Traditional and modern scientific ideas about plant sources, nutritional value, therapeutic and prophylactic properties, allergological and other risks of nutritional use of Wild Rice (Zizania Spp.)

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Traditional and modern scientific approaches to plant sources, nutritional value, therapeutic and prophylactic properties, allergy risks of Wild rice (Zizania)

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SUMMARY

The analysis and generalization of the results of information-analytical, experimental and clinical studies in terms of raw materials, nutritional value, therapeutic and prophylactic properties, allergological and other risks of food use of wild rice grains have been carried out. It is shown that wild rice is a traditional food plant for the North American continent. In the 21st century, it is used all over the world as a whole grain source of biologically active substances and energy, which has a unique composition and ratio of macro- and micronutrients, as well as a dietary product with a proven pharmacotherapeutic effect on the body. Prognostic allergological and other risks of food use of wild rice grains have also been identified.

Key words: Wild rice, stinging, chemical composition, ferulic acid, pharmacotherapeutic properties, allergological risks, traditional medicine, nutritional value, nutrition, dietetics.

RESUME

We analyzed analytical, experimental and clinical data on raw material sources, nutritional value, therapeutic and preventive application, allergy risk and nutritional usage of grain wild rice. Wild rice is a traditional food for the North American continent. In our century it is used all over the world as a grain source of biologically active substances and energy. It is known as a dietary product for unique composition, macro and micronutrient composition and pharmacological effects. We considered allergy and other risks of nutritional use of Wild rice grains.

keywords:Wild rice, Zizania, chemical composition, ferulic acid, pharmacological properties, allergological risk, traditional medicine, nutritional value, nutrition, dietetics.

The current popularity of wild rice is largely due to the fashion for cleansing and reducing diets, the desire for healthy eating and weight loss, including the use of "miracle" drugs and foods. In the global Internet network, scientifically based information and fictions coexist with respect to the properties of wild rice, a complex

its nutrients and biologically active substances (BAS). At the same time, reliable sources of evidence-based information, as a rule, are difficult to access for a wide range of readers and even doctors, including in connection with the localization of such publications in special foreign scientific periodicals in specialized databases and in foreign languages.

In particular, there is taxonomic confusion in several species of the genus Zizania (tsitsaniya), called wild rice in Russian. Such confusion and attempts to clarify the taxonomy of the four species of the genus of chitzing have been revealed by us both in domestic and foreign publications. In particular, Terrell E.E. et al. (1997) attempted to understand the taxonomy of three North American species of the genus Zizania, including Z. palustris var. Interior [49, 50]. In Russian, confusion began, apparently, starting with the Brockhaus and Efron dictionary, published in the first decade of the 20th century [7]. Since then, there have been significant changes in the scientific taxonomy of plants and biogeography, but often on the Internet, the authors of publications proceed from outdated or unverified information. In some foreign works, in order to avoid taxonomic errors,

In addition to botanical errors in popular articles on various sites (including medical ones) on the Internet, we have identified a significant number of commercial articles containing a number of statements (not supported by links to scientific research results) regarding the uniqueness of the chemical composition and spectrum of biological action of wild rice grain, as well as its medicinal properties. It follows from these articles that wild rice is a dietary panacea in terms of weight loss, health improvement, and even a remedy for almost all known diseases.

The purpose of this work is to objectify the array of information (identify and analyze reliable information) and summarize the results of scientific research in terms of biological sources, chemical composition, therapeutic and prophylactic properties and predictive risks of the food use of wild rice grains (zicania).

MATERIALS AND METHODS

The objects of the study were normative documents and bibliographic sources of a high degree of reliability, including monographs, scientific periodicals, reference books, dissertations, abstracts of dissertations and textbooks (in terms of cereal production technology), recommended for use in the prescribed manner. Internet resources with links to bibliographic sources of a high degree of reliability were also taken into account, including official databases: Agroecological Atlas of Russia and neighboring countries [1], Information and analytical system "Chemical composition of food products used in the Russian Federation" (Database data of the Federal Research Center for Nutrition and Biotechnology) [19], Multilingual multiscript plant name database [35], US National Plant Germplasm System [39, 59], The Plant List [51], USDA Branded Food Products Database [54], USDA National Nutrient Database for Standard Reference [53], etc.

When performing the work, the following research methods were used: information-analytical, historical, content analysis, systematization.

1. Characteristics of the object of study

1.1. Botanical characteristics and systematics

Wild rice is a self-reproducing herbaceous aquatic plant that grows naturally in shallow lakes and slow-moving rivers in the Great Lakes region of North America. Wild varieties of this grain plant were not subjected to selection and selection, unlike cultivated cereals. Lake wild rice is unique among commercial crops in this sense because it is grown and harvested in water and, once born in a water body, will reproduce itself almost indefinitely. After the introduction

wild rice into cultivation, breeding work was carried out in several directions [60].

In total, the Genus Zizania (Wild Rice) includes four species that are officially represented in The Plant List today: Zizania aquatica L., Zizania latifolia (Griseb.) Turcz. ex Stapf, Zizania palustris L., Zizania texana Hitchc. [65]; distributed in East Asia and North America [62].

Three out of four species (Z. aquatica, Z. palustris, Z. texana) are distributed in North America and one (Z. latifolia) is found in East Asia. The divergence between related East Asian and North American species occurred 3.74 million years ago (95% HPD: 1.04-7.23) [62]. Biogeographic analysis using the probability method allowed X. Xu et al. (2010) suggest that Zizania species of North American origin migrated to East Asia at this time overland across the Bering Bridge [62].

