FOOD HYGIENE

THE POTENTIAL OF PINE NUT AS A COMPONENT OF SPORT NUTRITION

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Abstract: The development of personified medicine, aimed at prevention, makes relevant any development of foodstuffs with improved quality characteristics, including by addition of natural plant ingredients. Nuts are a high-calorie food with a high protein and fat content, including pine nuts. They have a positive impact on human health and attract the attention of researchers due to their anti-inflammatory and antioxidant characteristics. The study objects were samples of a nut kernel of *Pinus sibirica*, growing in the Kemerovo Oblast. In the *Pinus sibirica* nut samples the protein composition (15–16%) is not lower by content than in many other kinds of nuts; as for the fat content (62–67%), the greatest one belongs to linolenic acid; oleinic and linolenic acids are the next by content. Palmitic acid dominates among the saturated fatty acids. The studied nut samples exceeded the ones of the Tuva Republic, the Far East region and China by many indicators of nutrition value. By the protein and fat content of the studied nut samples are comparable with the ones of the Far East region. By the protein content they exceed the nut samples of China (15%); by the fat content - the ones of Tuva (40%). It is stated that by chemical and microbiological parameters the *Pinus sibirica* nuts, growing in the Kemerovo Oblast, satisfy the requirements of the current normative documents, they do not have any toxic effect on a human, and their nutrition value can be considered as a promising ingredient for various food products, including sport nutrition and special food.

Keywords: *Pinus sibirica*, nut kernel, chemical compound, nutrition value, sport nutrition

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INTRODUCTION

On the domestic market of functional food, sport nutrition and dietary supplements of plant origin mainly products are represented, based on ingredients, supplied by foreign producers (India, South-East Asia and southern Europe). At the same time, the Russian Federation, with its potentially large raw material base for the production of functional food and dietary supplements of plant origin, occupies a small volume of this market segment. At the moment, the requirements of the domestic market in food additives and functional food ingredients are satisfied through import by 75–80%.

A promising source of biologically active substances is wild-growing raw materials. In the Siberian Federal District 6.5% of wild-growing products are implemented, in other Russian regions - 18.5%. The share of export in total sales of wild-growing products of Tomsk companies is 36.5%, the main export (80%) goes to China.

In the Siberian Federal District on the territory of 5114800 km², covered with forests and marshes, considerable biological resources are located. These include first of all wild plants (berries, mushrooms and nuts). Nuts are a high-calorie food with a high content of fat, most of which is represented by unsaturated fatty acids [1]. Nuts also contain a significant amount of fiber, folic acid, minerals and antioxidative substances [2, 3, 4]. The interest of researchers to nuts is due to their nutrition content. Influence of nuts on health, cardiovascular diseases risk mitigation [5], high cholesterol [6, 7] and diabetes [8, 9] was studied. Nuts are also often considered as a source of selenium [10–14].

The most studied nuts are almonds, hazelnuts, walnuts, pistachios and cashews, however, only few researchers have examined the characteristics of pine nuts. Pine nuts differ with a high content of protein, unsaturated fatty acids and dietary fiber, low-molecular carbohydrates, vitamins (folic acid, niacin, tocopherol, B6 and B2), minerals, phytoesterols and polyphenols [15–18]. There are few works, in which characteristics of *Pinus sibirica du tour* nuts of the Kemerovo Oblast have been studied. The objective of this paper is to study the potential of seeds of *Pinus sibirica* of the

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Kemerovo Oblast as a component of functional food for people with a high physical activity.

OBJECTS AND METHODS OF STUDY

Objects of study were the samples of Pinus sibirica nut kernel, growing in the Kemerovo Oblast (Tashtagol region, crop of 2016 and 2017). The shell was preliminarily separated from the pine nut kernel, sample No. 1 is from the crop of 2016, sample No. 2 is from the crop of 2017.

Moisture mass fraction was determined according to GOST 31852-2012 (ISO 6756:1984) "Peeled pine nuts".

A sample was placed in the distillation apparatus flask; a sufficient amount of distillate (toluene, xylene) was added to it, so that to fully cover the sample, taken for analysis. The flask content was mixed with slewing. The apparatus was assembled, the receiver was filled with a solvent by pouring it through the cooler until it started to overflow into the distillation flask. Cold water was turned on.

The flask was heated until the distillation speed reached approximately four drops per second. Heating was going on until water began to collect in the graduated part of the receiver.

