 % in terms of potassium. The rate of consumption of trace elements has a value of 3.4 % for copper, reaching a maximum of 138 % for the content of cobalt. The results of the study of the mineral composition of freeze-dried vegetable powders indicate the feasibility of using them as a source of minerals in the composition of enriched products.

1. Introduction

An important nutritional factor that is of particular importance for human health is a full and regular supply of the body with the necessary micronutrients: vitamins and minerals. Minerals, along with proteins, fats, carbohydrates and vitamins, are special elements of nutrition. They are involved in all processes occurring in the human body. Micronutrients are essential substances of food, which are necessary for the normal implementation of metabolism, ensuring vital functions. Therefore, these food components must be supplied with food in an amount corresponding to physiological norms [1].

The source of mineral substances is enriched food products containing functional ingredients. A promising direction in the development of functional products is the use of enriching components in the formulation, which may include vegetable and fruit and berry powders. Vegetable raw materials are rich in almost all the necessary antioxidants, vitamins, minerals and polysaccharides, which reduce the risk of developing socially significant diseases. Therefore, the use of vegetable powders in the development of fortified food products is appropriate [2].

2. Relevance, scientific significance of the issue

Of practical interest is the use of plant raw materials obtained by freeze-drying in the composition of enriched products. The advantages of freeze-drying are the high level of preservation of organoleptic characteristics in dried food products, which can be used to give the developed products new consumer



properties, as well as to create innovative technologies for storing and selling perishable food products. In freeze-dried products, a high level of preservation of thermolabile components - vitamins, enzymes, and amino acids-is noted. In addition, freeze-dried powders are characterized by rapid rehydration, complete solubility in the composition of fine and powdered materials [3].

The aim of the work was to study the mineral content of freeze-dried vegetable powders and determine whether the level of satisfaction of the daily requirement for certain substances corresponds to the physiological norms of the daily requirement [4].

3. Material and methods

The objects of the study were strawberry, raspberry, black currant, apricot and pumpkin powders, which were obtained on the device of a vacuum drying device. The innovative technology provides for the use of a low-power lyophilizer designed for freeze-drying food products under conditions of deep vacuum, which reduces production costs by reducing the material consumption and energy consumption of the process [5]. The freeze-dried powders obtained in this way have good organoleptic characteristics and standard quality indicators.

The mineral composition was determined by atomic adsorption spectrometry using an inductively coupled plasma emission spectrometer SCp (Liber-z-220) manufactured by Variant. Calibration was carried out according to the standards of the company "Megek". All studies were carried out in four repetitions.

4. Results and discussion

According to the literature data, the studied plant raw materials in fresh form have a full-fledged mineral composition. Strawberries contain potassium in the amount of 160 mg, calcium – 40 mg, magnesium – 18 mg, sodium – 16 mg, phosphorus – 23 mg per 100 g of the product. Strawberries are a source of such trace elements as copper – 125 mcg, cobalt – 4 mcg, iron – 1.2 mg, molybdenum – 10 mcg. The following macronutrients were determined in the composition of raspberries: potassium – 225 mg, calcium – 40 mg, sulfur – 16 mg, phosphorus – 37 mg per 100 g of the product. Among the micronutrients, silicon prevails – 39 mg, copper – 170 mcg, and molybdenum – 15 mcg. The mineral composition of apricot is characterized by the presence of potassium – 305 mg, calcium – 28 mg and phosphorus – 26 mg. A sufficient amount of silicon – 5 mg, manganese-0.22 mg and copper – 140 micrograms per 100 g of the product was also determined. Black currant berries contain an average of 350 mg of potassium, 36 mg of calcium, 32 mg of sodium, 33 mg of phosphorus, 60 mg of silicon, 130 mcg of copper, 24 mcg of molybdenum, and 13 mg of iron [6]. Macronutrients of pumpkin fruits are represented by potassium – 204 mg, calcium – 25 mg, phosphorus – 25 mg. In the composition of the micronutrients, silicon – 30 mg, copper – 180 mg, molybdenum – 4.6 mg, iron – 0.4 mg, zinc – 0.24 mg were determined.

It is experimentally proved that in the process of freeze-drying, oxidative transformations, reactions of melanoidin formation, enzymatic processes occur, which can contribute to changing the mineral composition of fruit, berry and vegetable powders. The results of the study of freeze-dried vegetable powders are presented in table 1.