Four species, as a rule, are distinguished by specialists on the basis of morphology, range, and habitat [60]. The database of the US National Plant Germplasm System [39] includes the species Zizania latifolia (Griseb.) Stapf (tertiary genetic relative of wild rice - based on affinity for Zizania palustris - Mol Phylogenet Evol 55: 1012, 1013. 2010) [67] and Zizania aquatica L. (secondary genetic relative of wild rice - based on crossing Z. palustris - Syst Bot. 13: 233, 1988) [66], Zizania palustris L. (tertiary genetic relative of Zizania latifolia - Mol Phylogenet EVOL 55: 1013 2010) [68], which, in fact, is a food source of wild rice grains, in contrast to the two previous species, erroneously interpreted in popular literature as wild rice [68].

Zizania texana Hitchc. - Texan chicania - endemic to a small region in Texas near the San Marco River [69], which has no nutritional value [21]. According to Terrell EE et al. (1978), a certain confusion is also associated with this species in terms of the taxonomy and practical use of the plant [49].

Zizania latifolia (Griseb.) Stapf – broadleaf water rice, broadleaf zizania, familyPoaceae Barnh., genus Zizania L. [16, 67]; Synonym: Hydropyrum latifolium Griseb. [16, 67], Zizania caduciflora Hand. - Mazz. nom. illeg., Zizania caduciflora (Turcz. ex Trin.) Hand-Mazz. [35], wild rice, Chinese wild rice, Manchurian wild rice, aquatic bamboo [35], Manchurian aquatic rice, Manchurian wild rice (English), aquatic bamboo (German), makomo (Japanese) [67].

Perennial plant 80-200 cm high with thick hollow roots up to 50 cm long and 10 (20) cm thick. The stems at the lower nodes are easily rooted, erect, thick, with a spongy core. Leaf sheaths glabrous and smooth, slightly rough above; uvula 7–15 mm long. Panicles 30–60 cm long, compressed above, sprawling below, their branches are rough because of the spines covering them. Pistillate spikelet 15–20 mm long, staminate spikelet 8–15 mm long. The staminate flowers have a lower lemma with 5 veins and a straight spine 2–3 mm long at the apex. In pistillate flowers, this awn is up to 25 mm long. Upper lemma with 3 veins. Anthers 5–8 mm long. Flowering in July, fruiting in September [16].

Zizania latifolia grows along the banks of water bodies; it is distributed in the European part of Russia as an introducer, in Eastern Siberia, Japan, China, and South Asia [16]. According to the US National Plant Germplasm System, it is a vegetable plant [67]. According to the Agroecological Atlas of Russia and neighboring countries [1], it is considered a fodder plant of a rather high dignity, as well as a food plant - caryopses, young shoots and leaf bases are edible [16]. It has been cultivated in China for more than 2000 years as a vegetable plant, the shoots of which resemble leeks [29].

Zizania palustris L. – wild rice, familyPoaceae Barnh., genus Zizania L. [68], synonym: northern wild rice [35]. Grains are used for food, therefore it is considered a cereal plant that naturally grows in North America - in western and eastern Canada, the northern, northeastern, and central states of the United States. It is cultivated in North America as a cereal grain plant [68].

Zizania aquatica L. – wild rice, familyPoaceae Barnh., genus Zizania L. [4, 68], syn.: English. -estuary rice (estuary is a geographical and geological term for a greatly expanded mouth of a river), Rus. -Indian rice [35], duck rice [3]. It is distributed in western Canada, in the northern, central, northeastern, southeastern states of the USA [66], and in central Russia [4]. "Duck rice" formed thickets along the shores of Lake Vyalye in the Leningrad Region, where it was sown in 1912 by Generozov V.Ya. [3].

According to [21, 60], the fruits (grains) of only two species of water squash (Zizania aquatica) and, especially, marsh squash (Zizania palustris), naturally growing in shallow lakes and rivers [60], have long served as food for indigenous peoples (Indians) of North America from the upper Midwest of the United States and central Canada, harvested by hand from boats for food use as cereals. A grain of wild rice was the main food product for these semi-nomadic peoples - a valuable, even sacred resource, which was protected in every possible way as a source of the most important food product and an object of trade [60].

By the end of the 19th century, American settlers began to become interested in the potential of wild rice as a commodity, first as brokers, controlling the processing and sale of grain, and then as planters and farmers. Ultimately, they gained control of production. However, thanks to more recent legislative initiatives, most of the wild rice lakes in Minnesota and Wisconsin are now under Native American control. Legislation in Canada also provides for Aboriginal participation in the production of wild rice in natural northern lakes [60].

The distribution of wild species was originally carried out by early European navigators, who stockpiled a grain of wild rice for future use in order to create food supplies for the duration of a long voyage. Modern commercial exploitation of thickets has significantly increased the production and distribution of crops far beyond the natural range [60]. The cultivation of this marsh grass began in earnest only in the early 1950s, first in the United States, then in Canada and other countries [22]. In the same years, they tried to grow wild rice in the south of the Irkutsk region, in the lower reaches of the Dnieper and Kuban [10, 22]. Increasing commercial demand and high raw material prices in the late 1970s led to the rapid creation of artificial fields, which now account for the majority of production [60].

