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Physicochemical research of macro- and microelements composition of tomato juice with various additives

The role of micronutrients for human organism is considered in the article. An inadequate diet and deficiency of macro- and microelements are the reasons of various kinds of illnesses. Obtained research results show that tomato juice enriched by greenery additives and with pectin has useful minerals. By physicochemical research methods, particularly Mass-spectrometry and Scanning Electron Microscope (were discovered) has been found new information about the macro- and microelements compositions of raw components grown in the South Kazakhstan region: tomatoes, dill, parsley and celery.

Key words: macro- and microelements, tomato juice, greenery, functional foodstuff, pectin, physical-chemical research.

Introduction

Nowadays at the demographic growth of the world population, a demand in ensuring of a balanced diet increases and at the deterioration of environment appears one of the relevant issues — a protection of human health and development the new functional foods. Such functional products should include natural juices, nectars and other fruit-vegetable canned products. Due to the development of new recipes of foodstuff for functional purpose by using the natural plants is one of the promising directions in the prevention and treatment of various diseases. Among such treatment-and-prophylactic plants can be distinguished: tomatoes, different types of greenery and pectin [1, 2].

Deficiency in the diet of essential proteins, vitamins, macro- and microelements, dietary fibers will form the risk factors of a large number of common chronic diseases. It reduces the functional activity of immune system, greatly increases the probability of development of hard curable diseases, also reduced immunity and protective potential of the body in relation to adverse environmental factors. In this regard, the solution of the urgent problem — the formation of the healthy population, connected with a necessity of creation the functional, medical-preventive food products, systematic method that not only improves the course of physiological processes in the organism and strengthens the human health [1].

The natural canned juices contain all the necessary chemical elements and available during a full year. So, for maintaining a healthy organism is recommended daily intake about 200 ml of natural juices. Unfortunately, the level of consumption of juice-containing beverages per capita in the Kazakhstan is below the average of developed countries. However, the assortment of offered local fruit-and-vegetable canned production not sufficiently corresponds to the consumer's demand and requires the creation of new recipes of treatment-prophylactic food products.

Tomato juice is very rich in potassium, magnesium, zinc, iron contains some other elements. The presence of vitamin C in tomato juice improves the immune system and strengthens the human organism. All types of greenery are rich in macro — and microelements that are very important for balanced diet. Dill, celery and parsley easily digested by human and are widely used in herbal medicine and in many culinary reci-

pes. Fiber of pectin has a unique sorption properties and ion selective activity to the allocation of heavy metals and toxins from the organism of the patient [3].

Thus, in the presented work a special value has the development of functional food products based on the local vegetative raw material with treatment-prophylactic properties. Minerals are essential micronutrients for the human body. They take place in the cytoplasm and biological processes, and provide constancy of osmotic pressure that is important for the normal vital activity of cells and tissues. Micro elements are considered essential, in their lack or absence the normal body activity is broken.

At small intake of minerals, the human body functions are on the verge of survival. This is due to the lower activity of enzymes and cofactors that includes this element, and vice versa in the case of the element dose increasing occurs the toxic effect, then in the result probably will be a fatal outcome [4].

Long-term shortage or surplus in the diet of some mineral substances leads to metabolic violation of proteins, carbohydrates, fats, vitamins, water and development of appropriate disease. Table 1 shows the deficiency of several chemical elements in the human body [1].

Table 1

Consequences of the deficiency of basic macro- and micro-elements in the human organism

Macroelements	Ca	Violation of the growth and strengthening of skeleton: in children develop rickets and osteoporosis in adults; restlessness, muscle spasms
	Na	deficiency or excess appear violations of the cardiovascular system, disorders of kidney and water-salt metabolism, diabetes mellitus
	Mg	Insomnia, muscle spasms, kidney stones, migraine, physical and mental fatigue, nervousness, pain in the joints
	K	Deficiency or excess appear violations of the cardiac muscles, drowsiness, decreased blood pressure
	P	Thyroid disease, inadequate work of the brain, depression, loss of appetite, reduced immunity, osteoporosis
Microelements	Fe	Anemia, impaired immune system, heart attack, hair loss
	Zn	Slowdown, disorders of the nervous system, the skin damage
	Cu	Secondary anemia, violation of the activity of liver, the weakness of the arteries
	Mn	Anemia, infertility, growth impairment skeleton
	Cr	Symptoms of diabetes
	Co	Pernicious anemia
	Ni	Depression, dermatitis
	Mo	Slowed cell growth, the tendency to tooth decay
	Se	Weakness of the heart muscle stress and disease, cardiomyopathy

Materials and methods

Research objects: As the objects of the research were selected: ripe red tomatoes, various kinds of greenery: dill, parsley, celery, also beet and citrus pectins. In the preparation of tomato juice were used domestic tomatoes and greenery that have grown in the South Kazakhstan region. Comparative analyses were considered in relation to the tomato juice «Pesnya Leta (Summer Story)» product of the JSC «Ecoproductgroup» of South Kazakhstan region.