Table 1. The results of the study of the mineral composition of plant raw materials.

Minerals substances	Consumption rate for adults, mg / mcg	Content per 100 g of product				
		strawberry powder	raspberry powder	apricot powder	blackcurrant powder	pumpkin powder
Macronutrients						
Potassium, K, mg	2500	703.6	866.4	1051.5	923.9	1610.7
Calcium, Ca, mg	1000	124.3	163.8	174.2	223.3	216.2
Magnesium, Mg, mg	400	73.1	117.5	156.4	149.3	170.4

Sodium, Na, mg	1300	62.7	131.2	132.7	152.2	90.7
Phosphorus, P, mg	800	115.7	136.7	174.4	128.6	340.1
Sulfur, S, mg	750	9.4	81.6	27.4	15.5	124.4
Micronutrients						
Iron, Fe, mg	14	9.9	3.8	8.5	9.7	11.6
Zinc, Zn, mg	12	2.4	2.8	5.3	3.1	3.6
Manganese, Mn, mg	2	0.7	0.3	0.8	1.1	1.4
Silicon, Si, mg	30	18.3	6.4	19.1	17.8	22.8
Molybdenum, Mo, mcg	70	51.6	68.6	25.5	72.3	53.7
Copper, Cu, mcg	1000	226.1	381.0	464.1	252.4	34.0
Cobalt, Co, mcg	10	6.6	11.8	8.8	13.8	8.1
Selenium, Se, mcg	55	4.8	16.1	7.5	7.8	6.1
Nickel, Ni, mcg	60	24.5	34.6	26.7	22.7	42.4

The daily requirement for mineral substances was determined taking into account the physiological norms of consumption in the main food components when consuming 100 g of the product [4]. The calculation results are shown in the figure 1.

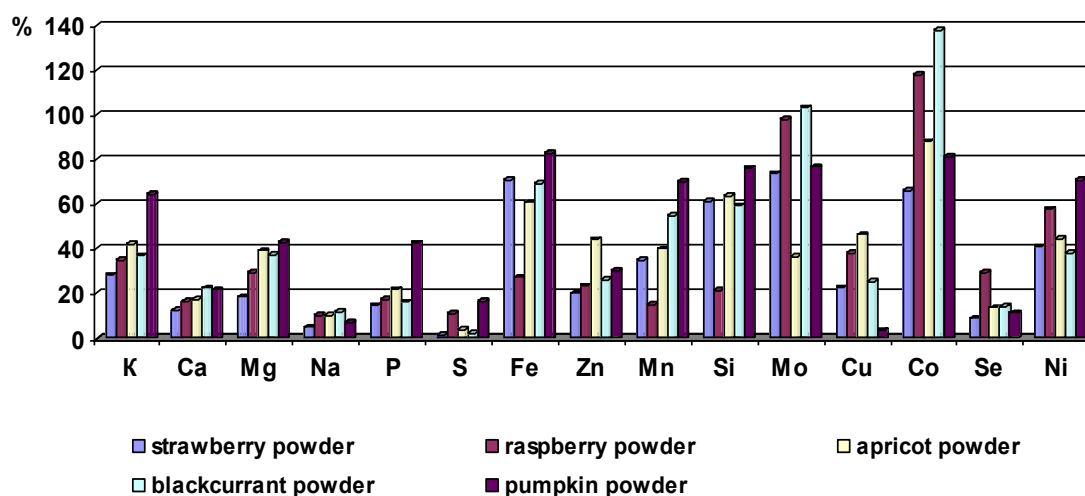


Figure 1. Satisfaction level in essential minerals, %.

The analysis of the obtained results showed that all the studied plant powders are characterized by a balanced mineral composition. They contain a large amount of potassium, the maximum value is noted in pumpkin powder, which is 64 % of the daily intake. It is proved that potassium is necessary for the normal activity of the muscular system, including cardiac activity, contributes to the maintenance of water balance, osmotic pressure and the acid-base state of the internal environment of the body. The maximum amount of calcium is determined in the composition of black currant powder. The level of satisfaction in this element is from 12.4 to 21.6 % in the studied powders. According to the literature, the content of calcium salts in the human body exceeds the amount of all other elements. This macronutrient is involved in the formation and strengthening of bone tissue. The absorption of calcium depends on the amount of phosphorus, fat, oxalic acid and phytin, the excess of which reduces the intensity of this process.