According to [22], today in the states of California and Minnesota, aquatic chimney is grown in flood fields, and in the Canadian province of Saskatchewan, along the shores of lakes and rivers; small areas are planted with water rice in Australia and Hungary. However, according to modern scientific periodicals [40], Zizania palustris L. is still cultivated, but Zizania palustris L., which, according to the official database of the US National Plant Germplasm System, is the source of wild rice grain [68]. For Native Americans, wild aquatic rice is still an important part of the diet, and local peoples continue to harvest this plant in their natural habitat [22, 60].

At one time, French researchers noted the similarity of wild rice with tares - a wheat weed, at that time known as folle avoine. Therefore, the scientific name given by K. Linnaeus comes from the Greek zizanion - a weed of the Mediterranean grain fields. And by the early nineteenth century, English-speaking explorers began to call the grain "wild rice" or "Indian rice" because its habitat reminded them of Asian white rice (Oryza spp.). "Wild rice" and the French-Canadian equivalent "rhys savage" are still preserved as common names for species of the genus Zitzania [60], and seeds of various species of this plant continue to be supplied to Europe under the common name as "Indian rice" or "wild rice". ".

The modern common name "wild rice" refers to all Zizania species that are native to eastern and central North America [60]. In scientific publications on the issues of phytochemistry, nutrition, food production and the pharmacotherapeutic action of wild rice (tsinki), specialists outside of botanical nomenclature also continue to mix speciesZizania aquatica L. and Zizania palustris L., introducing some confusion in the evaluation of the results and objectification of their studies. Based Therefore, later in this paper we use the generalized term "wild rice" or "grain of wild rice".

1.2. grain of wild rice

The grain of wild rice was an important food item for the indigenous peoples of the Great Lakes region and is still part of many legends and rituals [60]. In modern Europe and America, its use is constantly growing due to its unusual taste and aroma, as well as the unique ratio of macronutrients. Currently, zirconia grain is considered a delicacy, since the more sophisticated technology of cultivation and production makes it more expensive than other cereals [21].

Most wild rice is now produced in plantations in artificial ponds, where specialized machinery has supplanted traditional manual harvesting methods. Vigorous marketing and the expansion of knowledge about the grain of wild rice have created global

markets for this highly nutritious crop [60]. The grain is in high demand not only for its unique nutritional properties, but also for its special, very distinct aroma [34]. It is used as the main ingredient in everyday or fast food (form) and has many uses [34]. For unknown reasons, some domestic authors call the grain of wild rice black wild rice [2], apparently taking into account the color of the grain, although black rice is usually called chumizu.

Interest in wild rice from companies such as Uncle Ben's and General Foods has spurred the development of the US rice industry. The number of combination products containing 12-18% wild rice mixed with long-grain white or brown rice is constantly increasing on supermarket shelves. Moreover, the smaller the size of the grains bred by breeders, the less problems the consumer has in connection with the duration of cooking with wild rice. An increase in the number of small grains in a package (for the same weight of the product) also makes it more attractive to consumers [60].

When analyzing the USDA database (National Nutrient Database, United States Department of Agriculture), we identified 70 products based on wild rice grains. The assortment on the US market includes both pure grain of wild rice (monocomponent products) and products containing this type of grain mixed with other grains [53, 54].

Taking into account the technology of cultivation and production, as well as the fact that wild rice, with a low fat content in its grain, is rich in minerals, vitamins, protein, starch, dietary fiber, various biologically active substances with antioxidant action, the Food and Drug Administration (FDA) in the USA has been recognized as a whole grain, and is currently marketed in the North American market as a "food that promotes the health of the nation" [47]. The UK Department of Health also encourages the choice of whole grain starchy carbohydrate food sources as they are higher in fiber [45].

With the increasing popularity of wild rice, various semi-finished and ready-made products based on it began to appear, including fillings, frozen casseroles, bread and pancake mixes, and a variety of rice snacks. There are also many cookbooks and recipes. For connoisseurs of healthy eating, an important point is the preferred choice of wild rice grains obtained from plants in natural lakes over cultivated plants. Currently, the United States has a legislative requirement to indicate on the packaging the method of growing wild rice - whether the grain was produced from plants in culture or from wild individuals [60].

1.3. Chemical composition and biologically active substances of wild rice grains

Fats. With a low fat content (Tab.1, 2) wild rice grain is rich in minerals (Tables 1, 4), B vitamins (Tables 1, 5), protein, starch, dietary fiber (Tables 1, 2), as well as various biologically active antioxidants [47].

Table 1

The results of a comparative analysis of the chemical composition of 100 g of polished rice (rice groats) (according to [18,19] *) and wild rice (according to [53]**) indicating % of the recommended intake (RDA) in the Russian Federation

Product (name of cereal /cereals)	Water	Squirrels	Fats	Carbohydrates			food fibers	Minerals						vitamins					
				Are common	Mono and di-saccharides	Starch		Na	TO	Sa	mg	R	Fe	rotin Ka	retin eq (RE)	Tocopherol eq (TE)	IN 1-thiamine	IN 2-ribo-flavin	RR - niacin, VZ
one	2	3	4	5	6	7	eight	9	10	eleven	12	thirteen	14	15	sixteen	17	eighteen	nineteen	twenty
Physiological norms. required (RF)		g/day, 65-117 M 58-87 F	g/day, 70-150 M 60-102 F	g/day, 257-586	-	-	twenty	1300	2500	1000	400	800	10 (M) 18 (W)	5.0	900	15	1.5	1.8	twenty
Unit measurements	grams							mg	mg	mg	mg	mg	mg	mcg	mcg	mg	mg	mg	mg
Rice groats*	14.0	7.0	1.0	74.0	0.7	72.9	3.0	12.0	100.0	8.0	50.0	150.0	1.0	0	0	0.4	0.08	0.04	1.6
% of RNP		10.8% M 12.1% F	1.4%M 1.7% F	28.8%			15.0%	0.9%	4.0%	0.8%	12.5%	18.8%	10.0% M 5.6% F			2.7%	5.3%	2.0%	8.0%
Wild rice**	7.76	14.73	1.08	74.9	2.5	-	6.2	7.0	427.0	21.0	177.0	433.0	1.96	-	19.0	Vit E 0.8	0.115	0.262	6.73
% of RNP		22.7% M 25.4% F	1.5% M 1.8% F	29.2%			31.0%	0.5%	17.1%	2.1%	44.3%	54.1%	19.6% M 10.9% F		2.0%	5.5%	7.7%	14.6%	33.7%