The content of mineral substances in tomato juice was determined by the method of Mass-spectrometry with inductively coupled plasma (ICP-MS) and using a Scanning Electron Microscope (SEM). The method of mass-spectrometry with inductively coupled plasma (ICP-MS) allows defining a number of metals and several non-metals at concentrations up to 10^{-10} %, i.e. one particle of 10^{12}, with the atomic mass from 7 to 250, i.e. from Li to U elements. It is able to determine the content of nanograms per liter to 10 to 100 milligrams per liter. The method is based on using of the inductive-connected plasma, as a source of ions and mass spectrometer for their separation and detection in an argon atmosphere.

Unlike atomic absorption spectroscopy, defining only one element, ICP-MS can identify all elements simultaneously, which allows to considerably speed up the process of measurement [5].

Scanning electron microscope (SEM) allows observing the subtle features of using micro analyzing of chemical composition, and the details of the structure of micro-objects on the atomic and molecular level. It can also to receive the image of object surface with a high (up to 0.4 nm) spatial resolution, also information about the composition, structure and some other properties of the surface layers. SEM has a great depth of

focus that allows observing the three-dimensional image of the structure with the possibility of its qualitative evaluation [6, 7].

Preparation of ash samples for the analysis of the chemical composition were performed according to the SS 26929–94 (State standard) [8]. The method of dry mineralization is based on full decomposition of organic substances by combustion of the sample in an electric stove at a controlled temperature of 450–500 ºC.

Results and discussion

In the Table 2 is shown the data of chemical composition of ash of tomato juice that obtained by SEM (Scanning Electron Microscope).

Table 2

Microelement composition of the ash of tomato juice by SEM

Elements	№ 1 Tomato juice, %	№ 2 Tomato juice with juice of greenery, %	№ 3 Tomato juice with fresh chopped greenery %	№ 4 Tomato juice with dry chopped greenery, %	№ 5 Tomato juice with dry chopped greenery and with sugar beet pectin, %	№ 6 Tomato juice «Pesnya Leto» of JCS «Ecoproductgroup», %
Na	1.52	0.90	1.62	1.61	1.38	22.05
Mg	2.42	1.92	2.69	2.41	2.16	1.59
Si	0	0.07	0.09	0	0	0.45
P	3.74	4.13	2.64	3.55	3.85	1.12
S	2.25	1.57	2.54	2.53	2.32	0.38
Cl	6.30	8.18	7.69	6.02	6.52	38.29
K	52.52	55.76	52.35	50.60	53.18	15.62
Ca	2.77	1.52	2.12	3.33	2.64	1.46
Zn	1.58	–	–	2.99	1.32	
Fe	0.32	0.48	2.18	–	–	0,10

The obtained analyses are presented in the figures 1–6:

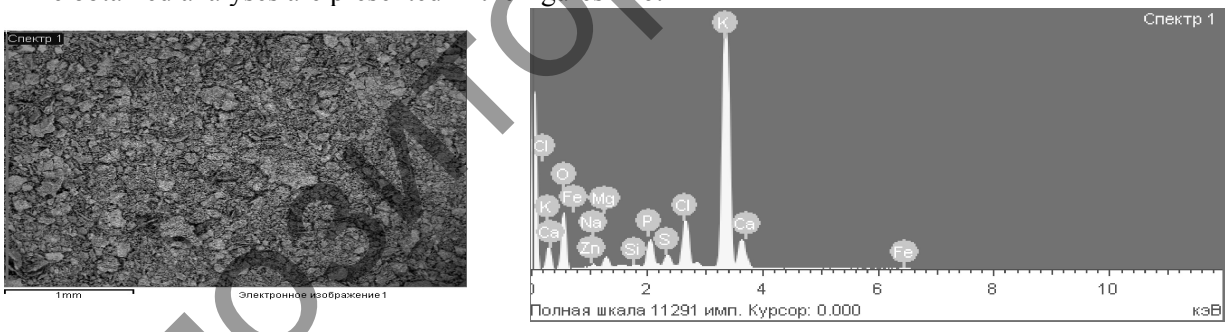

Figure 1. Sample № 1, Tomato juice

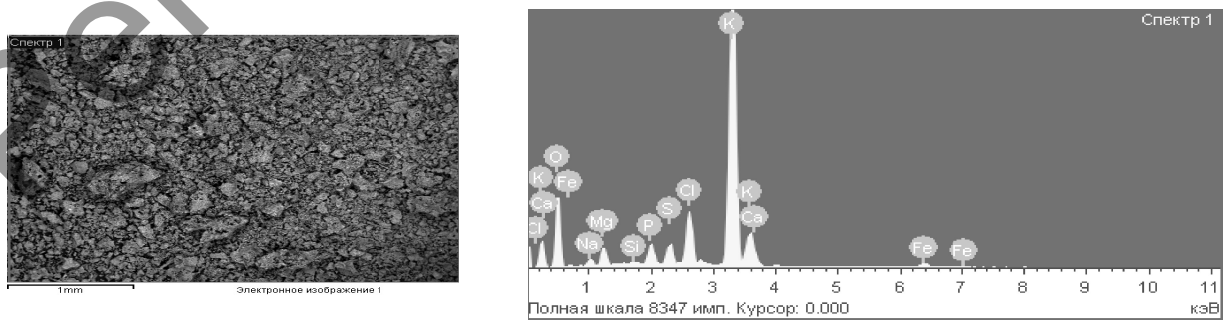

Figure 2. Sample № 2, Tomato juice with juice of greenery

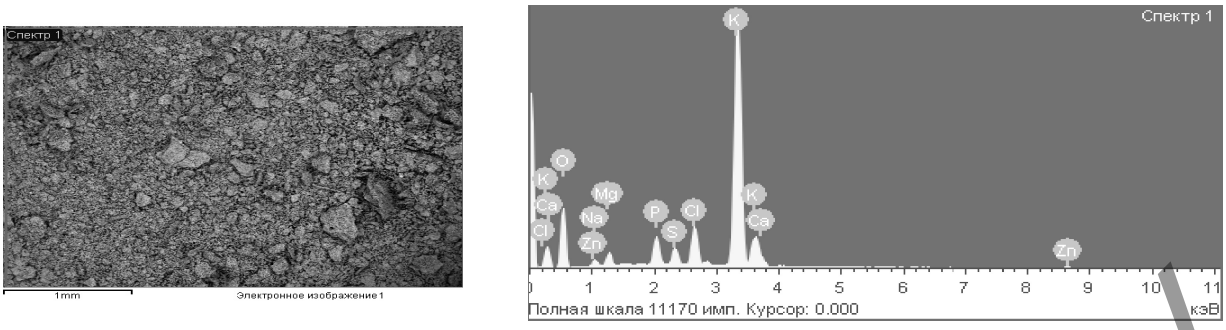

Figure 3. Sample № 3, Tomato juice with fresh chopped greenery

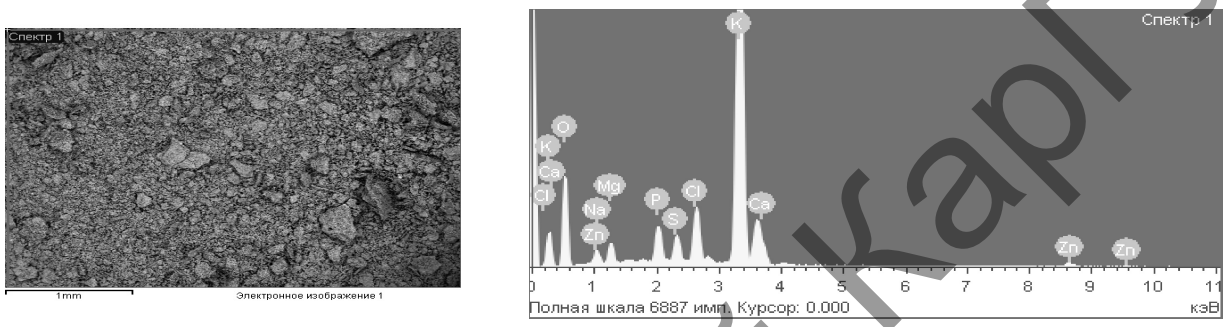

Figure 4. Sample № 4, Tomato juice with dry chopped greenery

Figure 5. Sample № 5, Tomato juice with dry chopped greenery and with sugar beet pectin