The studied powders are characterized by a significant content of magnesium, their amount is from 18.3 to 42.6 % of the physiological norm of consumption, and the maximum amount is recorded in pumpkin powder – 170.4 mg. Magnesium affects the activity of redox processes, transmits neuromuscular impulses that promote muscle relaxation, is an essential element of ribosomes and binds amino acids to RNA in the process of protein synthesis [7]. Sodium in the human body generates nerve impulses, participates in muscle contraction, and regulates blood sugar levels. In vegetable powders, the sodium content is from 62.7 to 152.2 mg per 100 g of the product, the minimum amount is determined in strawberry powder. Since sodium is a potassium antagonist, its low content in the studied objects is a positive factor.

The satisfaction level in phosphorus ranges from 14.5 % for strawberry powder to 42.5 % for pumpkin powder. Phosphorus, along with calcium, is part of proteins, phosphatides, and forms bones, teeth, and nerve cells in the human body. Strawberry, apricot and blackcurrant powders are characterized by a low sulfur content – the satisfaction level is from 1.3 to 3.6 %, in contrast to raspberry and pumpkin powders, for which this indicator is 10.8 and 16.6%, respectively. The physiological role of sulfur is that it is part of the amino acids cystine and cysteine, which support the structure of proteins. In the human body, sulfur maintains the stability of the structure of proteins and is part of the essential amino acids [8].

In raspberry powder, the level of satisfaction in iron is 27.1 %, in the rest of the studied products, the amount of this trace element is higher – from 60.7 to 82.8% of the daily physiological norm of consumption. It should be noted that iron is involved in the formation of blood hemoglobin, contributes to the normal functioning of the muscles. Manganese in the human body regulates the level of glucose in the blood, normalizes brain activity, affects lipid metabolism and prevents the deposition of fat in the liver. Its content in the studied powders is from 0.3 to 1.4 mg per 100 g of the product.

In the composition of vegetable powders, a fairly high content of zinc is noted, the physiological norm reaches from 20 % in strawberry powder to 44.2 % in apricot powder. Zinc increases the body's resistance to infectious diseases, is part of more than 300 enzymes, participates in the synthesis and breakdown of carbohydrates, proteins, fats, and nucleic acids. The trace element silicon plays an important role in the course of all physiological processes, helps to ensure the full state of connective tissue: blood, bones, cartilage, tendons [7]. The level of satisfaction in this element when using 100 g of powders ranges from 21.3 for raspberry powder to 76 % for pumpkin powder.

Molybdenum, which promotes carbohydrate metabolism in the human body, is present in large quantities in the studied plant powders-from 25.5 to 72.3 mg per 100 g of the product. At the same time, the satisfaction level in molybdenum in blackcurrant powder is 103 %. In the composition of fruit and berry powders, a sufficient amount of copper was found from 226.1 to 464.1 mg, in pumpkin powder, the amount of this trace element is much lower – 34 mg per 100 g of the product. It is known that copper is involved in the formation of collagen and elastin, promotes the transition of iron to hemoglobin. The biological role of cobalt, the level of satisfaction of which in plant powders is from 66 to 138 %, is an active participation in enzymatic reactions for the transfer of hydrogen and the methyl group between substances.

The trace element composition of the studied products is characterized by the presence of a sufficient amount of nickel, which affects the processes of hematopoiesis and is involved in many redox processes in the body. The level of satisfaction for this element is from 40.8 to 70.6 %, with the maximum value recorded in pumpkin powder. The highest amount of selenium, 16.1 micrograms, is found in raspberry powder, which is 30 % of the daily physiological intake. For other powders, this indicator is 8.7-14.2 %. According to the literature, selenium plays an important role in the human body: it increases immunity and prevents the development of tumors.

5. Conclusions

Thus, the results of the study of the mineral composition of freeze-dried vegetable powders indicate the feasibility of using them as a source of minerals in the composition of enriched products, including in the formulation of dairy products. In addition, the excellent organoleptic characteristics of fruit, berry

and vegetable powders allow them to be used as flavoring and coloring substances in the composition of functional food products.

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