Note to table. one.

Retinol equivalent (RE). It takes into account the sum of retinol in the product and retinol formed in the body from beta-carotene (1 μg of retinol is equivalent to 6 μg of beta-carotene and 12 μg of other carotenoids).

Vit. E equivalent (tocopherol equivalent) (TE). Takes into account the entire group of tocopherol compounds (4 tocopherols and 4 tocotrienols), united by the common name "vitamin E". To obtain this indicator, the following conversion factors are used: alpha-tocopherol - 1.0, beta-tocopherol - 0.4, gamma-tocopherol - 0.1, delta-tocopherol - 0.01, alpha-tocotrienol - 0.3, beta -tocotrientol - 0.05, gamma- and delta-tocotrienols - 0.01 [18]

table 2

Typical macronutrient composition of a grain of wild rice compared to some other cereals (g per 100 g dry cereal) [60]

	Wild rice	Brown rice	Corn	Solid wheat	oatmeal groats
Starch	74.0	78.0	71.5	66.5	62.0
Protein	13.5	8.7	9.0	14.5	15.5
dietary fibers	6.8	5.3	9.5	11.5	11.0
Sahara	1.7	1.3	2.3	1.7	1.4
Oils and fats	0.8	2.6	4.7	1.8	6.5
Ash	1.8	1.5	1.5	2.0	2.0

Table 3

Composition of essential amino acids in grains of wild rice and some other cereals (g, per 100 g protein) [60]

Amino acids	Wild rice	brown-fresh rice	Corn	Solid wheat	oatmeal groats	Need human
Lysine	4.5	3.9	2.5	2.6	4.1	5.8
Methionine	2.8	2.1	1.8	1.5	2.2	2.5
tryptophan	1.6	1.5	0.9	1.2	1.6	1.1
Threonine	3.4	3.7	3.8	2.8	3.4	3.4
Phenylalanine	5.1	5.0	5.0	4.7	5.5	6.3
Histidine	2.8	2.6	2.4	2.2	2.3	1.9
Isoleucine	4.4	4.0	3.9	3.7	4.0	2.8
Leucine	7.4	8.3	11.4	6.7	7.7	6.6
Valine	5.9	5.9	4.7	4.5	5.6	3.5

Table 4

Mineral composition of grain of wild rice in comparison with some other grain crops (mg, per 100 g of dry cereals) [60]

macro and trace elements	Wild rice	brown-fresh rice	Sanded-white rice	Oat groats whole grain	winter wheat	Corn
Calcium	17-22	32	24	53	46	22
Iron	4.2	1.6	0.8	4.5	3.4	2.1
Magnesium	80-161		28	144	160	147
Potassium	55-344	214	92	352	370	284
Phosphorus	298-400	221	94	405	354	268
Zinc	3.3-6.5		1.3	3.4	3.4	2.1

Table 5

Vitamin composition (vitamins of group B) of wild rice grains in comparison with some other grain crops (mg, per 100 g dry cereals) [60]

vitamins group B	Wild rice	brown-fresh rice	Sanded-white rice	Oat groats whole grain	winter wheat	Corn
Thiamine	0.45	0.34	0.07	0.60	0.52	0.37
Riboflavin	0.63	0.05	0.03	0.14	0.12	0.12
Niacin	6.20	4.70	1.60	1.00	4.30	2.20

Proteins and amino acids. From the data in Table.1 it can be seen that 100 g of wild rice (air-dry grain) satisfy the daily human need for protein by almost a quarter, while rice groats (white polished and polished rice) - only by 10-12%. The protein content in zirconia grains is 13–15 g per 100 g of dry product (Tables 1, 2) [22, 53, 60]. Wild rice has not only a high protein content, but also the most adequate (among other grains) balance of essential amino acids (Table 3) [34, 60] - out of 20 amino acids, it contains 18, i.e. to a complete protein lacks two - asparagine and glutamine. Thus, its grain contains in its composition an almost complete list of proteins and amino acids necessary for humans, and, importantly, it is rich in lysine [2]. According to experts, due to the unique composition and balance of nutrients,

Carbohydrates. This whole grain is gluten-free (as is white rice) [22]. The amount of carbohydrates is 75% [63]; of which 60-65% is starch [30, 64]; 1.7-2.9% - pentosans [43]; 0.65-1.94% - dietary fiber [30, 43, 64]; 1.1-3.7% - sugars [30, 64].

The size of starch granules is very small - 2-7μ. The amylose content of wild rice starch is only about 2%. The gelatinization temperature range is higher than that of wheat starch. The swelling capacity and enzyme sensitivity of wild rice starch are higher and the solubility is lower than that of wheat starch. The viscosity is higher than that of wheat starch in equal concentrations. Rice starch from wild rice has better properties for inclusion in a variety of fillings (storable for several days at room temperature and refrigerated), compared with wheat starch [34].