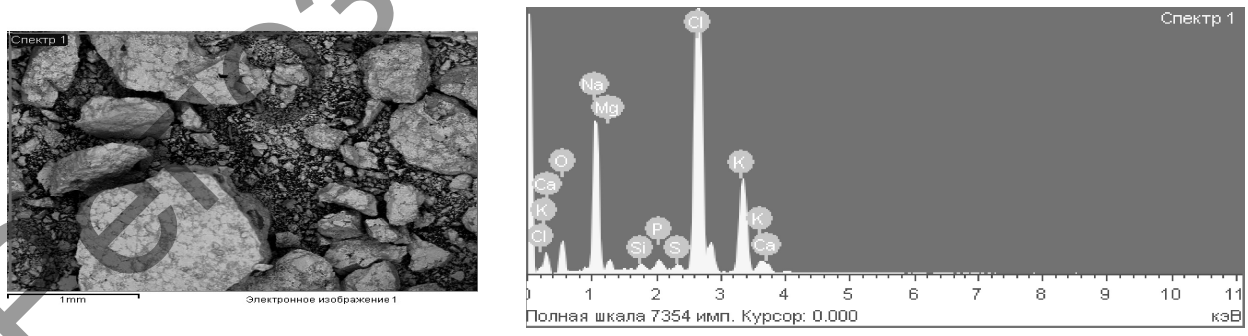

Figure 6. Sample № 6, Tomato juice «Pesnya Leto» from JSC «Ecoproductgroup»

In the following Table 3 is shown the data of chemical composition of ash of tomato juice with various quantities of greens additives, obtained by SEM (Scanning Electron Microscope).

Table 3

Chemical composition of the ash of tomato juice with various quantities of greenery additives obtained by SEM

Elements	№ 1 Tomato juice	№ 2 Tomato juice with salt	№ 3 Tomato juice with 0,5 % greenery	№ 4 Tomato juice with 1 % greenery	№ 5 Tomato juice with 3 % greenery	№ 6 Tomato juice with 5 % greenery
Na, %	2,57	25,96	2,46	3,19	3,84	4,17
Mg, %	1,69	1,21	2,27	2,52	3,10	3,34
Si, %	0,42	0,20	0,24	0,37	0,61	0,68
P, %	4,15	1,63	4,16	4,30	4,53	4,53
S, %	1,28	0,77	1,81	1,64	1,32	2,06
Cl, %	10,96	38,90	9,85	10,06	10,40	9,56
K, %	54,42	13,27	51,31	47,36	41,17	37,38
Ca, %	1,85	0,94	4,06	6,04	9,65	11,36
Al, %	0	0,03	0	0,03	0	0,08

The obtained data are shown in the following figures 7–12.