Condensation was removed from the cooler from time to time during distillation. 5 cm^3 of the solvent were used to clean the moisture, which deposited on the cooler or receiver walls. To separate water from the solvent, a copper spiral was put in the receiver and cooler, which was periodically moved up and down, thus causing deposition of water on the receiver bottom.

Distillation process was going on until the water level in the graduated receiver was permanent during 15 min, then heating was stopped. The receiver was immersed in water at room temperature at least for 15 min or until the solvent became transparent, then the water volume was measured with accuracy rate of 0.1 cm^3.

Moisture mass fraction in % was measured according to the formula:

$$X = V \cdot \rho \cdot 100 / M, \qquad (1)$$

where V is the volume of water, collected in the receiver with a graduated test tube, cm^3; ρ is the water density, ρ=1 g/cm^3; M is the mass of the sample, taken for analysis, g.

Protein mass fraction was measured by express-method of combustion according to Dumas using the express analyser Rapid N Cube (Elementar, Germany).

Protein fractional content was measured by ion-exchange chromatography using a chromatograph ARACUS.

Fat mass fraction was measured according to GOST [State Standard] 10857–64 Interstate Standard oily seeds. Oil content measuring method.

Kernel weighed amount, taken with consideration for oil content, was thoroughly minced and put in the weighed holder, prepared in advance. The holder was closed and put in the Soxhlet apparatus for extraction. To the extractor a clean flask was connected, which was preliminarily dried during 1 h at 100–105°C and weighed after cooling. Diethyl ether was poured to the extractor and connected with the cooler, after which extraction began.

After extraction ether was distilled and oil was dried in a dryer at a temperature of 100–105°C until the constant mass. The first weighting was carried out after 1–1.5 h, the next was in 30 minutes. In case of twice increase in mass, drying was stopped and the minimal mass was taken for measuring.

The fat content in % in kernels, freed from dirt, and dried, was measured according to the formula:

$$X = (m - m_1) \cdot 100 / m_2, \qquad (2)$$

where m is the flask mass with oil, g; m_1 is the mass of the empty flask, g; m_2 is the weighed amount of the dried seeds, g.

The fatty acid content was analyzed with gas-chromatography method using a gas-liquid mass-spectrometer GCMS-QP2010 Ultra (Shimadzu, Japan).

The ash mass fraction was measured according to GOST 26226–95 "Fodder, compound fodder, compound fodder raw materials. Crude ash measuring methods".

In a crucible, dried to a constant weight, the tested sample was placed with a mass of approximately 0.5–2.0 g (the amount of the tested ash should be at least 50 mg). The sample was put in the crucible without compression so that atmospheric oxygen flew to its lower layers. Up to half of the crucible was filled with the sample.

The crucible with the sample was weighed with the accuracy rate of 0.001 g; then it was placed in a cold furnace and temperature was increased up to 200–250°C (until smoke appeared, it is allowed to carry out preliminary combustion at the open door of a muffle, heated to dark red heat (525 ± 25)°C on an electric heater or gas burner, in a fume hood, avoiding ignition of the sample).

After the smoke exhalation stopped, the furnace temperature was adjusted to (525 ± 25)°C and the crucible with the sample was being annealed during 4–5 h. The absence of the coal particles and the ash uniform grey color indicated the complete ashing of the material.

The mass fraction of crude ash (X) in % in the test sample was measured according to the formula:

$$X = (m_2 - m_0) \cdot 100 / (m_1 - m_0), \qquad (3)$$

where m_0 is the crucible mass, g; m_1 is the mass of the crucible with the sample before ashing, g; m_2 is the mass of the crucible with ash, g;

The vitamin content was measured with a capillary electrophoresis method with the use of the system of capillary electrophoresis Kapel'-105 (Lumex, Russia); the method is based on the migration and separation of ionic forms of the analyzed components under the influence of electric field due to their different electrophoretic mobility, with the following registration at a wavelength of 200 nm.

The vitamin PP content was measured according to GOST R 50479–93. "Products of fruit and vegetable processing. The vitamin PP content measuring method".