A comparative analysis of the chemical structure and physicochemical properties of starch of 6 varieties of cultivated wild rice with long grain rice starch made it possible to establish their similarity in terms of morphological features, X-ray diffraction patterns, swelling, and water solubility index [55]. However, differences were found in the content of amylose, the distribution of chain lengths, and thermal properties. The structure of wild rice amylopectins was close to that of waxy rice amylopectins with more branches and a higher proportion of short-branched chains with a degree of polymerization of 6-12, compared with amylopectin from white waxy rice starch with a similar amylose content. Differences in the content and distribution of the lengths of the chain branches of amylopectin and amylose were also revealed [55].

Vitamins and minerals. A grain of wild rice is rich in B vitamins, magnesium (177 mg), phosphorus (433 mg) and especially zinc (6 mg per 100 g of dry rice) [22, 60]. It is considered a complete source of B vitamins - thiamine, riboflavin, niacin [34] (section 1.3). It also contains key minerals in amounts comparable to oatmeal, wheat, and corn [34] (Sec. 1.3).

According to official data, wild rice grain is also a natural source of vitamins, primarily B vitamins and folic acid, as well as micro and macro elements: iron, manganese, zinc, copper, selenium, magnesium, phosphorus, sodium, potassium and calcium [53].

Phenolic compounds. In recent years, there has been an increased interest in the study of phenolic profiles of cereals and cereals from them.

due to established antioxidant activity and potential positive effects on overall health. The results of numerous studies confirm their therapeutic and prophylactic effects, in terms of lowering cholesterol levels, antioxidant action, prevention of atherogenesis and type II diabetes mellitus [46].

Ferulic acid and its derivative, the disaccharide β-D-xylopyranosyl-(l→2)-5-O-(trans-feruloyl)-L-arabinofuranose (FAX)), were found in the grain of wild rice, which was previously identified in the leaves of various herbs , as well as in rye and corn [44].

Ferulic acid (4-hydroxy-3-methoxy-cinnamic acid) is a natural phenylpropanoid and belongs to the class of hydroxycinnamic acids. The growing interest in this natural compound is associated with its high biological activity: ferulic acid has strong antioxidant properties due to its structure, antitumor and antibacterial properties, has a healing effect, and can also be used as a stabilizer in the food industry [23].

The raw materials richest in the content of ferulic acid are corn and wheat bran, flax seeds, rye, spinach, broccoli, and red cabbage [25, 52]. Ferulic acid is one of the precursor substances in the synthesis of lignin, a component of plant mechanical tissues. It forms diferulic bridges between polysaccharide molecules in the plant cell wall, which increases its strength [44]; in the form of esters with triterpene alcohols and sterols, it is part of γ-oryzanol, an antioxidant component contained in rice bran oil [6].

In the 90s of the last century, it was shown that ferulic acid is a component that is almost universally present in higher plants, but appears mainly in seeds, as a result of the metabolism of phenylalanine and tyrosine. It can remain both in free form and covalently bound to lignin and other biopolymers. Thanks to the phenolic ring and side chain, it easily forms a resonantly stabilized phenoxy radical, which provides a powerful antioxidant potential. UV absorption of ferulic acid enhances the ability of the radical to terminate free radical chain reactions. Due to the effective neutralization of harmful radicals and the suppression of radiative oxidative reactions, this compound can serve as an important antioxidant in the process of maintaining the physiological integrity and function of cells, including those exposed to ultraviolet (UV) radiation. Its addition to food products inhibits lipid peroxidation and subsequent oxidative degradation. By the same mechanism, ferulic acid can have a protective effect on the cell in various inflammatory diseases [28].

When studying the effect of thermostable α-amylase on the complex of phenolic compounds in wild rice grain, it was shown that ferulic acid makes a significant contribution both to the change in the physicochemical properties and the antioxidant activity of products containing it [63].

Sumczynskia D. et al. (2016) studied the contribution of individual phenolic compounds to antioxidant activity, as well as the digestibility of Zizania aquatica L.in vitro [46]. The analysis of flavonoids and other phenolic compounds made it possible to obtain an HPLC profile of free and bound phenolic fractions. The highest content of flavonoids (378-455 mg/kg) was found in the fraction of bound compounds, while the highest content of polyphenols (1061-2988 mg/kg) was found in the fractions of free compounds. In addition to identifying the predominant phenols, an assessment was made of the cross-correlations of individual phenolic compounds and antioxidant activity. A linear correlation has been established between the total content of phenolic compounds and antioxidant activity. The total amount of flavonoids also showed a positive correlation with the antioxidant activity of wild rice grain [46].

In particular, among free flavonoids, the main contribution to the antioxidant activity ($r > 0.7111$) is made by epigallocatechin, epicatechin, and rutin; in the fraction of related compounds ($r > 0.6868$) - epicatechin, quercetin and rutin. As for free phenolic acids, the main contribution to the antioxidant activity of free compounds ($r > 0.7585$) is made by ferulic, vanillic, ellagic, synapic, and lilac acids; while caffeic, synapic, lilac, o-coumaric, p-hydroxy-benzoic, vanilla, protocatechuic, gallic and cinnamic acids make the main contribution to the bound fractions of wild rice ($r > 0.6538$) [46].