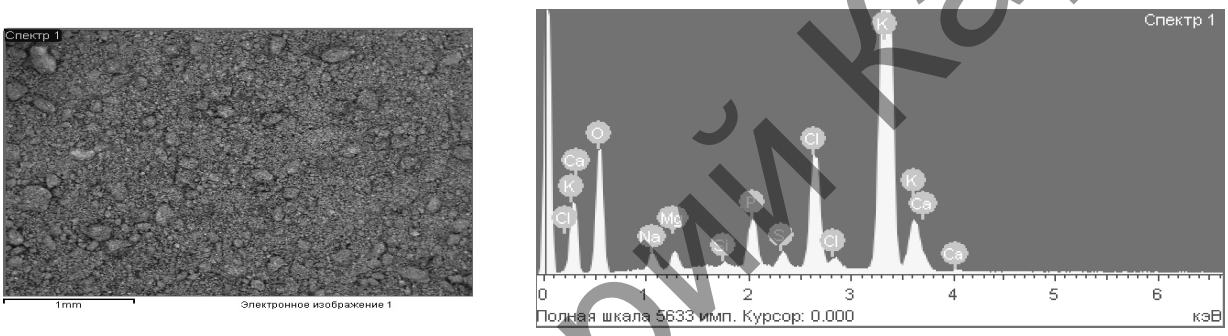

Figure 7. Sample № 1, Tomato juice

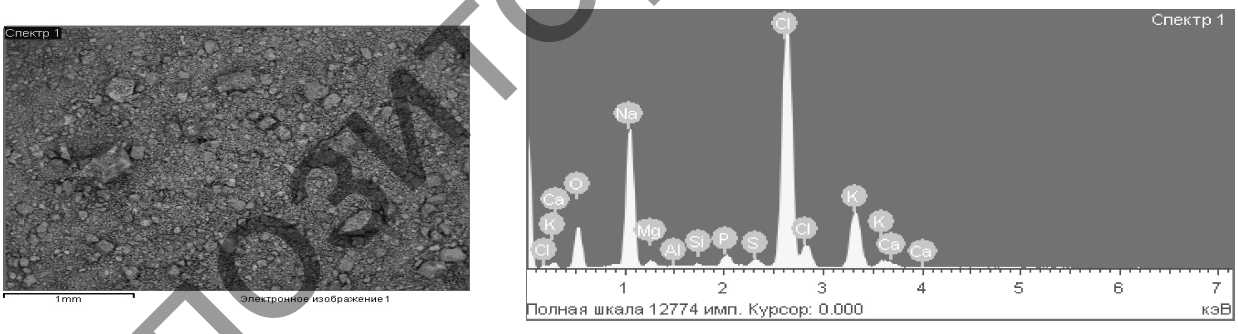

Figure 8. Sample № 2, Tomato juice with salt

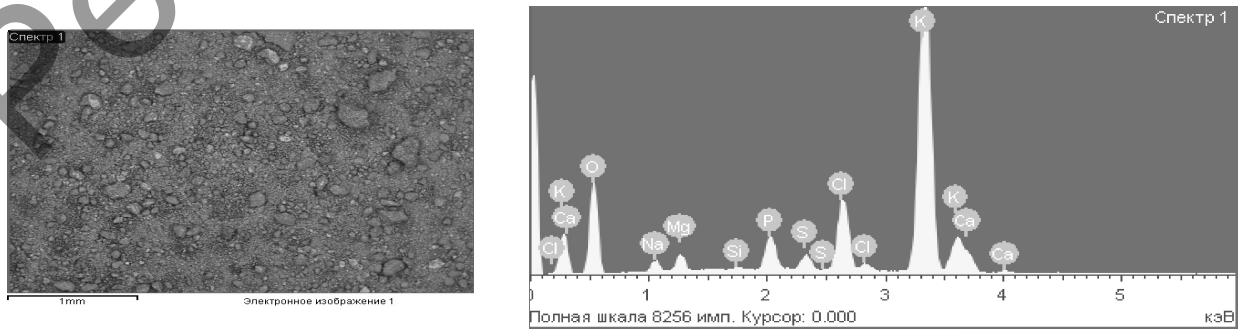

Figure 9. Sample № 3, Tomato juice with 0.5 % greenery

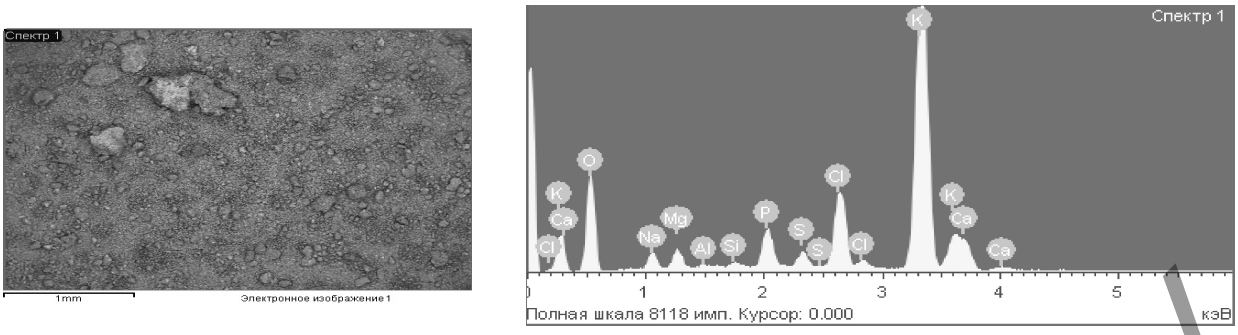

Figure 10. Sample № 4, Tomato juice with 1 % greenery

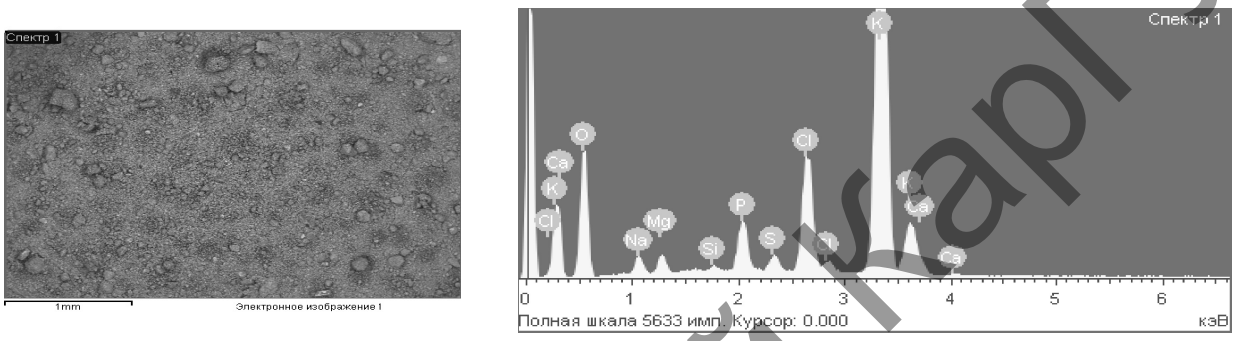

Figure 11. Sample № 5, Tomato juice with 3 % greenery

Figure 12. Sample № 6, Tomato juice with 5 % greenery

The chemical composition of the ash of dill, parsley and celery additives by SEM is shown in the Table 4.

