Biochemical and physiological properties non-traditional food raw materials

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Abstract. The botanical and commodity characteristics are given, the physiological functions of the calamus root are indicated. The methods used to study its quantitative and qualitative composition of nutrients, including physiologically active substances and antiradical activity, are given. The general chemical composition is investigated, the results of the study of the mineral composition of the calamus root are presented, it is established that the root is rich in potassium, calcium, magnesium, phosphorus, as well as trace elements manganese, iron, molybdenum, which perform important physiological functions in the human body. The calculation of the percentage of satisfaction of the daily need for individual minerals was carried out, it was found that the calamus root belongs to functional food ingredients, since it satisfies the SNP by more than 15% for individual minerals. It has been shown that the calamus root contains a significant amount of vitamins C, B2, E, β-carotene. The qualitative composition of organic acids, phenolic compounds and carbohydrates is given, indicating the release time of individual substances and the values of chromatogram profiles. The antioxidant activity of the original calamus root sample ranges from 37.7 to 47.4%, depending on the extractant, heat treatment reduces the activity by 5.8-6.7%. The conducted studies allow us to consider the calamus root as a plant ingredient for a nutrient mixture.

1 Introduction

Currently, considerable attention is paid to a special category of healthy lifestyle foods that contribute to improving the health of the population, since according to various data, more than 50% of the population's health depends on nutrition. An important aspect of a healthy diet is a full, balanced, functional diet, the use of biologically active and dietary supplements [1]. During the development of functional food products, physiologically functional food ingredients are introduced into traditional food products to prevent the occurrence or correction of nutritional deficiencies in the body [2, 3].

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The sources of physiologically functional food ingredients, including bioflavonoids, are certain types of plant, animal, medicinal and technical raw materials allowed in food technologies [4, 5, 6].

We propose the use as a functional additive of a mixture of vegetable raw materials, which includes the calamus root.

Calamus (acoru calamus L.) is a perennial herbaceous plant of the Aracal family, whose height reaches 60-120 cm, the rhizome is thick, cylindrical, sinuous, has a tart astringent taste (the presence of tannins) and a pleasant aroma (the content of essential oils). In practice, calamus rhizomes are used, which are used in dried form (moisture content is not more than 14%), no more than 5% of rhizomes that have browned in the fracture are allowed [7].

In special nurseries, such as the Siberian Garden (Kemerovo region), the Smirnov nursery (Vladimir), calamus is grown on an industrial scale. In early spring or late autumn, when they contain the largest amount of valuable substances, rhizomes are harvested. When harvesting, the roots are dug selectively, no more than 30% of the total number of shoots, since it takes at least 3 years to restore the raw material base, spoiled and rotted rhizomes are not allowed to be harvested. After harvesting, the rhizomes are washed, the stem and small roots are cut, cut into pieces 1.5-3 cm long and split into pieces.

Using the method of neutron activation analysis at the Siberian State Medical University, the content of macro- and microelements of the elemental composition of calamus growing on the territory of the European part of Russia, Siberia and Kazakhstan was determined. Regardless of the place of growth, 25 trace elements were found in calamus, including silver, chromium, gold, and a significant spread in the values of calcium, iron, zinc, chromium, and cobalt was also established [8].

The value of calamus when eaten is primarily in the high content of essential oils, respectively, calamus is used as a flavoring agent for many foods. The physiological functions of calamus are related to the content of essential oils and glycosides. In the form of a decoction, the calamus root is used to stimulate appetite in various gastrointestinal diseases [9].

Calamus root is a part of gastric and mouth-watering collections. In the production of the drug olimetin, calamus essential oil is used to treat urolithiasis and prevent sand deposition. The composition of the drugs vikalin and vikair, for the treatment of peptic ulcer of the stomach, duodenum and gastritis also includes calamus root powder. The possibilities of creating new medicines based on aira pharmacological research are being considered [10].

2 Materials and methods

The aim of the work is to study the quantitative and qualitative composition of nutrients, including physiologically active substances and antiradical activity of the calamus root.

The object of the study was the calamus root – dosage form, reg. No. LS – 001938, manufacturer: JSC "Krasnogorskleksredstva", sold in the pharmacy chain of Oryol.