1.4. Comparative macro- and micronutrient analysis of wild rice grains with other cereals

Focusing on the official and generally accepted tables of the chemical composition of food products used in the Russian Federation [18, 19], we compiled Table. 1, which clearly shows the nutritional benefits of wild rice grains compared to rice groats (white polished and polished rice). When analyzing the data in Table. 1 noteworthy is the significantly higher grain content of wild rice compared to white rice:

- protein (more than 2 times) with a similar content of fats and carbohydrates;
- dietary fiber (more than 2 times);
- potassium (more than 4 times);
- calcium (almost 3 times);
- magnesium (more than 3 times);
- phosphorus (almost 3 times);
- iron (almost twice);
- thiamine (vitamin B_{one}- almost one and a half times;
- niacin (vitamin B_3, PP) - more than 4 times;
- riboflavin (vitamin B_2) - 6.5 times.

At the same time, the sodium content in a grain of wild rice is almost half as much as in white rice groats, and the tocopherol equivalent is twice as high, and the retinol equivalent is almost 20 times higher than in rice groats (Table 1).

In table. 1, we were forced to compare Russian data with American ones, since there is no wild rice in the databases (and corresponding tables) of the chemical composition of food products used in the Russian Federation. However, in foreign bibliographic sources, we found tables of the chemical composition of grains of wild and brown rice, in comparison with grains of corn, durum wheat, and oatmeal (Table 2) [60].

From the data in Table. Figure 2 shows that the starch content of wild rice is somewhat lower than that of brown rice, while that of dietary fiber and easily digestible sugars is higher. The value of the wild rice grain also lies in its extremely low fat content compared to all crops analyzed. The high nutritional value of this product is also due to the high protein content (Table 2), which includes a unique spectrum of essential amino acids in higher amounts compared to most of the compared cereals (Table 3).

In table. Figures 3–5 present the micronutrient composition of a wild rice grain compared to some of the most popular cereal crops in terms of essential amino acids, minerals, and vitamins according to [60].

From the data in Table. Figure 3 shows the results of a comparative analysis of the amino acid composition of wild and brown rice grains in terms of essential amino acids, as well as corn, durum wheat, and oatmeal (according to [60]). It has been revealed that the human need for such essential amino acids as methionine, tryptophan, threonine, histidine, isoleucine, leucine and valine can be fully satisfied with wild rice grains (in terms of 100 g of protein).

From Table. 4 it can be seen that the iron content in the grain of tsitsania is more than 5 times higher than in white polished and polished rice, 2.5 times higher than in brown rice, 2 times higher than in corn, 1.5 times higher than in winter wheat. Particular differences are noted by researchers in the content of zinc. In particular, even its minimal amount in a grain of wild rice is significantly higher than in white rice and corn and is approximately equal to the content in winter wheat and oatmeal. The upper limits of its accumulation in zirconia exceed the zinc content in other cereals by several times (Table 4) [60].

The vitamin complex of wild rice is also unique (Table 5). Almost all B vitamins are selectively accumulated in zitsia, which makes it possible to consider the grain of wild rice as a unique source of biologically available thiamine, riboflavin, and niacin (Table 5).

2. Biological action of wild rice grain and its physiologically active compounds

According to modern concepts, diet therapy and healthy nutrition are one of the most important strategic directions for the prevention and treatment of cardiovascular diseases, and also significantly affect risk factors, including high cholesterol and atherosclerosis.

Scientific studies in recent years have made it possible to establish the antioxidant and hypolipidemic properties of wild rice, while its positive effect on the cardiovascular system with long-term consumption has been proven under experimental conditions [47]. Evidence continues to accumulate regarding the clinical benefits of regular consumption of wild rice and its effects on the cardiovascular system [47].

In particular, G. Surendiran et al. (2013) revealed the potential of wild rice to positively affect the cardiovascular system in male and female mice with a deficiency of low-density lipoprotein receptor (LDL-receptor - a membrane protein that mediates endocytosis of cholesterol-rich low-density lipoprotein, specifically recognizes apoB- 100 and apoE (LDLr-KO) mice). Wild rice has been used in a semi-synthetic diet containing about 60% carbohydrates of total energy. The other experimental diets in the other two experimental groups were similar in terms of macronutrient composition but contained either white rice or commercial carbohydrate sources. All three diets were supplemented with 0.06 wt% dietary cholesterol. The mice were divided into six experimental groups,

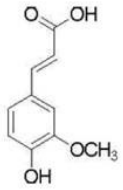
It was found that the consumption of wild rice significantly reduces the size and severity of atherosclerotic lesions in the aortic roots of male and female mice by 71 and 61%, respectively, compared with the control group of the same sex. This effect was associated with a significant reduction in plasma cholesterol by 15% and 40%, low-density lipoprotein (LDL) by 12% and 42%, and very-low-density lipoprotein (VLDL) by 35% and 75%, respectively, in males and females. female mice compared with a control group of the same sex. There was also an increase in fecal cholesterol excretion up to 34%, compared with the control group of the same sex. However, the anti-atherogenic effect of wild rice was not associated with an increase in the activity of superoxide dismutase (SOD) and catalase (CAT) [48].

Thus, G. Surendiran et al. (2013) it was shown that long-term consumption of wild rice in the experiment reduces plasma cholesterol levels in mice and prevents atherogenesis (LDL-receptor-KO), increases cholesterol excretion. The results suggest that, in order to lower cholesterol levels, the use of wild rice may be a major factor in the prevention of atherogenesis in LDLR-KO mice [48].