The sample weighed amount with a mass of 1.0–10.0 g was ground in a porcelain mortar with 1.5 g of calcium hydroxide. Then the mortar content was transferred in portions in a conical flask with a capacity of 100 cm^3, washing away 50–60 cm^3 of water in small portions. The flask with the sample

was heated during 90 min on a boiling water bath, having closed preliminary the flask neck with a small funnel or a special glass insert stopper, and shaken periodically. After heating, the flask was cooled to room temperature. Then the hydrolysate volume was adjusted with water to 75 cm^3, stirred, cooled during 2 hours on an ice bath or placed in a refrigerator for the whole night. The cooled hydrolysate was filtered or centrifuged.

The filtrate volume of 25 cm^3 was placed in a cylinder with a capacity of 50 cm^3, 1–2 drops of phenolphthalein solution and sulfuric acid solution 2.5 mol/dm^3 were added by drops until discoloration.

8 test tubes or flasks with ground stoppers were used for carrying out the color reaction. In three tubes 5 cm^3 of the working standard solution of vitamin PP were added with a pipette. In 4 tubes 5 cm^3 of the obtained filtrate were added with a pipette, in the control tube 5 cm^3 of water instead of the filtrate were added. All tubes were closed with stoppers and heated on a water bath at a temperature of 48–52°C during 5–10 min. Then, in the tubes with a standard vitamin solution, in the tube with water and in two tubes with the test filtrate, 2 cm^3 of rodenberger were added from the burette in a fume hood.

All tubes were closed with stoppers, shaken and left on a water bath at a temperature of (50 ± 2)°C during 10 min. After 10 min all the tubes were cooled with water to room temperature and left for 10 min in a dark place, then 3 cm^3 of metol solution were added to each of them, they were shaken and left for 1 h in a dark place. Then the optical density of the solutions was measured with a spectrophotometer. Distilled water was a control solution.

Vitamin E content was measured according to GOST R 54634–2011 "Functional food. Vitamin E measuring method".

For carrying out the alkaline hydrolysis, 5–20 g of the analyzed sample were placed in a flat-bottomed flask with a capacity of 100–500 cm^3. 5–20 cm^3 of water were added to the dry material and heated on a water bath at a temperature of 60–70°C, stirring during 5 min. Then 50–150 cm^3 of ethyl rectified alcohol were added, 0.2–2.0 g of antioxidant (ascorbic acid, hydroquinone, butylhydroxytoluene) and 3–40 cm^3 of 50%-potassium hydroxide-solution, all these were then heated during 15–40 min on a water bath with a reflux condenser at a temperature of 80–100°C.

After hydrolysis, the flask content was rapidly cooled to (20 ± 5)°C and transferred in portions to the separatory funnel. The flask was rinsed with water, the volume of which is equal to the volume of the added ethyl alcohol, and water was poured into the same funnel. Tocopherols were extracted with diethyl ether, ethyl acetate, n-hexane and n-hexane with the addition of diethyl ether in a volume ratio of 1 : 1 during 2 min.

The extraction was repeated three or four times with the extractant portions of 50–100 cm^3. The combined extract was washed from alkali three or four times with water portions of 50–150 cm^3 until the alkaline wash water disappears (according to universal detector paper). To remove water, the extract was filtered through a filter with 2–5 g of anhydrous sodium sulfate. Then, the extract was evaporated to dryness with the use of a rotary evaporator and re-suspended in n-hexane.

The obtained solution was analyzed with a method of normal-phase high performance liquid chromatography (NP HPLC).

The macronutrient content (phosphorus, potassium, magnesium, manganese, iron, iodine) was measured with atomic absorption spectrophotometry. The analysed samples were transferred to the atomic state and the optical density of the atomic vapour of the determined element was measured in a certain spectral range. The element concentration was measured by the intensity of the light absorption by the atomic vapour of the determined element with a specific wavelength. To obtain the atomic vapour, a gas burner with spray was used. The light source was a lamp with a hollow cathode.

The micronutrient content was measured with a capillary electrophoresis method with the use of the system of capillary electrophoresis Kapel'-105 (Lumex, Russia), which is based on the separation of cations due to the differences in their electrophoretic mobility during migration in quartz capillary in the electrolyte under the action of electric field with the following registration of the difference of optical absorption by electrolyte and cations in the UV-area of the spectrum (wavelength is 254 nm).

Chemical and microbiological safety indicators. Measurement of mercury is according to GOST 26927–86 "Raw materials and foodstuffs. Mercury measuring method (with Amendment No. 1)".