The following indicators were determined in the rhizome of calamus:

- humidity and ash content – according to GOST 24027.2-80.
- sugar and starch content – according to GOST 26176-91.
- fiber content – according to GOST 13496.2-91.
- protein content – according to GOST 10846-91 "Grain and its processed products. Method of protein determination";
- mineral composition - the method of atomic adsorption spectrometry on the inductively coupled plasma emission spectrometer ICP (Libertz-220) of the company

"VARIANT", calibration - according to the standards of the company "Merk", research - in threefold repetitions;

- antiradical activity – a spectrophotometric method using 2,2-difinyl-1picrylhydrazyl (DPPG) as the main solution, which was mixed with extracts of crushed raw materials and changes in the optical density of the solutions were recorded over time. Extractants are water and methyl alcohol, since water- and alcohol-soluble substances have antioxidant properties, studies are carried out in threefold repetitions;

- low molecular weight metabolites – gas chromatography-mass spectrometry (GC/MS) with mass spectrometric detection (GC/MS) on a chromatograph JMS-Q1050GC ("JE0L Ltd"), Japan. Identification of substances - by retention parameters and mass spectra of the WiST-5 library of the National Institute of Standards and Tehnology (USA). The scanning range is 33-900 m/z, the changes are in three-fold repetitions;

- vitamin composition - a method of high–performance liquid chromatography on "Milichrome - 6", extractant - 70% alcohol solution.

3 Results and discussion

Calamus root in powder form is supposed to be used as an ingredient in a nutrient mixture for food enrichment. The obtained results of the chemical composition can be used to optimize the formulation composition in the development of enriched products, and also in calculating the nutritional value of finished foods enriched with a nutrient mixture, which includes the calamus root.

A study of the total chemical composition of the calamus rhizome showed that the humidity is 8.46%. The root is characterized by a high content of proteins (27.9%), starch (21.51%), mono- and disaccharides (13.52%), fiber (15.31%), ash content is 5.88%.

The results of the study of the mineral and vitamin composition of the calamus root are presented in Table 1. The data obtained take into account the mass fraction of moisture in the powder of the calamus root, which is important when calculating the consumption rates of raw materials when composing a nutrient mixture.

Table 1. Mineral and vitamin composition of calamus rhizome.

Mineral substances		Vitamins, mg/100g	
Name	Content	Name	Content
Macroelements, mg/100g			
Potassium	710.0	C	126.0
Calcium	470.9	PP	0.21
Silicon	3.5	B_1	0.11
Magnesium	482.8	B_2	1.6
Sodium	18.5	B_5	0.83
Sulfur	46.9	B_6	0.2
Phosphorus	246.1	E	5.11
Chlorine	103.6	ß-carotene	2.12
Microelements, mcg/100g		P– active substances	1627.8
Iron	3.2		
Manganese	3.2		
Molybdenum	41.9		

Studies of the mineral composition have shown that the root is rich in potassium, calcium, magnesium, phosphorus, as well as trace elements manganese, iron, molybdenum, which perform important physiological functions in the human body.

Taking into account the physiological norms of consumption, the percentage of satisfaction of the daily need for certain minerals is calculated (Fig. 1).

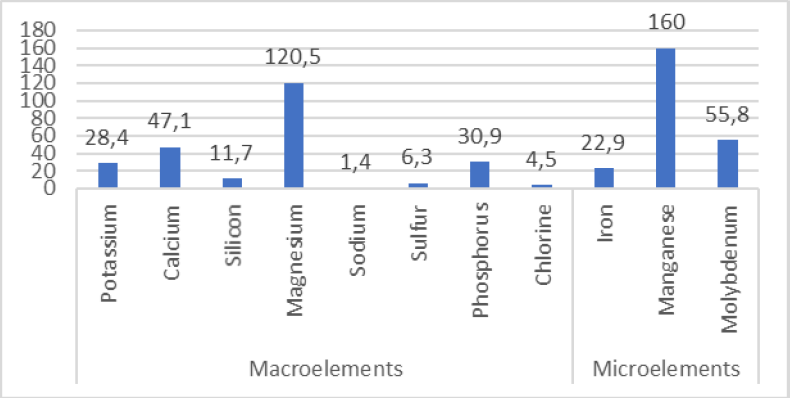

Fig. 1 Satisfaction of the daily need for certain minerals (%).

Restriction in the daily diet of certain foods causes a violation of the state of equilibrium and constancy (homeostasis) associated with a lack of individual macro- and microelements [11].

For the normal functioning of nervous and muscular tissue, special importance is given to potassium, the content of which in the root of the calamus of the marsh is about 30% of the daily consumption rate (SNP).