For one of the classic antioxidants, ferulic acid (Fig. 1), found in wild rice grains [44], anti-inflammatory, anti-allergic, antiplatelet, antitumor, antitoxic, hepatoprotective, cardioprotective, antibacterial, antiviral and other types of action were found, which is due to main antioxidant effect - inhibition of lipid peroxidation and inhibition of free radical stages of prostaglandin synthesis [5].

Interesting data were obtained [12]: in the experiment, ferulic acid had a cardioprotective effect in conditions of acute alcohol intoxication, which was manifested by a more pronounced increase in the rate of contraction and relaxation of the myocardium, an increase in left ventricular pressure in the experimental groups of animals, compared with the control, during functional tests.

One of the key links in the pathogenesis of alcoholic myocardial damage is the intensification of free radical oxidation processes under the influence of ethanol and acetaldehyde, which leads to the destruction of the membranes of cardiomyocytes and their mitochondria, which entails inhibition of respiratory processes and oxidative phosphorylation and, as a result, a violation of energy production [9, eleven]. As a result of the resulting deficiency of adenosine triphosphatase (ATP), a decrease in myocardial contractile activity is observed. In this regard, biologically active substances with an antioxidant effect are relevant to protect the myocardium from damage by ethanol. Ferulic acid, due to the presence in the structure of a carbon chain containing a double bond (propenoic acid residue) and a hydroxyl group in the phenyl core, easily enters into free radical reactions with the formation of a stable,



Rice. one.4-hydroxy-3methoxycinnamic (ferulic) acid.

The authors of the article [12] also suggest that a positive effect in acute alcohol intoxication is achieved due to the antioxidant properties of ferulic acid, which, obviously, protect the membranes of cardiomyocytes and their mitochondria from the damaging effects of ethanol and acetaldehyde, which probably helps prevent dysfunction of the oxidative phosphorylation that occurs during acute alcohol intoxication, and intensification of energy production processes to provide ATP for myocardial contraction.

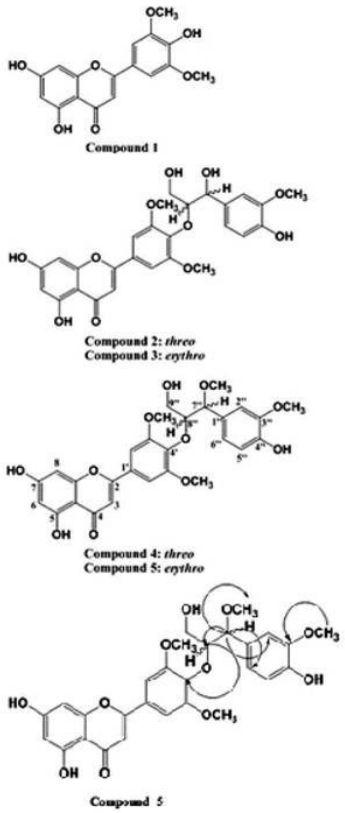
For a number of polyphenolic compounds of the aerial part of Zizania latifolia, anti-inflammatory and anti-allergic effects were revealed [31]. In particular, [31] isolated a new flavolignan salsolin D (5) from this plant, along with the previously known flavone and three known flavonolignans, tricine (1), salsolins A (2), B (3), and C (4), respectively. The chemical structure of the new flavolignan was determined as tricine-4>-O-[erythro-beta-guaisyl-(7'-O-methyl)-glyceryl]-ester (Fig. 2). All 5 compounds were isolated from this plant for the first time.

Tricin derivatives (2)-(5) showed more pronounced anti-inflammatory and anti-allergic properties than tricine itself. In particular, salsolin D (5) has been shown to have the strongest inhibitory activity against LPS-induced NO production in RAW 264.7 cells as well as P-hexosaminidase release in IgE-sensitized RBL-2H3 cells. These results indicate that the presence of tricine derivatives is responsible for the ability of Zizania latifolia to treat allergies and inflammation.

Previously, an antiallergic effect was described [32] for a methanol extract of the same plant. The extract did not show any signs of cytotoxicity against IgE-sensitized RBL-2H3 cells, inhibited substance 48/80-induced degranulation and antigen-induced release of hexosaminidase, as well as the production of tumor necrosis factor in RBL-2H3 mast cells in a dose-dependent manner. The results obtained indicate that Zizania latifolia extracts can be used to prevent type I allergic reactions [32].

In 2010, encouraging data were obtained regarding the degranulating effect in mast cells, established for the extract of the same plant in atopic dermatitis (AD) - a chronic inflammatory skin disease that occurs with itching, remissions and exacerbations [33]. The important role of mast cells in immediate-type allergic reactions is well known: activation of mast cells leads to a process of degranulation, which leads to the fusion of cytoplasmic membrane granules with the plasma membrane. Since Zizania latifolia has been one of the most popular species in East Asia for a long time, used for the prevention and treatment of cardiovascular diseases, diabetes, skin diseases, [33] set the task to study in an experiment (rats) the effect of an extract from the aerial part of Zizania latifolia on the release of ß-hexosaminidase from DNPBSA-activated mast cells. Positive results

The experiment, according to [33], makes it reasonable to further targeted studies on the isolation of pharmacologically active compounds from Zizania latifolia for the treatment of atopic dermatitis.



Rice. 2. Tricin and its derivatives isolated from wild rice.