Measurement of arsenic is according to GOST 26930–86 "Raw materials and foodstuffs. Arsenic measuring method (with Amendment No. 1)".

Measurement of lead is according to GOST 26932–86 "Raw materials and foodstuffs. Lead measuring method (with Amendment No. 1)".

Measurement of cadmium is according to GOST 26933–86 "Raw materials and foodstuffs. Cadmium measuring method (with Amendment No. 1)".

Measurement of pesticides is according to GOST 30349–96 "Fruits, vegetables and products of their processing. Methods of measuring of residual quantities of organochlorine pesticides".

Measurement of mycotoxin is according to GOST 30711–2001 "Foodstuffs. Methods of detection and determination of aflatoxins B(1) and M(1)".

The total number of yeast and mold fungi is in accordance with GOST 10444.12–2013 "Microbiology of foodstuffs and fodder. Methods of identification and calculation of the number of yeast and mold fungi (with Amendment)".

The number of coliform bacteria is according to GOST 31747–2012 "Foodstuffs. Methods of detection and determination of coliform bacteria".

The number of pathogenic microorganisms is according to GOST ISO 22118–2013 "Microbiology of foodstuffs and fodder. Polymerase chain reaction (PCR) for detection and quantitative accounting of pathogenic microorganisms in foodstuffs. Technical characteristics".

Statistical analysis. All repeated experiments were performed triply. Data processing was carried out with standard methods of mathematical statistics. The test of homogeneity of the obtained value selection was performed with the use of the Student criterion. Differences between means are considered significant when the confidence interval is smaller than 5% ($P \leq 0.05$).

Table 1. Chemical compound of pine nut samples

Parameter	Mass fraction, %	
	sample No. 1	sample No. 2
Moisture	5.20 ± 0.52	4.87 ± 0.49
Protein	15.15 ± 0.76	16.04 ± 0.80
Fats	62.10 ± 3.11	66.72 ± 3.34
Ash	2.51 ± 0.25	2.24 ± 0.22

RESULTS AND DISCUSSION

All nuts, including pine nuts, have a high fat and protein content, which determines their high energy value. A decreased risk of disorders of metabolic exchange and morbidity of diabetes of the 2nd type [19] are associated with the intake of protein of plant origin, such as nuts, legumes and grains. The results of determination of chemical compound of the pine nut kernel samples are presented in Table 1. Lipids are a predominant component of the pine nut kernel (62.10–66.72%). Also pine nuts, including our samples, differ with a high protein content and are second only to peanuts [20]. The moisture content in the nuts is up to 8.0%, which meets the requirements of GOST 31852-2012 (ISO 6756:1984).

The study results of the qualitative composition of the protein component in pine nuts in the Kemerovo Oblast are indicated in Fig. 1 and Table 2. In water-soluble protein fraction of the samples No. 1 and No. 2, fractions with a molecular weight of 19 kDa (line B2, C2) and 11 kDa (line B5, C5) dominate.

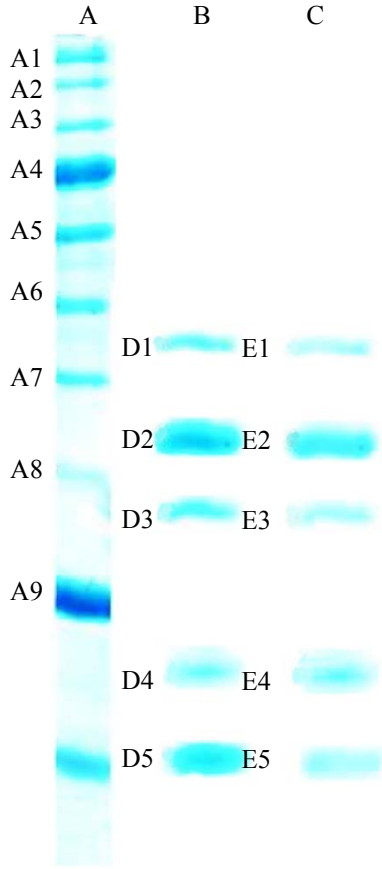

Fig. 1. Profile of water-soluble protein fraction of pine nut kernel: track A - marker, track B - sample No. 1, track C - sample No. 2