Calcium and its compounds, which are part of bone tissues and surpass all other mineral compounds, are a permanent component of the human body. At the root of the calamus, its content is about 50% of the SNP.

Silicon in the calamus root contains more than 10% of the SNP. Silicon, necessary for the assimilation of many other macro- and microelements, sorbs radionuclides and suppresses bacteria and viruses.

The high magnesium content in the calamus root (more than 120% of the SNP), allows it to be attributed to physiologically functional ingredients. Magnesium participates in metabolic processes, is an activator of more than 300 enzymes and a universal regulator of biochemical and physiological reactions in the human body.

The phosphorus content in the calamus root is more than 30% of the SNP. Phosphorus in the form of organic compounds is a part of bone tissues, fats, phospholipids and proteins.

Calamus root is a source of manganese (160% of SNP). In the body, manganese participates in the formation of the skeleton, regulates the level of glucose in the blood.

A significant amount of molybdenum (more than 55% of the SNP) involved in carbohydrate metabolism was found in the calamus root.

The calamus root contains a significant amount of vitamins C, B_2, E, β-carotene, necessary for the functioning of all organs and systems, involved in the implementation of vital functions occurring in a living cell [12]. Taking into account the physiological norms of consumption, the percentage of satisfaction of the daily need for individual vitamins is calculated (Fig. 2).

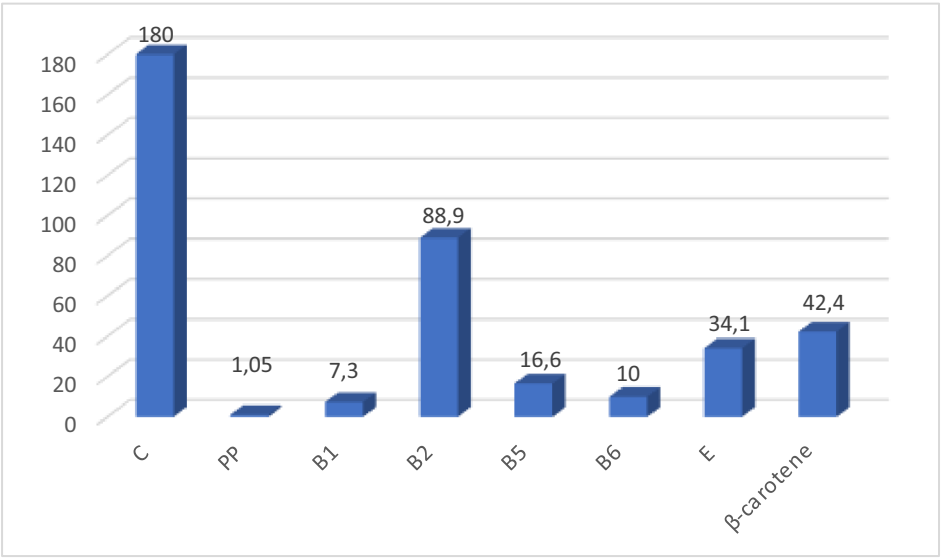

Fig. 2. Satisfction of the daily requirement for certain minerals (%).

The high content of vitamin C in the calamus root (180% of the SNP) determines its physiological properties. Vitamin C, easily undergoing both reduction and oxidation, performs various functions, plays an important role in metabolism.

Vitamin B_2 is a biologically active substance, the calamus root contains a significant amount (about 90% of the SNP). The biological role of riboflavin is determined by its inclusion in the composition of derivatives (coenzymes).

Vitamin E, being a powerful antioxidant, suppresses oxidative degradation of lipids under the action of free radicals. The calamus root has a content of more than 30% of the SNP. In addition, this vitamin reduces the level of cholesterol in the blood, is a stabilizer of cell membranes.

ß - carotene has a pronounced immunomodulatory effect, the content of calamus in the root is more than 40% of the SNP. In the human body, it is broken down to form vitamin A, which is characterized by antioxidant properties.

The qualitative composition of low-molecular metabolites allows you to have a more detailed understanding of the properties of plant raw materials and nutritional value, therefore, low-molecular metabolites, in particular organic acids, phenolic substances, carbohydrates and their derivatives, which are formed as a result of metabolism during plant development and which can be detected and identified using chromatographic methods, are of great importance for nutritional value [13].