Table 4

The chemical composition of the ash of greenery additives

Elements	№ 1 Dried dill	№ 2 Dried parsley	№ 3 Dried celery	№ 4 Mixture of three types of greenery
Na, %	5,04	4,78	4,62	4,81
Mg, %	3,48	3,67	3,35	3,50
Al, %	0.33	0,27	0,27	0,29
Si, %	1,14	1,40	0,71	1,08
P, %	3,33	4,06	3,15	3,51
S, %	4,16	1,77	4,59	3,51
Cl, %	10,67	6,63	14,32	10,54
K, %	29,71	38,87	26,52	31,7
Ca, %	14,00	10,69	14,46	13,05
Fe, %	0,15	0,46	0	0

The obtained data are shown in the following figures 13–15.

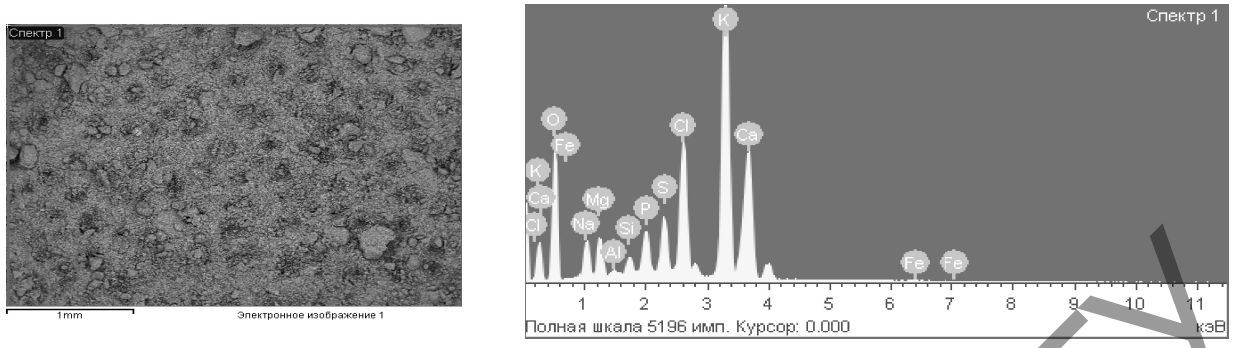

Figure 13. Sample № 1, Dried dill

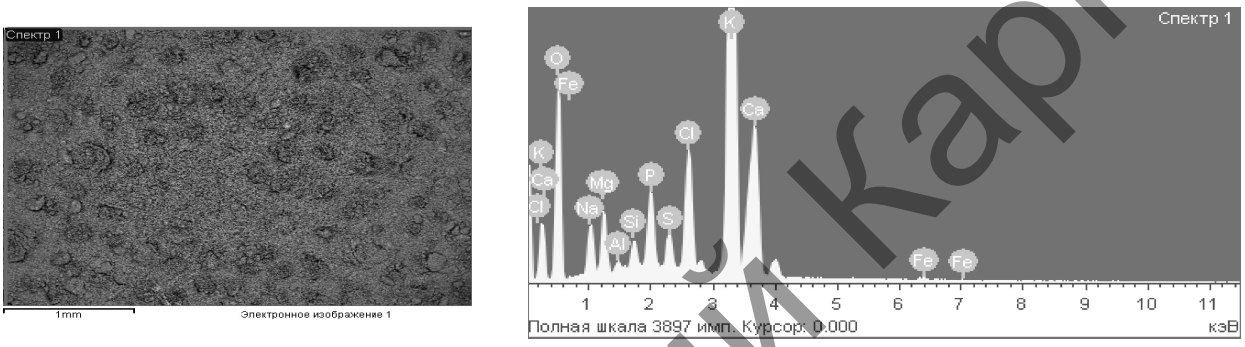

Figure 14. Sample № 2, Dried parsley

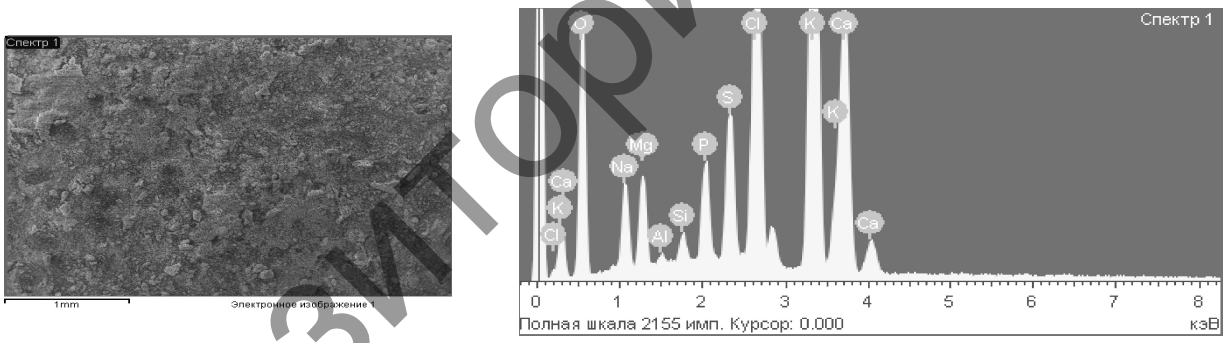

Figure 15. Sample № 3, Dried celery

For the mass-spectrometric analysis it has taken a sample in liquid form, and then 3 ml HNO_3 was filled. The sample was poured in a graduated flask for 100 ml. Further aliquots apply in the ICP-MS by THOMSON. The obtained results by using ICP-MS are shown in the Table 5.

Table 5

The chemical composition of tomato juice by ICP-MS, mkg/liter

Element	Samples						
	№ 1 Tomato juice	№ 2 Tomato juice with 1 % beet pectin	№ 3 Tomato juice with 1 % citrus pectin	№ 4 Tomato juice with 1 % beet and citrus pectin	№ 5 Tomato juice with 1 % greenery and with 1 % beet pectin	№ 6 Tomato juice with 1 % greenery and with 1 % cit-rus pectin	№ 7 Tomato juice with 1 % greenery and 1 % beet and citrus pectin
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
B 11	0	1138,794	7560,898	1318,433	3375,244	1221,665	2530,410
Na 23	12219,100	5256,937	32098,500	15141,960	12097,410J	26259,860	20090,060

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Mg 24	14586,200	8000,729	18868,850	13256,190	13648,990	16395,820	17094,610
Al 27	141,034	4268,777	550,975	3282,692	4999,743	1122,030	3617,928
P 31	9807,620	12590,410	29204,110	22216,140	22686,030	24619,880	25359,680