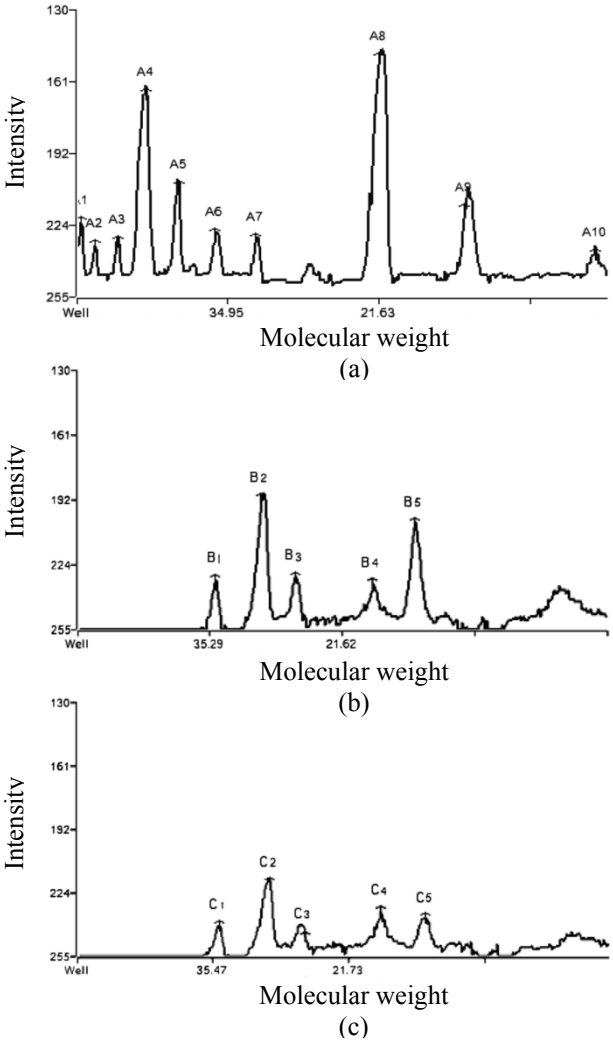

Fig. 2. Protein profile (a) in the marker, (b) sample No. 1, (c) sample No. 2.

Table 2. Protein profile of water-soluble fraction in the marker and in the pine nut samples

Track name	Line number	Molecular mass, kDa	Mobility coefficient, R_f
A	A1	227.17	0.0223
	A2	115.89	0.0487
	A3	67.83	0.0911
	A4	45.55	0.1449
	A5	33.96	0.2056
	A6	25.81	0.2812
	A7	21.19	0.3557
	A8	17.09	0.4611
	A9	13.88	0.5928
B	B 1	23.39	0.3167
	B 2	19.17	0.4007
	B 3	17.09	0.4611
	B 4	12.64	0.6770
	B 5	11.31	0.7572
C	C 1	23.39	0.3167
	C 2	18.94	0.4070
	C 3	17.09	0.4611
	C 4	12.73	0.6622
	C 5	11.10	0.7572

Note. A - in the marker, B - sample No. 1, C - sample No. 2.

Table 3. Amino acid content of the pine nut kernel

Amino acid name	Content, g/100 g of protein	
	sample No. 1	sample No. 2
Alanine	5.44 ± 0.27	5.33 ± 0.27
Arginine	15.41 ± 0.77	15.44 ± 0.77
Asparagine acid	5.89 ± 0.29	6.12 ± 0.31
Valine	3.37 ± 0.17	3.52 ± 0.18
Histidine	2.84 ± 0.14	2.79 ± 0.14
Glycine	4.58 ± 0.23	4.65 ± 0.23
Glutamic acid	11.84 ± 0.59	11.75 ± 0.59
Leucine+Isoleucine	15.73 ± 0.79	15.70± 0.79
Lysine	6.04 ± 0.30	5.84 ±0.29
Methionine	1.66 ± 0.08	1.62 ± 0.08
Proline	5.47 ± 0.27	5.52 ± 0.28
Serine	6.72 ± 0.34	6.81 ± 0.34
Thirosine	2.86 ± 0.14	2.80 ± 0.14
Threonine	3.15 ± 0.16	3.10 ± 0.15
Triptophane	1.18 ± 0.06	1.24 ± 0.06
Phenylalanine	6.49 ± 0.32	6.52 ± 0.33
Cystine	1.33 ± 0.07	1.25 ± 0.06

Amino acid content of the pine nut sample is indicated in Table 3. The analyzed samples differ with a high content of such essential amino acids as leucine and isoleucine, phenylalanine and lysine: 15.72 g, 6.50 g and 5.94 g per 100 g of protein respectively. Also, there is a high content of such non-essential amino acids as arginine, glutamic acid, serine, asparagine acid, proline and alanine: 15.43 g, 11.80 g, 6.77 g, 6.00 g, 5.50 g and 5.39 g per 100 g of protein respectively.