Substances of secondary origin include organic acids, but they play an important role in the metabolism of plants and in the human body. It is almost impossible to isolate some organic acids quantitatively in pure form.

A large group of organic substances include phenolic substances, which differ in the presence of an aromatic (benzene) ring in their molecule. Pyrocatechin, hydrochiton, resorcinol (the simplest phenolic substances) are rare, but they play an important role in plant metabolism and are the starting products for the formation of bioflavonoids with P-vitamin properties and belong to biologically active substances. Many phenolic compounds increase nutritional value, are resistant to phytopathogenic microorganisms, and form consumer properties of food products.

Derivatives of polyatomic alcohols, low-molecular carbohydrates, being in the process of plant development undergo mutual transformations, including oxidized to organic acids under the action of enzymes.

Table 2 shows the qualitative composition of organic acids, phenolic compounds and carbohydrates, indicating the release time of individual substances and the values of chromatogram profiles.

Table 2. Qualitative composition of low molecular weight metabolites.

No. n\n	Rt, min	Indicator	The value of the chromatogram profile, %
Organic acids			
1	10.17; 10.19	Dairy	about 10
2	10.28	Glycolic	about 90
3	10.34; 12.48	Pyrovinogradnaya	10-30
4	13.57; 17.28	Amber	more 50
5	14.25	Glycerin	about 100
6	15.46	Butane	about10
7	16.26	Apple	about 100
8	20.19	Lemon	10-20
9	21.14	Gulonova	about 80
Phenolic compounds			
1	16.58	Pyrocatechin	about 20
2	23.19	Caffeic acid	in small quantities
Carbohydrates and their derivatives			
1	20.20; 20.35; 20.48	Fructose	about 100
2	21.21	Mannose	about 50
3	21.4; 23.28	Myo-inositis	about 80
4	17.20	Ethidronic acid	about 50
5	22.45; 31.26	Xylose	in small quantities
6	36.30	Mannonic Acid	in small quantities

Nine organic acids are present in the calamus root, the largest chromatogram profile is malic, glycerol (100%), glycolic (90%), gulonic (80%), amber (50%) acids. The role of individual organic acids in the physiology of humans and plants is great. Thus, succinic acid participates in energy metabolism at the cellular level, glyceric acid is formed as an intermediate product of glucose oxidation, glycolic acid is formed from glucose under the action of the oxidase enzyme, and gulonic acid participates in the biosynthesis of ascorbic acid. Glucose oxidase preparations, due to their high specificity of action, are used in medicine.

Of the phenolic compounds in the calamus root, pyrocatechin and caffeic acid were found in small quantities, belonging to P–active substances that strengthen the walls of blood vessels.

Carbohydrates and their derivatives are mainly represented by fructose (100% of the chromatogram profile). A special role is assigned to a carbohydrate derivative, a vitamin-like substance with biological activity, myo-inositol (80% of the profile).

Antiradical activity, which is of great importance in oxidative processes in the human body, inhibits oxidation by molecular oxygen, has been studied. A number of works are devoted to the study of antioxidants of plant raw materials [14]. We used water and methanol as extractants. The studies were carried out in the feedstock and after heat treatment. The results of the study are presented in Table 3.

Studies have shown that the percentage of radical inhibition in the aqueous extract is 37.7, in the alcohol extract it is 9.7% higher, the heat treatment of the calamus root reduces

the antioxidant activity by 5.8% when extracted with methanol and by 6.7% when extracted with water.

Table 3. Antioxidant activity of calamus root.

Name of the study sample	AOA, % inhibition of the DPH radical, during extraction	
	methanol	with water
The original sample	47.4±0.3	37.7±0.3
After heat treatment	44.4±0.4	35.1±0.2
% of the original sample	94.2	93.3

4 Conclusions

The conducted research allowed us to establish:

- calamus root is characterized by a high content of calcium, magnesium, phosphorus, iron, manganese and molybdenum, the level of satisfaction of daily needs is more than 15%, which allows it to be attributed to a functional food ingredient;
- high content and proportion of satisfaction of daily needs (more than 15%) in vitamins C, B2, B5, E, beta-carotene gives the calamus root functional properties;
- nine organic acids, two phenolic compounds, six carbohydrates and their derivatives were found in the calamus root;
- the antioxidant activity of the initial sample, depending on the extractant, ranges from 37.7 to 47.4%, heat treatment reduces the activity by 5.8-6.7%.

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