K 39	157493,900	165391,000	426581,400	309203,000	239706,600	319828,300	304976,100
Ca 40	40936,790	7122,913	14130,700	10791,460	25188,300	23679,020	30473,940
Ti 47	39,581	123,771	63,440	123,114	178,652	76,182	148,608
Cr 52	23,684	163,105	111,6061	173,030	157,998	138,239	155,679
Mn 55	42,101	46,688	84,873	71,422	140,987	149,973	167,062
Fe 56	1110,246	1105,013	1201,779	1337,591	2404,279	2132,779	2343,363
Co 59	0,706	1,014	1,829	1,510	1,382	1,927	1,672
Ni 60	11,827	63,162	57,703	66,403	52,727	66,931	63,941
Cu 63	25,204	83,021	80,562	101,268	216,487	115,432	151,960
Zn 65	55,820	93,294	181,274	130,118	231,674	176,790	206,381
Ge 72	0,921	0,708	0,868	1,015	1,150	1,294	1,445
As 75	0	6,425	12,584	4,792	3,522	8,066	4,410
Rb 85	90,687	141,870	348,152	249,070	194,812	274,558	254,250
Sr 88	23,988	56,013	86,734	71,413	245,226	273,975	304,701
Zr 91	0,391	5,959	0,994	2,728	0,918	6,504	1,572
Nb 93	0,346	1,385	1,051	0,858	0,746	0,728	0,666
Mo 95	2,869	3,865	7,604	5,715	6,821	8,947	8,615
Ag 107	2,330	0,078	0	0,495	0,771	1,484	0
Cd 112	1,501	2,075	3,633	3,133	2,881	3,041	3,712
Sn 118	0,449	0,716	0,491	0,465	4,929	2,463	2,503
Sb 121	0,133	0,136	0,131	0,146	0,300	0,518	0,211
Te 127	1,991	0,537	0,692	0,802	0,964	1,030	1,153
Cs l33	0,011	0,314	0,682	0,470	0,403	0,558	0,485
Ba l37	7,001	39,913	22,528	30,122	58,051	47,473	57,481
La 139	0	0,141	0,118	0,124	0,328	0,249	0,259
Ce l40	0,070	0,376	0,202	0,297	0,782	0,465	0,581
Nd l46	0	0,225	0,091	0,188	0,409	0,213	0,310
Tm l69	0	0,006	0,004	0,007	0,009	0,007	0,009
Ta l81	0,014	0,070	0,120	0,072	0,056	0,059	0,043
W 183	0	0,503	0,711	0,533	0,418	0,691	0,517
Tl 204	0	0,042	0,064	0,046	0,054	0,069	0,057
Pb 207	3,400	7,823	5,518	6,743	11,989	16,450	15,736
U 238	0	0,056	0,088	0,091	0,059	0,146	0,106

In the following Table 6 is presented a comparative analysis of essential macro- and microelement composition of tomato juice obtained by ICP-MS before and after adding the powder of greenery and pectin.