3. Potential allergological and other risks of therapeutic and prophylactic use of wild rice grain

3.1. Prognostic allergological risks

The assessment of allergological risks in the food industry in developed countries is becoming an indispensable element in the development and production of food products [8, 27, 36, 37]. Informing doctors and patients at risk of developing allergic reactions and/or intolerance is also an extremely important aspect of preventing the occurrence of critical situations for both patients and those who consider themselves healthy [8, 36, 38]. It is especially important to assess the potential allergological risks of food use in children. In particular, according to [14, 17], neither rice groats (white polished rice) nor wild rice are among the most common allergens in children with atopic dermatitis, unlike, for example, buckwheat groats [8]. In general, the frequency of sensitization to rice groats (n = 525) is 15.4% [14,17]. For wild rice, bibliographic data on allergological risks have not been identified. To date, the WHO/IUIS Allergen Nomenclature also lacks information on the allergenic components of wild rice [24].

Discussing the pollination regime and pollen size of potential allergens of the Cereal family, [26] include Z. aquatica among plants with a strictly anemophilic pollination regime (pollen grain size 32–45 microns), whose pollen can potentially cause allergic reactions.

3.2. Other risks of food use of grains of wild rice

The available data on the contamination of wild rice habitats raises the concern of specialists due to the increased level of toxic metals in the grain, which can pose a health hazard [60]. High concentrations of copper, reaching levels of 14.4 μg/g, lead and cadmium, respectively, 6.2 and 6.7 μg/g, were recorded in some samples of dried and hulled wild rice grain. Locally elevated concentrations of metals were attributed by the researchers to the results of atmospheric pollution due to emissions from smelting furnaces. It has also been reported that lead from shotgun shells used in hunting lakes may have been taken up by wild rice during the growing season. High concentrations of lead (0.5-11.5 g per 100 g of 1 dry grain), cadmium (1.0-10.2 g per 100 g of dry grain) and arsenic (0.6-14.

3.3. Application for celiac disease

Celiac disease (gluten enteropathy) is a chronic disease characterized by damage to the mucous membrane of the small intestine and indigestion against the background of intolerance to gluten - the gluten proteins of wheat, rye, and oats [13, 20]. Celiac disease is the most common cause of prolonged wasting diarrhea in young children [14] and is increasingly being diagnosed in adolescence and adults [13].

The main method of treating celiac disease is a lifelong gluten-free diet, in which it is necessary to completely exclude from the diet gluten-containing foods and dishes containing wheat, rye, oat and barley flour, cereals, starches - bread, bakery products, semolina, oatmeal, barley, barley groats, flour, oatmeal, "Hercules", as well as meat and fish products (including canned food, bouillon cubes, etc.), mayonnaises and sauces containing the so-called "hidden" gluten [13, 15].

Therefore, when discussing the beneficial properties of any cereals, it is imperative to take into account the possibility of their use in celiac disease. According to modern concepts, celiac disease allows the use of a limited amount of cereals - rice, corn [15], buckwheat [8, 15]. Also gluten free are quinoa, sorghum, teff, wild rice, amaranth, millet, montina (Indian rice grass), so these

products can be included in the diet of patients with celiac disease if well tolerated [58].

4. Possibilities of nutritional and therapeutic and prophylactic use of wild rice grain

In modern dietology, wild rice is usually not used as a monocomponent dish, but it is widely used mixed with white and brown rice, as well as for preparing various combined cold and hot dishes and side dishes [54, 60].

The high nutritional value of the grain of wild rice makes it one of the most balanced (optimal) sources of protein and dietary fiber with a low fat content (section 1.3). Particularly valuable is the micronutrient composition of the grain, in particular, the polyphenol and multivitamin complex, as well as its mineral components - compounds of iron, magnesium, zinc and B vitamins (section 1.3).

Taking into account the experience of East Asian countries, where Zizania latifolia has long been one of the most popular plant and food species used for the prevention and treatment of cardiovascular diseases, diabetes mellitus, skin diseases [33], and also based on the results of modern scientific studies (sections 1-3), wild rice grain, with a certain degree of validity, can be recommended for inclusion in the diet (including use as a component of herbal medicine with food plants) for the following indications: vitamin B deficiency, microelementoses (deficiency zinc, iron, magnesium), intoxication of various etiologies, atherosclerosis and other diseases of the cardiovascular system, diabetes mellitus, allergic diseases, including atopic dermatitis, and other skin diseases.

Based on the results of our information and analytical study, nutritionists and representatives of the scientific community (researchers) also deserve the attention of anti-inflammatory, antiviral, desensitizing, detoxifying, anti-sclerotic and other types of action of wild rice in terms of their further experimental and clinical study from the standpoint of evidence-based medicine. From our point of view, it would be expedient for the authorized bodies to also consider the introduction of some representatives of the genus Zicania into culture in the Russian Federation, as well as the inclusion of wild rice grains in the list of promising sources of macro- and micronutrients for specialized food products.

CONCLUSIONS

1. The identification, analysis and synthesis of scientifically based information in terms of plant sources, nutritional value, therapeutic and prophylactic properties, allergological and other risks of food use of wild rice (Zizania spp.).

2. It has been shown that some representatives of the genus Zicania are valuable sources of wild rice grains containing a unique a complex of macro- and micronutrients - protein and dietary fiber, essential amino acids, B vitamins, minerals and antioxidants of various structures.

3. The conducted information and analytical study allows us to consider wild rice as a promising domestic agricultural crop, a source of macro- and micronutrients for specialized food products, and its grain as a dietary product with a scientifically substantiated spectrum of pharmacotherapeutic action.

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