Nuts are a good source of fat and are considered good for health due to the high content of unsaturated fatty acids [21, 22]. The fatty acid content of the pine nut kernel is indicated in Table 4. The total content of saturated fatty acids in the pine nut kernel is 9.53%, of unsaturated fatty acid – 90.47%. In the analyzed samples linolenic acid (omega-3 fatty acids) has the highest content - approximately 43% from the total fat content, oleinic and linolenic acids are the next by content - approximately 24% and 21% respectively. Palmitic (5.23%) and stearic (2.82%) acids dominate among the saturated fatty acids.

Table 5. Vitamin content of the pine nut kernel

Vitamin name	Vitamin content, mg/100 g of product	
	sample No. 1	sample No. 2
Water-soluble vitamins		
B1 (thiamine)	0.540 ± 0.180	0.470 ± 0.160
B2 (riboflavin)	0.270 ± 0.090	0.240 ± 0.080
B3 (niacin, PP)	3.780 ± 1.280	3.900 ± 1.330
B5 (nicotinamide, nicotinic acid)	0.450 ± 0.150	0.520 ± 0.180
B6 (pyridoxin)	0.120 ± 0.040	0.100 ± 0.030
C (ascorbic acid)	0.670 ± 0.230	0.740 ± 0.250
Fat-soluble vitamins		
E (alpha-tocopherol)	8.330 ± 0.830	8.120 ± 0.810
K (phylloquinone)	0.050 ± 0.005	0.050 ± 0.005

Table 6. Macro- and micronutrient content of the pine nut kernel

Element name	Element content, mg/100 g of product	
	sample No. 1	sample No. 2
Macronutrients		
Potassium	602.30 ± 30.10	595.60 ± 29.80
Calcium	15.90 ± 0.80	17.60 ± 0.90
Magnesium	246.00 ± 12.30	255.80 ± 12.80
Sodium	7.10 ± 0.40	7.90 ± 0.40
Phosphorus	789.00 ± 39.50	795.20 ± 39.80
Micronutrients		
Iron	5.67 ± 0.28	5.59 ± 0.28
Manganese	8.73 ± 0.44	8.88 ± 0.44
Copper	1.27 ± 0.06	1.39 ± 0.07
Zinc	4.41 ± 0.22	4.35 ± 0.22
Iodine	0.15 ± 0.01	0.12 ± 0.01

Table 4. The fatty acid content of the pine nut kernel

Fatty acid name	Fatty acid index	Fatty acid content, g/100 g of fat	
		sample No. 1	sample No. 2
Saturated			
Myristinic acid	$C_{14:0}$	0.44 ± 0.02	0.52 ± 0.03
Palmitic acid	$C_{16:0}$	5.18 ± 0.26	5.27 ± 0.26
Stearinic acid	$C_{18:0}$	2.89 ± 0.14	2.75 ± 0.14
Arachic acid	$C_{20:0}$	0.95 ± 0.05	1.06 ± 0.05
The amount of unsaturated fatty acids		9.46 ± 0.47	9.60 ± 0.48
Unsaturated			
Palmitoleic acid	$C_{16:1}$	0.35 ± 0.02	0.46 ± 0.02
Oleic acid	$C_{18:1}$	24.05 ± 1.20	24.27 ± 1.21
Linoleic acid	$C_{18:2}$	42.20 ± 2.11	42.77 ± 2.14
Linoleic acid	$C_{18:3}$	20.98 ± 10.49	20.43 ± 1.02
Gondoic acid	$C_{20:1}$	0.87 ± 0.04	0.93 ± 0.05
Eicosadienoic acid	$C_{20:2}$	0.65 ± 0.03	0.57 ± 0.03
Eicosatrienoic acid	$C_{20:3}$	1.44 ± 0.07	0.97 ± 0.05
The amount of unsaturated fatty acids		90.54 ± 4.53	90.40 ± 4.52