Table 6

Comparative analysis of tomato juice

	Elements	Tomato juice	Tomato juice with 1 % greenery and with 1 % beet and citrus pectin	Increased volume, %
Macroelements	Na	12219,100	20090,060	164
	Mg	14568,200	17049,610	117
	P	9807,620	25359,680	258
	K	157493,900	304976,100	193
	Ca	40936,790	30473,940	–74
Microelements	Fe	1110,246	2343,363	211
	Zn	55,820	206,381	374
	Cu	25,204	151,960	604
	Mn	42,101	167,062	397
	Cr	23,684	155,679	673
	Co	0,706	1,672	236
	Ni	11,827	63,941	573
	Mo	2,869	8,615	300

As well as there were investigated organoleptic properties according to the SS 52183–2003 (Tables 7, 8) [9].

Table 7

Organoleptic properties of new tomato juice

Name of the indicator	According to the requirements of SS 52183–2003	Obtained data, description
Appearance and consistency	Homogeneous liquid with evenly distributed a fine-grained pulp Allowed: – during a storage the lamination of liquid	Homogeneous liquid with evenly distributed a fine-grained greenery and pulp. During a storage the lamination of the liquid was not observed
Taste and smell	For tomato juice direct extraction — characteristic juice from fresh tomatoes For juice with additives characteristic of used ingredients Foreign taste and smell are not allowed	Specific, characteristic for fresh tomatoes, dill, parsley and celery, without foreign taste and odor
Color	Red or orange-red	Dark red with small greenery particles of dill, parsley and celery.

Table 8

Physical-chemical characteristics of new tomato juice

Name of parameters	According to the SS 52183–2003 requirements	Obtained data
Mass fraction of soluble dry substances,% not less: – for tomato juice direct extraction	4,5	5,0
Mass fraction of titration acids per citric acid, %, not more	0,6	0,56
Content of the pulp, %	12–20	21,5

Conclusion

Thus, it has been developed a new recipe of functional food product — tomato juice with additives of mixture of dried greenery (1 %), and a mixture of pectin (1 %). A synergistic effect of beet and citrus pectins positively influence to the process of stabilization of the finished product. Obtained research results show that the developed tomato juices in general correspond to the tomato juice and juice contain drinks characteristics.

By using Scanning Electron Microscope and Mass-spectroscopy have been investigated macro — and micro element compositions of the samples. In the result of using the greenery and pectin in tomato juice receipt, it has been found a significant increasing in the mass fraction of the basic macro-elements: Mg, Na, K, P; and micro-elements Fe, Zn, Cu, Mn, Cr, Co, Ni, Mo. There has been obtained new information about the ultra- and trace-elements composition of raw components that grown in the South Kazakhstan region: tomatoes, greenery, dill, parsley and celery. The results show that tomato juice with additives of greenery and pectin can well correspond to the functional foodstuff with treatment-prophylactic properties.

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Р.С.Әлібеков, А.А.Өтебаева

Әр түрлі қоспалар қосылған қызанақ шырынының макро- және микроэлементтік құрамын физика-химиялық әдістермен зерттеу

Мақалада микронутриенттердің адам ағзасына тигізетін негізгі әсері қарастырылды. Дұрыс тамақтанбау, макро- және микроэлементтердің жетіспеуі түрлі аурулардың тууына себепші болып табылады. Зерттеулер нәтижесі аскөк қоспасымен және пектинмен байытылған қызанақ шырынының құрамы пайдалы минералдарға бай екендігін көрсетті. Физика-химиялық зерттеу әдістері масс-спектроскопия және растрлық электрондық микроскоп көмегімен Оңтүстік Қазақстан облысында өсетін шикізаттардың: қызанақ, аскөк, ақжелкен және балдыркөк құрамынан макро- және микроэлементтік құрамы бойынша жаңа деректер табылды.

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Физико-химическое исследование макро- и микроэлементного состава томатного сока с различными добавками

В статье рассмотрена роль микронутриентов для организма человека. Несбалансированный рацион и дефицит макро- и микроэлементов являются причинами возникновения различных заболеваний. Полученные результаты исследований показывают, что томатный сок, обогащенный добавками зелени и пектина, имеет полезные минералы. Физико-химическими методами исследований, в частности, масс-спектроскопией и растровой электронной микроскопией были обнаружены новые данные о макро- и микроэлементном составе компонентов сырья, произрастающего в Южно-Казахстанской области: томаты, укроп, петрушка и сельдерей.

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