Table 7. Chemical and microbiological pine nut safety indicators

Parameters	Content, mg/kg	
	sample No. 1	sample No. 2
Mercury,	not detected	not detected
Arsenic	0.0500 ± 0.0030	0.0350 ± 0.002
Lead	0.1000 ± 0.0050	0.0600 ± 0.0003
Cadmium	0.0100 ± 0.0005	0.0070 ± 0.0004
Aflatoxin B1	0.0050 ± 0.0003	0.0030 ± 0.0002
Hexachlorocyclohexane (the sum of isomers)	0.0060 ± 0.0003	0.0050 ± 0.0003
Dichlorodiphenyltrichloroethane and its metabolites	0.0100 ± 0.0005	0.0150 ± 0.0008
Product mass (g), in which coliform bacteria were not detected	0.01	0.01
Product mass (g), in which pathogenic microorganisms, including Salmonella, were not detected	25.00	25.00
Fungi, CFU/g	$1.00 \cdot 10^1$	$1.10 \cdot 10^1$

Nuts have a wide range of micro-, macronutrients and vitamins in sufficient quantities [23, 24], which can have a positive impact on health and contribute to the prevention of nutritional deficiency (Tables 5–6). Pine nut kernel samples are rich in a fat-soluble vitamin alpha-tocopherol and water-soluble vitamins PP, C, B1 and B5: 8.23 mg and 3.84 mg, 0.71, 0.51 mg, 0.49 mg per 100 g of the product respectively. The main macronutrients in the samples content are phosphorus (792.1 mg/100 g of the product), potassium (600.0 mg/100 g of the product) and magnesium (250.9 mg/100 g of the product); as for micronutrients, the main ones are manganese (8.81 mg/100 g of the product), iron (5.63 mg/100 g of the product) and zinc (4.38 mg/100 g of the product).

Chemical compound and content of micro - and macronutrients and vitamins may vary depending on climatic and soil conditions [25]. The protein content in the kernels of Kuzbass *Pinus sibirica* is comparable with the protein content of the nuts of cedar of Tuva and the Far East region [26, 27] and exceeds by approximately 15% the samples, obtained in China [28]. By content the nut kernels of the Far Eastern cedar are less full-valued than the ones of *Pinus sibirica* [27]. The fat content in our samples is comparable with the content of nut samples of China and the Far East region and exceeds by more than 40% the samples of Tuva.

The difference in content of micro - and macronutrients between our nut samples and the ones of China and Tuva was as follows: potassium is +20% and -15%; calcium is 400% and -2%; phosphorus is +40% and +4% respectively [26, 28]. The zinc and vitamin B2 content in Kuzbass and China nuts is comparable, by 25% less by sodium and by 400% by vitamin E, exceeds 3000 times by the vitamin B1, by other micro- and macronutrients, except iodine, exceeds by 40%-220% [28].

While growing and ripening, nuts, including pine nuts, can accumulate in their fruits toxic chemicals (mercury, arsenic, lead, etc.), as well as during storage and transportation they can accumulate toxins (waste products of fungi, pathogens, etc.). Pine nut samples (Table 7) satisfy the requirements of the current regulations (CU TR [Technical Regulations of the Customs Union] 021/2011, SanPiN [Sanitary Regulations and Norms] 2.3.2.1078–01) by chemical and microbiological parameters and do not have a toxic effect on a human.

CONCLUSIONS

The desire to prevent cancer, cardiovascular, gastrointestinal and other diseases preserves the relevance of developments of foodstuffs of high biological value with addition of natural ingredients. To achieve this goal, a full-valued protein, individual amino acids, probiotics, prebiotics, vitamins, micro- and macronutrients and plant raw material [28–36] are considered as supplements. Traditionally, nuts are considered as a source of nutrients to improve the food quality. Those, who eat nuts, usually do not feel the deficiency of vitamins A and C, folate, calcium, iron, magnesium and zinc [37, 38]. Pine nuts of *Pinus sibirica* differ with a high content of proteins, in some samples the content is equal to the one in a peanut. Nuts have a positive impact on health due to their anti-inflammatory and antioxidative characteristics [39, 40], which reduce the impact on cholesterol level. Nutritional value of *Pinus sibirica* nuts allows to using them as ingredients in different food, such as: cereals, bread and cakes, cheese and functional products, including sport nutrition.

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